

Indian Health Service Division of Engineering Services Addendum 001 – Bid Set Specifications – Volume 2 Browning, Montana



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**Professional Architect-Engineer (A-E) Services for
Design for Browning 18-Unit Apartment Building,
Blackfeet Service Unit, Browning, Montana**

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SECTION 21 00 00 - FIRE PROTECTION GENERAL PROVISIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SECTION INCLUDES

- (A) PIPE, FITTINGS, VALVES, AND CONNECTIONS FOR SPRINKLER SYSTEMS.

1.03 RELATED SECTIONS

- (A) SECTION 22 05 00 – COMMON PLUMBING MATERIALS AND REQUIREMENTS.
(B) SECTION 23 05 00 – COMMON HVAC MATERIALS AND REQUIREMENTS.

1.04 REFERENCES

- (A) ASME (BPV IX) – BOILER AND PRESSURE VESSEL CODE, SECTION IX – WELDING AND BRAZING QUALIFICATIONS; THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS; 1998.
(B) ASME B16.1 – CAST IRON PIPE FLANGES AND FLANGED FITTINGS; THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS; 1998.
(C) ASME B16.3 – MALLEABLE IRON THREADED FITTINGS; THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS; 1998.
(D) ASME B16.4 – GRAY IRON THREADED FITTINGS; THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS; 1999.
(E) ASME B16.9 – FACTORY-MADE WROUGHT STEEL BUTTWELDING FITTINGS; THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS; 1993.
(F) ASME B16.18 – CAST COPPER ALLOY SOLDER JOINT PRESSURE FITTINGS; THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS; 1984, REAFFIRMED 1994 (ANSI B16.18).
(G) ASTM A 47/A 47M – STANDARD SPECIFICATION FOR FERRITIC MALLEABLE IRON CASTINGS; 1999.
(H) ASTM A 53/A 53M – STANDARD SPECIFICATION FOR PIPE, STEEL, BLACK AND HOT-DIPPED, ZINC-COATED, WELDED AND SEAMLESS; 2000.
(I) ASTM A 795 – STANDARD SPECIFICATION FOR BLACK AND HOT-DIPPED ZINC-COATED (GALVANIZED) WELDED AND SEAMLESS STEEL PIPE FOR FIRE PROTECTION USE; 2000.
(J) AWS A5.8 – SPECIFICATION FOR FILLER METALS FOR BRAZING AND BRAZE WELDING; AMERICAN WELDING SOCIETY; 1992.
(K) AWWA C110 – AMERICAN NATIONAL STANDARD FOR DUCTILE-IRON AND GRAY-IRON FITTINGS, 3 IN. THROUGH 48 IN. (75 MM THROUGH 1200 MM), FOR WATER AND OTHER LIQUIDS; AMERICAN WATER WORKS ASSOCIATION, 1998.

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- (L) AWWA C111/A21.11 – RUBBER-GASKET JOINTS FOR DUCTILE-IRON PRESSURE PIPE AND FITTINGS; AMERICAN WATER WORKS ASSOCIATION; 1995 (ANSI/AWWA C111/A21.11).
- (M) AWWA C151/A21.51 – DUCTILE-IRON PIPE, CENTRIFUGALLY CAST, FOR WATER; AMERICAN WATER WORKS ASSOCIATION; 1996 (ANSI/AWWA C151/A21.51).
- (N) NFPA 13 – STANDARD FOR THE INSTALLATION OF SPRINKLER SYSTEMS; NATIONAL FIRE PROTECTION ASSOCIATION; CURRENT EDITION.
- (O) NFPA 13R – AUTOMATIC SPRINKLER SYSTEMS IN LOW-RISE RESIDENTIAL OCCUPANCIES; CURRENT EDITION.
- (P) UL (FPED) – FIRE PROTECTION EQUIPMENT DIRECTORY; UNDERWRITERS LABORATORIES INC.; CURRENT EDITION.
- (Q) UL 262 – GATE VALVES FOR FIRE-PROTECTION SERVICE; UNDERWRITERS LABORATORIES INC.; CURRENT EDITION.
- (R) UL 312 – CHECK VALVES FOR FIRE-PROTECTION SERVICE; UNDERWRITERS LABORATORIES INC.; CURRENT EDITION.

1.05 SUBMITTALS

- (A) PRODUCT DATA: PROVIDE MANUFACTURERS CATALOGUE INFORMATION. WHEN MORE THAN ONE (1) MODEL, SIZE, FINISH, ACCESSORY, ETC. ARE PROVIDED ON A SINGLE VENDOR'S CATALOG CUT SHEET, MARK OR HIGHLIGHT ALL THAT APPLY AND/OR MARK THROUGH ALL THAT DO NOT APPLY.
- (B) SHOP DRAWINGS: PROVIDE SHOP DRAWING THAT IS IN COMPLIANCE WITH THE "WORKING DRAWINGS" DESCRIPTION IN NFPA 13. INDICATE PIPE MATERIALS USED, JOINTING METHODS, SUPPORTS, AND FLOOR AND WALL PENETRATION SEALS. INDICATE INSTALLATION, LAYOUT, PIPE ELEVATIONS, PIPE SIZES, MOUNTING AND SUPPORT DETAILS, PIPING CONNECTIONS, ALL CEILING DEVICES AND ALL EXPOSED OBSTRUCTIONS. IF MORE THAN ONE PIPE MATERIAL IS BEING USED, SHOP DRAWING SHALL PROVIDE UNIQUE LINE TYPES (COLOR OR LINE STYLE) TO INDICATE EACH MATERIAL TYPE. PROVIDE DETAILED SYMBOLS LEGEND FOR ALL SYMBOLS USED ON DRAWING. DRAWINGS SHALL BE PROVIDED USING COMPUTERIZED DRAFTING. HAND DRAWINGS SHALL NOT BE PERMITTED. DRAWINGS SHALL NOT BE CREATED FROM PDF'S OR HAVE PDF'S IMBEDDED WITH THE CAD FILES.
- (C) PROJECT RECORD DOCUMENTS: RECORD ACTUAL LOCATIONS OF COMPONENTS AND TAG NUMBERING.
- (D) OPERATION AND MAINTENANCE DATA: PREPARE AND SUBMIT OPERATION AND MAINTENANCE INSTRUCTIONS FOR ALL FIRE SPRINKLER DATA, QUANTITY AND DELIVERY METHOD AS DEFINED IN DIVISION 01. EACH MANUAL SHALL BE TABBED WITH TABS FOR: PRODUCT DATA, INCLUDE INSTALLATION INSTRUCTIONS AND SPARE PARTS LISTS; WARRANTIES; TESTING CERTIFICATIONS, INCLUDE BOTH ABOVEGROUND PIPING AND UNDERGROUND PIPING CERTIFICATIONS; FINAL HYDRAULIC CALCULATIONS; "AS BUILT" DRAWINGS FOLDED AND PLACED IN PLASTIC POUCHES WITH HOLES FOR INSERTION INTO A THREE-RING BINDER; AND SYSTEM MAINTENANCE REQUIREMENTS. INCLUDE CONTACT INFORMATION FOR EMERGENCY RESPONSE. AS WITH ORIGINAL SUBMITTAL, PRODUCT DATA SHALL BE MARKED TO REFLECT MARKED, MODEL, SIZE AND FINISH(ES) USED ON PROJECT.
 - 1. CONTENT: OPERATIONS AND MAINTENANCE MANUAL CONTENT IS SPECIFIED IN INDIVIDUAL SPECIFICATION SECTIONS TO BE REVIEWED AT THE TIME OF SECTION SUBMITTALS. SUBMIT REVIEWED CONTENT FORMATTED AND ORGANIZED AS REQUIRED BY THIS SECTION. ENGINEER WILL COMMENT ON CONTENT OF OPERATIONS AND MAINTENANCE SUBMITTALS AND INDICATE WHERE REVISIONS OR RE-SUBMITTALS ARE REQUIRED. CLARIFY AND UPDATE REVIEWED CONTENT TO CORRESPOND TO REVISIONS AND FIELD CONDITIONS.
 - 2. ORGANIZATION: ORGANIZE EACH MANUAL INTO TABBED SECTIONS AS NOTED ABOVE. MANUAL SHALL CONTAIN THE FOLLOWING MATERIALS, IN THE ORDER LISTED:

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- A. TITLE PAGE, INCLUDING NAME AND ADDRESS OF PROJECT AND OWNER, AND CONTACT INFORMATION FOR CONTRACTOR, CONSTRUCTION MANAGER AND ARCHITECT.
 - B. TABLE OF CONTENTS, INCLUDING EACH PRODUCT INCLUDED IN MANUAL, IDENTIFIED BY PRODUCT NAME, INDEXED TO THE CONTENT OF THE VOLUME, AND CROSS-REFERENCED TO SPECIFICATION SECTION NUMBER IN PROJECT MANUAL.
 - C. MANUAL CONTENTS: ORGANIZE INTO SETS OF MANAGEABLE SIZE. ARRANGE CONTENTS ALPHABETICALLY BY SYSTEM, SUBSYSTEM, AND EQUIPMENT. IF POSSIBLE, ASSEMBLE INSTRUCTIONS FOR SUBSYSTEMS, EQUIPMENT, AND COMPONENTS OF ONE SYSTEM INTO A SINGLE BINDER.
 - D. ELECTRONIC FILES: USE ELECTRONIC FILES PREPARED BY MANUFACTURER WHERE AVAILABLE. WHERE SCANNING OF PAPER DOCUMENTS IS REQUIRED, CONFIGURE SCANNED FILE FOR MINIMUM READABLE FILE SIZE.
3. FORMAT: ASSEMBLE EACH MANUAL INTO A COMPOSITE ELECTRONICALLY INDEXED FILE. SUBMIT ON DIGITAL MEDIA ACCEPTABLE TO ARCHITECT/ENGINEER. NAME EACH INDEXED DOCUMENT FILE IN COMPOSITE ELECTRONIC INDEX WITH APPLICABLE ITEM NAME. INCLUDE A COMPLETE ELECTRONICALLY LINKED OPERATION AND MAINTENANCE DIRECTORY. ENABLE INSERTED REVIEWERS COMMENTS ON DRAFT SUBMITTALS.

1.06 QUALITY ASSURANCE

- (A) CONFORM TO UL AND FM REQUIREMENTS.
- (B) VALVES: BEAR UL LABEL OR MARKING. PROVIDE MANUFACTURER'S NAME AND PRESSURE RATING MARKED ON VALVE BODY.
- (C) PRODUCTS REQUIRING ELECTRICAL CONNECTION: LISTED AND CLASSIFIED AS SUITABLE FOR THE PURPOSE SPECIFIED AND INDICATED.

1.07 AUTOCAD DRAWING FILE REQUESTS

- (A) AS AN INSTRUMENT OF SERVICE TO AID IN SHOP DRAWING SUBMITTALS, FARRIS ENGINEERING (FEI) WILL PROVIDE AUTOCAD DRAWING FILES UPON REQUEST. THE FILES WILL BE SENT UPON RETURN RECEIPT OF THE "REQUEST FOR DRAWINGS" AGREEMENT SIGNED BY AN OFFICER OF THE REQUESTING FIRM. FEI DOES NOT ASSURE THAT THE DRAWINGS REPRESENT ALL CHANGES, ADDENDA ITEMS, CHANGE ORDERS OR MODIFICATIONS THAT MAY HAVE OCCURRED. THE DRAWINGS ARE SIMPLY A TOOL FOR USE IN PRODUCING SHOP DRAWING SUBMITTALS.
- (B) THE DRAWING FILES WILL BE "CLEANED-UP" BY HAVING THE FEI LOGO, PROFESSIONAL ENGINEER SEAL, AND ALL EXTRANEOUS NOTES AND DETAILS REMOVED. FEI MUST BE COMPENSATED FOR THIS ADDITIONAL SERVICE BY THE REQUESTING FIRM. A MINIMUM FEE OF \$400.00 FOR UP TO EIGHT (8) SHEETS AND \$50.00 PER SHEET FOR EACH ADDITIONAL REQUESTED DRAWING WILL BE INVOICED TO THE REQUESTING FIRM ONCE THE SIGNED AGREEMENT IS RECEIVED.

1.08 DELIVERY, STORAGE AND PROTECTION

- (A) DELIVER AND STORE VALVES AND SPRINKLERS IN SHIPPING CONTAINERS, WITH LABELING IN PLACE.

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(B) EXTREME CARE SHALL BE EXERCISED BY THE CONTRACTOR TO PREVENT DIRT AND OTHER FOREIGN MATTER FROM ENTERING PIPE OR COMPONENTS OF SYSTEM DURING CONSTRUCTION. PIPE STORED OUTSIDE ON THE SITE OF THE PROJECT SHALL HAVE OPEN ENDS CAPPED AND EQUIPMENT SHALL HAVE ALL OPENINGS FULLY PROTECTED. BEFORE ERECTION, EACH PIECE OF PIPE, FITTING OR VALVE SHALL BE VISUALLY EXAMINED AND ALL DIRT REMOVED. NOTE, CPVC PIPING AND PIPE MATERIALS SHALL NOT BE STORED OUTSIDE.

(C) WHEN STORING PIPING MATERIAL IN THE ELEMENTS ON A PROJECT SITE, PROVIDE TEMPORARY END CAPS AND CLOSURES ON PIPING AND FITTINGS. MAINTAIN IN PLACE UNTIL INSTALLATION.

1.09 EXTRA MATERIALS

(A) PROVIDE NFPA 13 REQUIRED QUANTITY OF SPARE STOCK OF SPRINKLERS AND PROVIDE TWO (2) SPARE SPRINKLER WRENCHES AND ANY OTHER SPECIALTY WRENCH NECESSARY TO PROVIDE MAINTENANCE ON THE SYSTEM FOR EACH SIZE/STYLE USED ON THE PROJECT.

PART 2 - PRODUCTS

2.01 GENERAL SYSTEM AND PRODUCT REQUIREMENTS

(A) SPRINKLER SYSTEMS: CONFORM WORK TO NFPA 13.

(B) WELDING MATERIALS AND PROCEDURES: CONFORM TO ASME CODE.

2.02 PIPE HANGERS AND SUPPORTS

(A) HANGERS FOR PIPE SIZES 1/2 TO 3 INCH: CARBON STEEL, ADJUSTABLE SWIVEL, SPLIT RING.

(B) HANGERS FOR PIPE SIZES OVER 3 INCH: CARBON STEEL, ADJUSTABLE, CLEVIS.

(C) MULTIPLE OR TRAPEZE HANGERS: STEEL CHANNELS WITH WELDED SPACERS AND HANGER RODS.

(D) WALL SUPPORT FOR PIPE SIZES TO 3 INCHES: CAST IRON HOOK.

(E) WALL SUPPORT FOR PIPE SIZES 4 INCHES AND OVER: WELDED STEEL BRACKET AND WROUGHT STEEL CLAMP.

(F) VERTICAL SUPPORT: STEEL RISER CLAMP.

(G) FLOOR SUPPORT: CAST IRON ADJUSTABLE PIPE SADDLE, LOCK NUT, NIPPLE, FLOOR FLANGE, AND CONCRETE PIER OR STEEL SUPPORT.

2.03 BUTTERFLY VALVES

(A) BRONZE BODY, UP TO AND INCLUDING 12":

1. STAINLESS STEEL DISC, RESILIENT REPLACEABLE SEAT, THREADED OR GROOVED ENDS, EXTENDED NECK, HANDWHEEL AND GEAR DRIVE AND INTEGRAL INDICATING DEVICE, AND BUILT-IN TAMPER PROOF SWITCH RATED 10 AMP AT 115 VOLT AC.

(B) CAST OR DUCTILE IRON BODY:

1. CAST OR DUCTILE IRON, CHROME OR NICKEL PLATED DUCTILE IRON OR ALUMINUM BRONZE DISC, RESILIENT REPLACEABLE EPDM SEAT, WAFER, LUG, OR GROOVED ENDS, EXTENDED NECK, HANDWHEEL AND GEAR DRIVE AND INTEGRAL INDICATING DEVICE, AND INTERNAL TAMPER SWITCH RATED 10 AMP AT 115 VOLT AC.

2.04 CHECK VALVES

(A) 4 INCHES AND OVER:

1. IRON BODY, BRONZE DISC, STAINLESS STEEL SPRING, RESILIENT SEAL, THREADED, WAFER, OR FLANGED ENDS.

2.05 DRAIN VALVES

(A) COMPRESSION STOP:

1. BRONZE WITH HOSE THREAD NIPPLE AND CAP.

(B) BALL VALVE:

1. BRASS WITH CAP AND CHAIN, 3/4 INCH HOSE THREAD.

2.06 EXPANSION COMPENSATION LOOPS

(A) MANUFACTURERS:

1. METRAFLEX, METRALOOP FIRELOOP MODEL MLUG.

(B) TWO 90° ELBOWS, BRAIDED CONNECTORS, 180° RETURN, AND FACTORY INSTALLED DRAIN/AIR RELEASE PLUG.

PART 3 - EXECUTION

3.01 PREPARATION

(A) REAM PIPE AND TUBE ENDS. REMOVE BURRS. BEVEL PLAIN END FERROUS PIPE.

(B) REMOVE SCALE AND FOREIGN MATERIAL, FROM INSIDE AND OUTSIDE, BEFORE ASSEMBLY.

(C) PREPARE PIPING CONNECTIONS TO EQUIPMENT WITH FLANGES OR UNIONS.

3.02 INSTALLATION

(A) INSTALL SPRINKLER SYSTEM AND SERVICE MAIN PIPING, HANGERS, AND SUPPORTS IN ACCORDANCE WITH NFPA 13.

(B) ROUTE WET PIPING IN ORDERLY MANNER, PLUMB AND PARALLEL TO BUILDING STRUCTURE. MAINTAIN GRADIENT.

(C) INSTALL ALL DRY PIPING PROPERLY SLOPED TO DRAIN. LOCATE DRUM DRIPS IN WARM LOCATIONS. COORDINATE LOCATION WITH A/E SUCH THAT DRUM DRIPS ARE IN AESTHETICALLY PLEASING LOCATIONS.

- (D) INSTALL PIPING TO CONSERVE BUILDING SPACE, TO NOT INTERFERE WITH USE OF SPACE AND OTHER WORK.
- (E) INSTALL COMPONENTS HAVING PRESSURE RATING EQUAL TO OR GREATER THAN SYSTEM OPERATING PRESSURE.
- (F) INSTALL PIPING IN CONCEALED LOCATIONS, EXCEPT IN EQUIPMENT ROOMS AND SERVICE AREAS UNLESS NOTED OTHERWISE ON PLANS.
- (G) INSTALL PIPING FREE OF SAGS AND BENDS.
- (H) INSTALL EXPOSED PIPING AT RIGHT ANGLES OR PARALLEL TO BUILDING WALLS. DIAGONAL RUNS ARE PROHIBITED, EXCEPT WHERE INDICATED. ROLLING OFFSETS ARE PROHIBITED.
- (I) INSTALL PIPING TIGHT TO SLABS, BEAMS, JOISTS, COLUMNS, WALLS, AND OTHER BUILDING ELEMENTS. ALLOW SUFFICIENT SPACE ABOVE REMOVABLE CEILING PANELS TO ALLOW FOR CEILING PANEL REMOVAL.
- (J) GROUP PIPING WHENEVER PRACTICAL AT COMMON ELEVATIONS.
- (K) SLEEVE PIPES PASSING THROUGH PARTITIONS, WALLS, AND FLOORS.
- (L) ALL SPRINKLER PIPE WELDING SHALL BE CONDUCTED IN A CONTROLLED SHOP ENVIRONMENT USING WELD-ON-LETS FOR ALL BRANCH TAKE-OFFS. UPON COMPLETION OF PIPE WELDS, SCRAPE, BRUSH, CLEAN AND APPLY ONE (1) COAT OF ZINC RICH PRIMER TO ALL PIPE WELDS.
- (M) INSTALL PIPING TO ALLOW FOR EXPANSION AND CONTRACTION WITHOUT STRESSING PIPE, JOINTS, OR CONNECTED EQUIPMENT.
- (N) INSERTS:
 - 1. PROVIDE INSERTS FOR PLACEMENT IN CONCRETE FORMWORK.
 - 2. PROVIDE INSERTS FOR SUSPENDING HANGERS FROM REINFORCED CONCRETE SLABS AND SIDES OF REINFORCED CONCRETE BEAMS.
 - 3. PROVIDE HOOKED ROD TO CONCRETE REINFORCEMENT SECTION FOR INSERTS CARRYING PIPE OVER 4 INCHES.
 - 4. WHERE CONCRETE SLABS FORM FINISHED CEILING, LOCATE INSERTS FLUSH WITH SLAB SURFACE.
 - 5. WHERE INSERTS ARE OMITTED, DRILL THROUGH CONCRETE SLAB FROM BELOW AND PROVIDE THROUGH-BOLT WITH RECESSED SQUARE STEEL PLATE AND NUT RECESSED INTO AND GROUTED FLUSH WITH SLAB.
- (O) PIPE HANGERS AND SUPPORTS:
 - 1. GENERAL: INSTALL HANGERS, SUPPORTS, CLAMPS AND ATTACHMENTS TO SUPPORT PIPING PROPERLY FROM BUILDING STRUCTURE; COMPLY WITH MSS SP-69. INSTALL SUPPORT WITH MAXIMUM SPACING COMPLYING WITH MSS SP-69. DO NOT USE WIRE OR PERFORATED METAL TO SUPPORT PIPING, AND DO NOT SUPPORT PIPING FROM OTHER PIPING. PIPING SHALL NOT BE SUPPORT FROM BOTTOM CORD OF BAR JOIST OR FROM METAL ROOF DECK, UNLESS APPROVED BY STRUCTURAL ENGINEER. PIPING MAY BE SUPPORTED AT PANEL POINTS OF BAR JOISTS.
 - 2. INSTALL IN ACCORDANCE WITH NFPA 13.

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3. INSTALL HANGERS TO PROVIDE MINIMUM 1/2 INCH SPACE BETWEEN FINISHED COVERING AND ADJACENT WORK.
 4. PLACE HANGERS WITHIN 12 INCHES OF EACH HORIZONTAL ELBOW.
 5. USE HANGERS WITH 1-1/2 INCH MINIMUM VERTICAL ADJUSTMENT. DESIGN HANGERS FOR PIPE MOVEMENT WITHOUT DISENGAGEMENT OF SUPPORTED PIPE.
 6. SUPPORT VERTICAL PIPING AT EVERY OTHER FLOOR. SUPPORT RISER PIPING INDEPENDENTLY OF CONNECTED HORIZONTAL PIPING.
- (P) PREPARE PIPE, FITTINGS, SUPPORTS, AND ACCESSORIES FOR FINISH PAINTING. WHERE PIPE SUPPORT MEMBERS ARE WELDED TO STRUCTURAL BUILDING FRAMING, SCRAPE, BRUSH CLEAN, AND APPLY ONE COAT OF ZINC RICH PRIMER TO WELDING.
- (Q) DO NOT PENETRATE BUILDING STRUCTURAL MEMBERS UNLESS SPECIFICALLY INDICATED ON CONTRACT DRAWINGS.
- (R) SLEEVES ARE NOT REQUIRED FOR CORE DRILLED HOLES.
- (S) PERMANENT SLEEVES ARE NOT REQUIRED FOR HOLES FORMED BY PE PLASTIC (REMOVABLE) SLEEVES.
- (T) INSTALL SLEEVES FOR PIPES PASSING THROUGH CONCRETE AND MASONRY WALLS AND CONCRETE FLOOR SLABS, AND WHERE INDICATED.
1. CUT SLEEVES TO LENGTH FOR MOUNTING FLUSH WITH BOTH SURFACES.
 - A. EXCEPTION: EXTEND SLEEVES INSTALLED IN FLOORS OF MECHANICAL EQUIPMENT AREAS OR OTHER WET AREAS 2-INCHES ABOVE FINISHED FLOOR LEVEL. EXTEND CAST-IRON SLEEVE FITTINGS BELOW FLOOR SLAB AS REQUIRED TO SECURE CLAMPING RING WHERE SPECIFIED.
 2. BUILD SLEEVES INTO NEW WALLS AND SLABS AS WORK PROGRESSES.
 3. INSTALL LARGE ENOUGH SLEEVES TO PROVIDE 1/4-INCH ANNULAR CLEAR SPACE BETWEEN SLEEVE AND PIPE OR PIPE INSULATION. USE THE FOLLOWING SLEEVE MATERIALS:
 - A. STEEL PIPE SLEEVES: FOR PIPES SMALLER THAN 6-INCHES.
 - B. STEEL SHEET-METAL SLEEVES: FOR PIPES 6-INCHES AND LARGER THAT PENETRATE GYPSUM-BOARD PARTITIONS.
 - C. CAST-IRON SLEEVE FITTINGS: FOR FLOORS HAVING MEMBRANE WATERPROOFING. SECURE FLASHING BETWEEN CLAMPING FLANGES. INSTALL SECTION OF CAST-IRON SOIL PIPE TO EXTEND SLEEVE TO 2-INCHES ABOVE FINISHED FLOOR LEVEL.
 4. EXCEPT FOR BELOW-GRADE WALL PENETRATIONS, SEAL ANNULAR SPACE BETWEEN SLEEVE AND PIPE OR PIPE INSULATION, USING ELASTOMERIC JOINT SEALANTS.

- (U) ABOVE GRADE, EXTERIOR WALL, PIPE PENETRATIONS: SEAL PENETRATIONS USING SLEEVES AND MECHANICAL SLEEVE SEALS. SIZE SLEEVE FOR 1-INCH ANNULAR CLEAR SPACE BETWEEN PIPE AND SLEEVE FOR INSTALLATION OF MECHANICAL SEALS.
1. INSTALL STEEL PIPE FOR SLEEVES SMALLER THAN 6-INCH.
 2. INSTALL CAST-IRON WALL PIPES FOR SLEEVES 6-INCH AND LARGER.
 3. ASSEMBLE AND INSTALL MECHANICAL SEALS ACCORDING TO MANUFACTURER'S PRINTED INSTRUCTIONS.
- (V) FIRE BARRIER PENETRATIONS: MAINTAIN INDICATED FIRE RATING OF WALLS, PARTITIONS, CEILINGS, AND FLOORS AT PIPE PENETRATIONS. SEAL PIPE PENETRATIONS WITH FIRESTOPPING SEALANT MATERIAL.
- (W) PIPING JOINT CONSTRUCTION: JOIN PIPE AND FITTINGS AS FOLLOWS AND AS SPECIFICALLY REQUIRED IN INDIVIDUAL PIPING SYSTEM SECTIONS.
1. THREADED JOINTS: THREAD PIPE WITH TAPERED PIPE THREADS ACCORDING TO ASME B1.20.1. CUT THREADS FULL AND CLEAN USING SHARP DIES. REAM THREADED PIPE ENDS TO REMOVE BURRS AND RESTORE FULL INSIDE DIAMETER. JOIN PIPE FITTINGS AND VALVES AS FOLLOWS:
 - A. NOTE THE INTERNAL LENGTH OF THREADS IN FITTINGS OR VALVE ENDS, AND PROXIMITY OF INTERNAL SEAT OR WALL, TO DETERMINE HOW FAR PIPE SHOULD BE THREADED INTO JOINT.
 - B. APPLY APPROPRIATE TAPE OR THREAD COMPOUND TO EXTERNAL PIPE THREADS (EXCEPT WHERE DRY SEAL THREADING IS SPECIFIED).
 - C. ALIGN THREADS AT POINT OF ASSEMBLY.
 - D. TIGHTEN JOINT WITH WRENCH. APPLY WRENCH TO VALVE END INTO WHICH PIPE IS BEING THREADED.
 - E. DAMAGED THREADS: DO NOT USE PIPE OR PIPE FITTINGS HAVING THREADS THAT ARE CORRODED OR DAMAGED. DO NOT USE PIPE SECTIONS THAT HAVE CRACKED OR OPEN WELDS.
 2. WELDED JOINTS: CONSTRUCT JOINTS ACCORDING TO AWS D10.12 "RECOMMENDED PRACTICES AND PROCEDURES FOR WELDING LOW CARBON STEEL PIPE" USING QUALIFIED PROCESSES AND WELDING OPERATORS ACCORDING TO THE "QUALITY ASSURANCE" ARTICLE.
 3. FLANGED JOINTS: ALIGN FLANGE SURFACES PARALLEL. SELECT APPROPRIATE GASKET MATERIAL, SIZE, TYPE, AND THICKNESS FOR SERVICE APPLICATION. INSTALL GASKET CONCENTRICALLY POSITIONED. ASSEMBLE JOINTS BY SEQUENCING BOLT TIGHTENING TO MAKE INITIAL CONTACT OF FLANGES AND GASKETS AS FLAT AND PARALLEL AS POSSIBLE. USE SUITABLE LUBRICANTS ON BOLT THREADS. TIGHTEN BOLTS GRADUALLY AND UNIFORMLY USING TORQUE WRENCH.
- (X) WHEN INSTALLING MORE THAN ONE PIPING SYSTEM MATERIAL, ENSURE SYSTEM COMPONENTS ARE COMPATIBLE AND JOINED TO ENSURE THE INTEGRITY OF THE SYSTEM. PROVIDE NECESSARY JOINING FITTINGS. ENSURE FLANGES, UNION, AND COUPLINGS FOR SERVICING ARE CONSISTENTLY PROVIDED.
- (Y) DIE CUT THREADED JOINTS WITH FULL CUT STANDARD TAPER PIPE THREADS WITH RED LEAD AND LINSEED OIL OR OTHER NON-TOXIC JOINT COMPOUND APPLIED TO MALE THREADS ONLY.

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- (Z) INSTALL VALVES WITH STEMS UPRIGHT OR HORIZONTAL, NOT INVERTED. REMOVE PROTECTIVE COATINGS PRIOR TO INSTALLATION.
- (AA) PROVIDE GATE OR BALL VALVES FOR SHUT-OFF OR ISOLATING SERVICE.
- (BB) PROVIDE DRAIN VALVES AT MAIN SHUT-OFF VALVES AND AT ALL LOW POINTS OF PIPING. SYSTEM MAIN DRAIN LOCATED AT MAIN RISER SHALL ROUTE TO BUILDING EXTERIOR AND BE EQUIPPED WITH A 45 DEGREE THREADED ELBOW TO ALLOW FOR PIPE EXTENSION DURING TESTING.
- (CC) PROVIDE STEEL WALL PLATE ON BOTH SIDES OF WALL FOR ALL PIPE PENETRATIONS. IF EXPOSED IN PUBLIC SPACE, PLATE SHALL MATCH WALL SURFACE COLOR.

3.03 EXCAVATION AND BACKFILL

- (A) SLOPE SIDES OF EXCAVATIONS TO COMPLY WITH LOCAL CODES AND ORDINANCES. SHORE AND BRACE AS REQUIRED FOR STABILITY OF EXCAVATION.
- (B) SHORING AND BRACING: ESTABLISH REQUIREMENTS FOR TRENCH SHORING AND BRACING TO COMPLY WITH LOCAL CODES AND AUTHORITIES. MAINTAIN SHORING AND BRACING IN EXCAVATIONS REGARDLESS OF TIME PERIOD EXCAVATIONS WILL BE OPEN.
 - 1. REMOVE SHORING AND BRACING WHEN NO LONGER REQUIRED. WHERE SHEETING IS ALLOWED TO REMAIN, CUT TOP OF SHEETING AT AN ELEVATION OF 30-INCHES BELOW FINISHED GRADE ELEVATION.
- (C) INSTALL SEDIMENT AND EROSION CONTROL MEASURES IN ACCORDANCE WITH LOCAL CODES AND ORDINANCES.
- (D) DEWATERING: PREVENT SURFACE WATER AND SUBSURFACE OR GROUND WATER FROM FLOWING INTO EXCAVATIONS AND FROM FLOODING PROJECT SITE AND SURROUNDING AREA.
 - 1. DO NOT ALLOW WATER TO ACCUMULATE IN EXCAVATIONS. REMOVE WATER TO PREVENT SOFTENING OF BEARING MATERIALS. PROVIDE AND MAINTAIN DEWATERING SYSTEM COMPONENTS NECESSARY TO CONVEY WATER AWAY FROM EXCAVATIONS.
 - 2. ESTABLISH AND MAINTAIN TEMPORARY DRAINAGE DITCHES AND OTHER DIVERSIONS OUTSIDE EXCAVATION LIMITS TO CONVEY SURFACE WATER TO COLLECTING OR RUN-OFF AREAS. DO NOT USE TRENCH EXCAVATIONS AS TEMPORARY DRAINAGE DITCHES.
- (E) MATERIAL STORAGE: STOCKPILE SATISFACTORY EXCAVATED MATERIALS WHERE DIRECTED, UNTIL REQUIRED FOR BACKFILL OR FILL. PLACE, GRADE, AND SHAPE STOCKPILES FOR PROPER DRAINAGE.
 - 1. LOCATE AND RETAIN SOIL MATERIALS AWAY FROM EDGE OF EXCAVATIONS. DO NOT STORE WITHIN DRIP-LINE OF TREES INDICATED TO REMAIN.
 - 2. REMOVE AND LEGALLY DISPOSE OF EXCESS EXCAVATED MATERIALS AND MATERIALS NOT ACCEPTABLE FOR USE AS BACKFILL OR FILL.
- (F) TRENCHING: EXCAVATE TRENCHES FOR MECHANICAL INSTALLATIONS AS FOLLOWS:
 - 1. EXCAVATE TRENCHES TO THE UNIFORM WIDTH, SUFFICIENTLY WIDE TO PROVIDE AMPLE WORKING ROOM AND A MINIMUM OF 6- TO 9-INCHES CLEARANCE ON BOTH SIDES OF PIPE AND EQUIPMENT.

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**FIRE PROTECTION GENERAL
PROVISIONS**

PROJECT NO. H IH BLAC 19100

2. EXCAVATE TRENCHES TO DEPTH INDICATED OR REQUIRED FOR PIPING TO ESTABLISH INDICATED SLOPE AND INVERT ELEVATIONS. BEYOND BUILDING PERIMETER, EXCAVATE TRENCHES TO AN ELEVATION BELOW FROST LINE.
 3. LIMIT THE LENGTH OF OPEN TRENCH TO THAT IN WHICH PIPE CAN BE INSTALLED, TESTED, AND THE TRENCH BACKFILLED WITHIN THE SAME DAY.
 4. WHERE ROCK IS ENCOUNTERED, CARRY EXCAVATION BELOW REQUIRED ELEVATION AND BACKFILL WITH A LAYER OF CRUSHED STONE OR GRAVEL PRIOR TO INSTALLATION OF PIPE. PROVIDE A MINIMUM OF 6 INCHES OF STONE OR GRAVEL CUSHION BETWEEN ROCK BEARING SURFACE AND PIPE.
 5. EXCAVATE TRENCHES FOR PIPING AND EQUIPMENT WITH BOTTOMS OF TRENCH TO ACCURATE ELEVATIONS FOR SUPPORT OF PIPE AND EQUIPMENT ON UNDISTURBED SOIL.
 - A. FOR PIPES OR EQUIPMENT 6-INCH OR LARGER IN NOMINAL SIZE, SHAPE BOTTOM OF TRENCH TO FIT BOTTOM 1/4 OF THE CIRCUMFERENCE. FILL UNEVENNESS WITH TAMPERED SAND BACKFILL. AT EACH PIPE JOINT OVER-EXCAVATE TO RELIEVE THE BELL OR PIPE JOINT OF THE PIPE OF LOADS, AND TO ENSURE CONTINUOUS BEARING OF THE PIPE BARREL ON THE BEARING SURFACE.
- (G) COLD WEATHER PROTECTION: PROTECT EXCAVATION BOTTOMS AGAINST FREEZING WHEN ATMOSPHERIC TEMPERATURE IS LESS THAN 35°F (2°C).
- (H) BACKFILLING AND FILLING: PLACE SOIL MATERIALS IN LAYERS TO REQUIRED SUBGRADE ELEVATIONS FOR EACH AREA CLASSIFICATION LISTED BELOW, USING MATERIALS SPECIFIED IN PART 2 OF THIS SECTION.
1. UNDER WALKS AND PAVEMENTS, USE A COMBINATION OF SUBBASE MATERIALS AND EXCAVATED OR BORROWED MATERIALS.
 2. UNDER BUILDING SLABS, USE DRAINAGE FILL MATERIALS.
 3. UNDER PIPING AND EQUIPMENT, USE SUBBASE MATERIALS WHERE REQUIRED OVER ROCK BEARING SURFACE AND FOR CORRECTION OF UNAUTHORIZED EXCAVATION.
 4. FOR PIPING LESS THAN 30-INCHES BELOW SURFACE OF ROADWAYS, PROVIDE 4-INCH THICK CONCRETE BASE SLAB SUPPORT. AFTER INSTALLATION AND TESTING OF PIPING, PROVIDE A 4-INCH THICK CONCRETE ENCASEMENT (SIDES AND TOP) PRIOR TO BACKFILLING AND PLACEMENT OF ROADWAY SUBBASE.
 5. OTHER AREAS, USE EXCAVATED OR BORROWED MATERIALS.
- (I) BACKFILL EXCAVATION AS PROMPTLY AS WORK PERMITS, BUT NOT UNTIL COMPLETION OF THE FOLLOWING:
1. INSPECTION, TESTING, APPROVAL, AND LOCATIONS OF UNDERGROUND UTILITIES HAVE BEEN RECORDED.
 2. REMOVAL OF CONCRETE FORMWORK.
 3. REMOVAL OF SHORING AND BRACING, AND BACKFILLING OF VOIDS.
 4. REMOVAL OF TRASH AND DEBRIS.

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- (J) PLACEMENT AND COMPACTION: PLACE BACKFILL AND FILL MATERIALS IN LAYERS OF NOT MORE THAN 8-INCHES IN LOOSE DEPTH FOR MATERIAL COMPACTED BY HEAVY EQUIPMENT, AND NOT MORE THAN 4-INCHES IN LOOSE DEPTH FOR MATERIAL COMPACTED BY HAND-OPERATED TAMPERS.
- (K) BEFORE COMPACTION, MOISTEN OR AERATE EACH LAYER AS NECESSARY TO PROVIDE OPTIMUM MOISTURE CONTENT. COMPACT EACH LAYER TO REQUIRED PERCENTAGE OF MAXIMUM DRY DENSITY OR RELATIVE DRY DENSITY FOR EACH AREA CLASSIFICATION SPECIFIED BELOW. DO NOT PLACE BACKFILL OR FILL MATERIAL ON SURFACES THAT ARE MUDDY, FROZEN, OR CONTAIN FROST OR ICE.
- (L) PLACE BACKFILL AND FILL MATERIALS EVENLY ADJACENT TO STRUCTURES, PIPING, AND EQUIPMENT TO REQUIRED ELEVATIONS. PREVENT DISPLACEMENT OF PIPING AND EQUIPMENT BY CARRYING MATERIAL UNIFORMLY AROUND THEM TO APPROXIMATELY SAME ELEVATION IN EACH LIFT.
- (M) COMPACTION: CONTROL SOIL COMPACTION DURING CONSTRUCTION, PROVIDING MINIMUM PERCENTAGE OF DENSITY SPECIFIED FOR EACH AREA CLASSIFICATION INDICATED BELOW:
1. PERCENTAGE OF MAXIMUM DENSITY REQUIREMENTS: COMPACT SOIL TO NOT LESS THAN THE FOLLOWING PERCENTAGES OF MAXIMUM DENSITY FOR SOILS WHICH EXHIBIT A WELL-DEFINED MOISTURE-DENSITY RELATIONSHIP (COHESIVE SOILS), DETERMINED IN ACCORDANCE WITH ASTM D 698 AND NOT LESS THAN THE FOLLOWING PERCENTAGES OF RELATIVE DENSITY, DETERMINED IN ACCORDANCE WITH ASTM D 4253 AND ASTM D 4254, FOR SOILS WHICH WILL NOT EXHIBIT A WELL-DEFINED MOISTURE-DENSITY RELATIONSHIP (COHESIONLESS SOILS).
 - A. AREAS UNDER STRUCTURES, BUILDING SLABS AND STEPS, PAVEMENTS: COMPACT TOP 12-INCHES OF SUBGRADE AND EACH LAYER OF BACKFILL OR FILL MATERIAL TO 95% MAXIMUM DENSITY FOR COHESIVE MATERIAL, OR 98% RELATIVE DENSITY FOR COHESIONLESS MATERIAL.
 - B. AREAS UNDER WALKWAYS: COMPACT TOP 6 INCHES OF SUBGRADE AND EACH LAYER OF BACKFILL OR FILL MATERIAL TO 95% MAXIMUM DENSITY FOR COHESIVE MATERIAL, OR 98% RELATIVE DENSITY FOR COHESIONLESS MATERIAL.
 - C. OTHER AREAS: COMPACT TOP 6-INCHES OF SUBGRADE AND EACH LAYER OF BACKFILL OR FILL MATERIAL TO 85% MAXIMUM DENSITY FOR COHESIVE SOILS, AND 90% RELATIVE DENSITY FOR COHESIONLESS SOILS.
 2. MOISTURE CONTROL: WHERE SUBGRADE OR LAYER OF SOIL MATERIAL MUST BE MOISTURE CONDITIONED BEFORE COMPACTION, UNIFORMLY APPLY WATER. APPLY WATER IN MINIMUM QUANTITY NECESSARY TO ACHIEVE REQUIRED MOISTURE CONTENT AND TO PREVENT WATER APPEARING ON SURFACE DURING, OR SUBSEQUENT TO, COMPACTION OPERATIONS.
- (N) SUBSIDENCE: WHERE SUBSIDENCE OCCURS AT MECHANICAL INSTALLATION EXCAVATIONS DURING THE PERIOD 12 MONTHS AFTER SUBSTANTIAL COMPLETION, REMOVE SURFACE TREATMENT (I.E., PAVEMENT, LAWN, OR OTHER FINISH), ADD BACKFILL MATERIAL, COMPACT TO SPECIFIED CONDITIONS, AND REPLACE SURFACE TREATMENT. RESTORE APPEARANCE, QUALITY, AND CONDITION OF SURFACE OR FINISH TO MATCH ADJACENT AREAS.
- 3.04 GROUTING
- (A) INSTALL NONMETALLIC NONSHRINK GROUT FOR FIRE PROTECTION EQUIPMENT BASE BEARING SURFACES, PUMP AND OTHER EQUIPMENT BASE PLATES, AND ANCHORS. MIX GROUT ACCORDING TO MANUFACTURER'S PRINTED INSTRUCTIONS.

- (B) CLEAN SURFACES THAT WILL COME INTO CONTACT WITH GROUT.
- (C) PROVIDE FORMS FOR PLACEMENT OF GROUT, AS REQUIRED.
- (D) AVOID AIR ENTRAPMENT WHEN PLACING GROUT.
- (E) PLACE GROUT TO COMPLETELY FILL EQUIPMENT BASES.
- (F) PLACE GROUT ON CONCRETE BASES TO PROVIDE A SMOOTH BEARING SURFACE FOR EQUIPMENT.
- (G) PLACE GROUT AROUND ANCHORS.
- (H) CURE PLACED GROUT ACCORDING TO MANUFACTURER'S PRINTED INSTRUCTIONS.

END OF SECTION 21 00 00 – FIRE PROTECTION GENERAL PROVISIONS

SECTION 21 05 00 - FIRE PROTECTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 WORK INCLUDED

- (A) THIS SECTION SPECIFIES AUTOMATIC SPRINKLER SYSTEMS AND STANDPIPE AND HOSE SYSTEMS FOR BUILDINGS AND STRUCTURES. MATERIALS AND EQUIPMENT SPECIFIED IN THIS SECTION INCLUDE:

1. PIPE, FITTINGS, VALVES, AND SPECIALTIES.
2. SPRINKLERS AND ACCESSORIES.

- (B) PRODUCTS FURNISHED AND INSTALLED SHALL INCLUDE SPRINKLER CABINET WITH SPARE SPRINKLERS AND SPRINKLER WRENCHES.

- (C) RELATED SECTIONS: THE FOLLOWING SECTIONS CONTAIN REQUIREMENTS THAT RELATE TO THIS SECTION:

1. See Division 33 specifications.
2. FIRE EXTINGUISHERS, CABINETS, AND ACCESSORIES FOR FIRE EXTINGUISHERS AND EXTINGUISHER CABINETS.
3. FIRE ALARM SYSTEM.

- (D) ELECTRICAL WORK: MOTORS, MANUAL OR AUTOMATIC MOTOR CONTROL EQUIPMENT AND PROTECTIVE OR SIGNAL DEVICES REQUIRED FOR THE OPERATION SPECIFIED HEREIN SHALL BE PROVIDED UNDER THIS SECTION IN ACCORDANCE WITH ELECTRICAL SPECIFICATIONS. ANY WIRING REQUIRED FOR THE OPERATION SPECIFIED HEREIN, BUT NOT SHOWN ON THE ELECTRICAL PLANS, SHALL BE PROVIDED UNDER THIS SECTION IN ACCORDANCE WITH ELECTRICAL SPECIFICATIONS.

1.03 DEFINITIONS

- (A) PIPE SIZES USED IN THIS SPECIFICATION ARE NOMINAL PIPE SIZE (NPS).

- (B) OTHER DEFINITIONS FOR FIRE PROTECTION SYSTEMS ARE LISTED IN NFPA STANDARDS 13 AND 24.

- (C) WORKING PLANS, AS USED IN THIS SECTION, MEAN THOSE DOCUMENTS (INCLUDING DRAWINGS AND CALCULATIONS) PREPARED PURSUANT TO THE REQUIREMENTS CONTAINED IN NFPA 13 FOR OBTAINING APPROVAL OF THE AUTHORITY HAVING JURISDICTION.

1.04 SYSTEM DESCRIPTION

- (A) FIRE PROTECTION SYSTEM IN AREAS NOT SUBJECT TO FREEZING SHALL BE A "WET-PIPE" SYSTEM EMPLOYING AUTOMATIC SPRINKLERS ATTACHED TO A PIPING SYSTEM CONTAINING WATER AND CONNECTED TO A WATER SUPPLY SO THAT WATER DISCHARGES IMMEDIATELY FROM SPRINKLERS OPENED BY FIRE.

- (B) SPRINKLER SYSTEM PROTECTION LIMITS: ALL SPACES WITHIN AREAS OF NEW BUILDING CONSTRUCTION AND EXISTING BUILDING REMODEL AREAS. INCLUDE CLOSETS, TOILET AND LOCKER ROOM AREAS, EACH LANDING OF EACH STAIR, AND SPECIAL APPLICATIONS AREAS.

1. EXCEPTION: LIGHT-HAZARD OCCUPANCY, DWELLING UNIT BATHROOMS 55 SQUARE FEET AND LESS AND CLOSETS 24 SQUARE FEET AND LESS THAT ALSO COMPLY WITH OTHER NFPA 13 REQUIREMENTS.

1.05 SYSTEM PERFORMANCE REQUIREMENTS

- (A) DESIGN AND OBTAIN APPROVAL FROM AUTHORITY HAVING JURISDICTION FOR FIRE PROTECTION SYSTEMS SPECIFIED.

- (B) CONDUCT FIRE HYDRANT FLOW TESTS AS REQUIRED TO OBTAIN HYDRAULIC DATA NEEDED TO PREPARE DESIGN FOR HYDRAULICALLY CALCULATED SYSTEMS. TESTS SHALL BE WITHIN 1 YEAR OF DATE SHOP DRAWING SUBMITTAL.

- (C) HYDRAULICALLY DESIGN SPRINKLER SYSTEMS ACCORDING TO:

1. SPRINKLER SYSTEM OCCUPANCY HAZARD CLASSIFICATIONS: AS SHOWN ON PLANS. WHEN PLANS DO NOT SPECIFY, SPRINKLER CONTRACTOR SHALL DETERMINE HAZARD CLASSIFICATIONS PER LOCAL AND/OR ANY OTHER GOVERNING FIRE CODES, LATEST NFPA CODES, AND APPLICABLE BUILDING CODES. AS A MINIMUM, PROVIDE HAZARD CLASSIFICATIONS AS FOLLOWS:

- A. RESIDENTIAL / LIVING AREAS: NFPA 13R.
- B. PUBLIC AREAS: LIGHT HAZARD.
- C. STORAGE AREAS: ORDINARY HAZARD (GROUP NUMBER AS DEFINED ON PLANS).
- D. EQUIPMENT ROOMS: ORDINARY HAZARD (GROUP NUMBER AS DEFINED ON PLANS).
- E. SERVICE AREAS: ORDINARY HAZARD (GROUP NUMBER AS DEFINED ON PLANS).

2. MINIMUM DENSITY REQUIREMENTS FOR AUTOMATIC SPRINKLER SYSTEM HYDRAULIC DESIGN: SPRINKLER CONTRACTOR SHALL PROVIDE DENSITIES AS NOTED ON PLANS. IN ABSENCE OF GUIDANCE, CONTRACTOR SHALL PROVIDE DENSITY REQUIREMENTS PER LOCAL AND/OR ANY OTHER GOVERNING FIRE CODES, LATEST NFPA CODES, AND APPLICABLE BUILDING CODES. AREA REDUCTIONS MAY BE USED WHERE LISTED QUICK RESPONSE INCLUDING QUICK RESPONSE EXTENDED COVERAGE SPRINKLERS, ARE USED THROUGHOUT THE SYSTEM OR PORTION OF SYSTEM HAVING SAME DESIGN AREA IN ACCORDANCE WITH NFPA 13 GUIDELINES. AS A MINIMUM, PROVIDE DENSITY REQUIREMENTS AS FOLLOWS:

- A. RESIDENTIAL (DWELLING UNIT SPACE): PER NFPA 13R.
- B. LIGHT HAZARD OCCUPANCY: 0.10 GPM PER SQUARE FOOT OVER 1500 SQUARE FEET AREA.
- C. ORDINARY HAZARD, GROUP 1 OCCUPANCY: 0.15 GPM PER SQUARE FOOT OVER 1500 SQUARE FEET AREA.

3. MAXIMUM SPRINKLER SPACING: SPRINKLER CONTRACTOR SHALL PROVIDE SPRINKLER SPACING PER LOCAL AND/OR ANY OTHER GOVERNING FIRE CODES, LATEST NFPA CODES, APPLICABLE BUILDING CODES, AND SPRINKLER UL LISTING. AS A MINIMUM, PROVIDE SPRINKLER SPACING AS FOLLOWS:

- A. DWELLING UNIT: PER NFPA 13R.

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- B. PUBLIC SPACE: 225 SQUARE FEET/SPRINKLER.
 - C. STORAGE AREAS: 130 SQUARE FEET/SPRINKLER.
 - D. MECHANICAL EQUIPMENT ROOMS: 130 SQUARE FEET/SPRINKLER.
 - E. ELECTRICAL EQUIPMENT ROOMS: 130 SQUARE FEET/SPRINKLER.
 - F. OTHER AREAS: ACCORDING TO NFPA 13.
- (D) COMPONENTS AND INSTALLATION: CAPABLE OF PRODUCING PIPING SYSTEMS WITH THE FOLLOWING MINIMUM WORKING PRESSURE RATINGS EXCEPT WHERE INDICATED OTHERWISE.
- 1. SPRINKLER SYSTEMS: 175 PSIG.
- 1.06 SUBMITTALS
- (A) GENERAL: SEE SUBMITTAL REQUIREMENTS IN "FIRE PROTECTION GENERAL PROVISIONS". PROVIDE ADDITIONAL ITEMS AS NOTED BELOW.
- (B) PRODUCT DATA: INCLUDE EACH TYPE SPRINKLER, VALVE, PIPING SPECIALTY, FIRE PROTECTION SPECIALTY, NFPA 13 REQUIRED SIGNS, FIRE DEPARTMENT CONNECTION, HOSE AND RACK, AND HOSE CABINET SPECIFIED. WHEN MORE THAN ONE MODEL, FINISH, SIZE, ETC. ARE PROVIDED ON A SINGLE VENDOR CUT SHEET, MARK OR HIGHLIGHT ALL THAT APPLY TO THIS PROJECT, AND/OR MARK THROUGH ALL THAT DO NOT APPLY.
- 1. SPRINKLERS SHALL BE REFERRED TO BY THE SPRINKLER IDENTIFICATION AND MODEL NUMBER AS SPECIFICALLY PUBLISHED IN THE APPROPRIATE AGENCY LISTING OR APPROVAL. TRADE NAMES OR OTHER ABBREVIATED DESIGNATIONS SHALL NOT BE ALLOWED.
- (C) SPRINKLER LAYOUT PLANS PREPARED IN ACCORDANCE WITH NFPA 13 GUIDELINES IDENTIFIED AS "WORKING PLANS," INCLUDING HYDRAULIC CALCULATIONS WHERE APPLICABLE, AND WHICH HAVE BEEN APPROVED BY THE AUTHORITY HAVING JURISDICTION. HYDRAULIC CALCULATIONS SHALL ACCOMPANY SHOP DRAWINGS AND SHALL INCLUDE CALCULATIONS FOR ALL REQUIRED DESIGN AREAS. CALCULATIONS SHALL BEGIN AT THE REMOTE DESIGN AREA SPRINKLERS AND END AT THE TEST HYDRANT WHERE THE HYDRANT FLOW TEST WAS CONDUCTED. INCLUDE REMOTE AREA DESIGN PLACARD INFORMATION ADJACENT TO EACH AREA THAT HYDRAULIC CALCULATIONS ARE BEING PROVIDED FOR. PROVIDE HYDRAULIC CALCULATIONS FOR ALL OF THE FOLLOWING DESIGN AREAS: MOST HYDRAULICALLY DEMANDING AREA ON EACH FLOOR OF PROJECT AND, IF APPLICABLE, THE MOST HYDRAULICALLY DEMANDING OF EACH OCCUPANCY HAZARD TYPE. INCLUDE ROOM NAME AND NUMBER ON THE COVER PAGE FOR EACH HYDRAULIC CALCULATION AND ON THE CORRESPONDING DESIGN PLACARD. INCLUDE DESIGN PLACARD DATA BY EACH DESIGN AREA ON THE DRAWINGS. INCLUDE UPDATED "AS BUILT" DRAWINGS AND CALCULATIONS WITH FINAL PROJECT OPERATIONS AND MAINTENANCE MANUAL.
- 1. SPRINKLER LAYOUT PLANS SHALL INCLUDE A SPRINKLER LEGEND. SPRINKLERS ON THE LEGEND SHALL BE REFERRED TO BY THE SPRINKLER IDENTIFICATION OR MODEL NUMBER AS SPECIFICALLY PUBLISHED IN THE APPROPRIATE AGENCY LISTING OR APPROVAL. TRADE NAMES OR OTHER ABBREVIATED DESIGNATIONS SHALL NOT BE ALLOWED.
 - 2. SPRINKLER LAYOUT PLANS SHALL INCLUDE A SYMBOLS LEGEND FOR ALL SYMBOLS USED ON THE PROJECT. IF MORE THAN ONE PIPE TYPE IS USED (I.E. EXISTING VS NEW, OR STEEL VS. CPVC), PROVIDE A UNIQUE LINE TYPE FOR EACH PIPE STYLE. IF PLOTTING IN COLOR, USE DIFFERENT COLORS IN LIEU OF DIFFERENT LINE TYPES.
- (D) MAINTENANCE DATA FOR EACH TYPE SPRINKLER, VALVE, PIPING SPECIALTY, FIRE PROTECTION SPECIALTY, FIRE DEPARTMENT CONNECTION, FOR INCLUSION IN OPERATING AND MAINTENANCE MANUAL.

- (E) WELDERS' QUALIFICATION CERTIFICATES.
- (F) GROOVED JOINT COUPLINGS AND FITTINGS SHALL BE SHOWN ON DRAWINGS AND PRODUCT SUBMITTALS AND BE SPECIFICALLY IDENTIFIED WITH THE APPLICABLE STYLE NUMBER.
- (G) TEST REPORTS AND CERTIFICATES INCLUDE "CONTRACTOR'S MATERIAL & TEST CERTIFICATE FOR ABOVEGROUND PIPING" AND "CONTRACTOR'S MATERIAL & TEST CERTIFICATE FOR UNDERGROUND PIPING" AS DESCRIBED IN NFPA 13. REPORTS SHALL BE INCLUDED AS PART OF PROJECT OPERATIONS AND MAINTENANCE MANUAL.
- (H) OPERATIONS AND MAINTENANCE MANUAL: INCLUDE ALL PRODUCT DATA USED ON PROJECT EXCEPT PIPE AND PIPE FITTINGS, PROJECT "AS BUILT" DRAWINGS, FINAL HYDRAULIC CALCULATIONS, COPIES OF ALL TEST REPORTS, WARRANTIES, AND OWNER TRAINING VERIFICATION. SEE SPECIFICATION 21 00 00 FOR ADDITIONAL INFORMATION.

1.07 QUALITY ASSURANCE

(A) SYSTEM CONTRACTOR CERTIFICATION:

- 1. PROVIDE PROOF OF FIRE EXTINGUISHING SYSTEM CONTRACTOR'S CERTIFICATION FOR THE LAYOUT, INSTALLATION, REPAIR, ALTERATION, ADDITION, MAINTENANCE OR MAINTENANCE INSPECTION OF THE AUTOMATIC FIRE EXTINGUISHING SYSTEMS. CERTIFICATION MAY BE IN THE FORM OF ONE OF THE FOLLOWING:
 - A. CURRENT CERTIFICATION BY THE NATIONAL INSTITUTE FOR CERTIFICATION OF ENGINEERING TECHNOLOGIES, LEVEL III OR ABOVE;
 - B. CURRENT LICENSURE AS A PROFESSIONAL ENGINEER WITH COMPETENCE IN FIRE EXTINGUISHER SYSTEM DESIGN.

(B) SYSTEM DESIGNER QUALIFICATIONS:

- 1. PROVIDE ENGINEERING SERVICES TO DESIGN THE SYSTEM IN ACCORDANCE WITH NFPA 13, THE DRAWINGS, AND THE SPECIFICATIONS. WHERE THE DRAWINGS AND SPECIFICATIONS IMPOSE REQUIREMENTS THAT ARE MORE SEVERE THAN THE REQUIREMENTS OF NFPA 13, THE DRAWINGS AND SPECIFICATIONS SHALL PREVAIL.
- 2. DESIGN THE SYSTEM UNDER THE DIRECT SUPERVISION OF A REGISTERED PROFESSIONAL FIRE PROTECTION ENGINEER EXPERIENCED IN DESIGN OF THIS WORK AND LICENSED IN THE STATE WHERE THE PROJECT IS LOCATED. THE SHOP DRAWINGS SHALL BEAR THE SEAL OF THE REGISTERED PROFESSIONAL FIRE PROTECTION ENGINEER WHO DESIGNED THE SYSTEM.

(C) INSTALLER QUALIFICATIONS: INSTALLATION AND ALTERATIONS OF FIRE PROTECTION PIPING, EQUIPMENT, SPECIALTIES, AND ACCESSORIES, AND REPAIR AND SERVICING OF EQUIPMENT SHALL BE PERFORMED ONLY BY A QUALIFIED INSTALLER. THE TERM QUALIFIED MEANS EXPERIENCED IN SUCH WORK (EXPERIENCED SHALL MEAN HAVING A MINIMUM OF FIVE (5) PREVIOUS PROJECTS SIMILAR IN SIZE AND SCOPE TO THIS PROJECT), FAMILIAR WITH ALL PRECAUTIONS REQUIRED, AND HAS COMPLIED WITH ALL THE REQUIREMENTS OF THE AUTHORITY HAVING JURISDICTION. UPON REQUEST, SUBMIT EVIDENCE OF SUCH QUALIFICATIONS TO THE ARCHITECT.

(D) QUALIFICATIONS FOR WELDING PROCESSES AND OPERATORS: COMPLY WITH THE REQUIREMENTS OF AWS D10.9, "SPECIFICATIONS FOR QUALIFICATIONS OF WELDING PROCEDURES AND WELDERS FOR PIPING AND TUBING, LEVEL AR-3."

(E) REGULATORY REQUIREMENTS: COMPLY WITH THE REQUIREMENTS OF THE FOLLOWING CODES AND STANDARDS:

- 1. NFPA 13 - STANDARD FOR THE INSTALLATION OF SPRINKLER SYSTEMS.

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2. NFPA 13R - STANDARD FOR THE INSTALLATION OF SPRINKLER SYSTEMS IN RESIDENTIAL OCCUPANCIES UP TO AND INCLUDING FOUR STORIES IN HEIGHT.
3. NFPA 26 - RECOMMENDED PRACTICE FOR THE SUPERVISION OF VALVES CONTROLLING WATER SUPPLIES FOR FIRE PROTECTION.
4. NFPA 70 - NATIONAL ELECTRICAL CODE.
5. ASME A17.1 - SAFETY CODE FOR ELEVATORS AND ESCALATORS.
6. LOCAL FIRE DEPARTMENT REQUIREMENTS.
7. UL AND FM COMPLIANCE: FIRE PROTECTION SYSTEM MATERIALS AND COMPONENTS SHALL BE UNDERWRITER'S LABORATORIES LISTED AND LABELED, AND FACTORY MUTUAL APPROVED FOR THE APPLICATION ANTICIPATED.
8. LOCAL PERMITS AND INSPECTION REQUIREMENTS.
9. LOCAL UTILITY REQUIREMENTS.

1.08 SEQUENCING AND SCHEDULING

- (A) SCHEDULE ROUGH-IN INSTALLATIONS WITH INSTALLATIONS OF OTHER BUILDING COMPONENTS.

1.09 EXTRA MATERIALS

- (A) SPRINKLER WRENCHES: FURNISH TO OWNER, TWO (2) SPRINKLER WRENCHES FOR EACH TYPE/SIZE OF SPRINKLER HEAD INSTALLED.
- (B) SPRINKLERS AND CABINETS: FURNISH SPARE SPRINKLERS IN QUANTITIES AS OUTLINED IN NPFA 13 AND SHALL INCLUDE EACH STYLE INCLUDED IN THE PROJECT OR AS DETAILED IN NFPA 13. FURNISH SPECIAL WRENCHES AS SPECIFIED IN THIS SECTION. FURNISH AND INSTALL A SPRINKLER CABINET OR CABINETS SIZED TO HOUSE THE NFPA 13 QUANTITY OF SPARE SPRINKLERS LISTED ABOVE.

PART 2 - PRODUCTS

2.01 SPRINKLER DESIGNERS/INSTALLERS

- (A) COMPANY SHALL BE A LICENSED SPRINKLER CONTRACTOR IN THE STATE WHERE THE PROJECT IS LOCATED.
- (B) COMPANY SHALL HAVE A NICET LEVEL III OR ABOVE CERTIFIED DESIGNER OR A REGISTERED FIRE PROTECTION ENGINEER WITH A MINIMUM OF 5 YEARS EXPERIENCE DESIGNING FIRE PROTECTION SYSTEMS ON STAFF.

2.02 MANUFACTURERS

- (A) MANUFACTURER: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE FIRE PROTECTION SYSTEM PRODUCTS FROM ONE (1) OF THE FOLLOWING:
1. SPECIALTY VALVES, WATER MOTOR ALARMS, AND AIR-PRESSURE MAINTENANCE DEVICES:
 - A. ASCOA FIRE SYSTEMS, FIGGIE INTERNATIONAL CO.
 - B. CENTRAL SPRINKLER CORP.

- C. FIREMATIC SPRINKLER DEVICES, INC.
- D. GEM SPRINKLER CO. DIV., GRINNELL CORP.
- E. GLOBE FIRE SPRINKLER CORP.
- F. RELIABLE AUTOMATIC SPRINKLER CO., INC.
- G. STAR SPRINKLER CORP.
- H. TYCO-GRINNELL.
- I. VICTAULIC COMPANY.
- J. VIKING CORP.

2. BACKFLOW PREVENTERS:

- A. AMES CO., INC.
- B. CLA-VAL CO.
- C. CONBRACO INDUSTRIES, INC.
- D. FEBCO.
- E. HERSEY PRODUCTS, INC., GRINNELL CORP.
- F. WATTS REGULATOR CO.
- G. WILKINS REGULATOR DIV., ZURN INDUSTRIES, INC.

3. WATERFLOW INDICATORS AND SUPERVISORY SWITCHES:

- A. GAMEWELL CO.
- B. GEM SPRINKLER CO. DIV., GRINNELL CORP.
- C. POTTER ELECTRIC SIGNAL CO.
- D. RELIABLE AUTOMATIC SPRINKLER CO., INC.
- E. SYSTEM SENSOR DIV., PITWAY CORP.
- F. VICTAULIC COMPANY OF AMERICA.
- G. WATTS REGULATOR CO.

4. FIRE DEPARTMENT CONNECTIONS:

- A. BADGER-POWHATAN, FIGGIE INTERNATIONAL CO.
- B. CROKER DIV., FIRE-END AND CROKER CORP.

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- C. ELKHART BRASS MFG. CO., INC.
- D. FIREMATIC SPRINKLER DEVICES, INC.
- E. GEM SPRINKLER CO. DIV., GRINNELL CORP.
- F. GUARDIAN FIRE EQUIPMENT, INC.
- G. POTTER-ROEMER DIV., SMITH INDUSTRIES, INC.
- H. RELIABLE AUTOMATIC SPRINKLER CO., INC.
- I. SIERRA FIRE EQUIPMENT CO.

5. SPRINKLERS:

- A. ASCOA FIRE SYSTEMS, FIGGIE INTERNATIONAL CO.
- B. CENTRAL SPRINKLER CORP.
- C. FIREMATIC SPRINKLER DEVICES, INC.
- D. GEM SPRINKLER CO. DIV., GRINNELL CORP.
- E. GLOBE FIRE SPRINKLER CORP.
- F. RELIABLE AUTOMATIC SPRINKLER CO., INC.
- G. STAR SPRINKLER CORP.
- H. TYCO-GRINNELL
- I. FIRELOCK; VICTAULIC COMPANY.
- J. VICTAULIC COMPANY OF AMERICA
- K. VIKING CORP.

6. FLEXIBLE HOSE SPRINKLER CONNECTIONS:

- A. VICFLEX; VICTAULIC COMPANY.
- B. RASCOFLEX; RELIABLE AUTOMATIC SPRINKLER CO., INC.

7. INDICATOR VALVES:

- A. GEM SPRINKLER CO. DIV., GRINNELL CORP.
- B. GRINNELL SUPPLY SALES CO., GRINNELL CORP.
- C. KENNEDY VALVE DIV., MCWANE, INC.
- D. MILWAUKEE VALVE CO., INC.

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- E. NIBCO, INC.
 - F. SPRINK-LINE BY SPRINK, INC.
 - G. VICTAULIC COMPANY OF AMERICA.
8. FIRE PROTECTION SERVICE GATE AND CHECK VALVES:
- A. GEM SPRINKLER CO. DIV., GRINNELL CORP.
 - B. KENNEDY VALVE DIV., MCWANE, INC.
 - C. NIBCO, INC.
 - D. STOCKHAM VALVES AND FITTINGS, INC.
 - E. VICTAULIC COMPANY OF AMERICA.
9. GROOVED COUPLINGS FOR STEEL PIPING:
- A. GRUVLOK; ANVIL INDUSTRIES.
 - B. SHURJOINT.
 - C. TYCO-GRINNELL
 - D. VICTAULIC COMPANY OF AMERICA.
10. GROOVED COUPLINGS FOR AWWA DUCTILE-IRON PIPING:
- A. SHURJOINT.
 - B. TYCO-GRINNELL
 - C. VICTAULIC COMPANY OF AMERICA.
11. GROOVED COUPLINGS FOR COPPER TUBING:
- A. VICTAULIC COMPANY OF AMERICA.
12. PRESS-SEAL FITTINGS FOR STEEL PIPING:
- A. VICTAULIC COMPANY OF AMERICA.
13. FITTINGS FOR CPVC PIPING:
- A. HARVEL PLASTICS.
 - B. IPEX, INC.
 - C. NIBCO, INC.
 - D. TYCO FIRE & BUILDING PRODUCTS.

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E. THE VIKING CORPORATION.

2.03 PIPE AND TUBING MATERIALS (SELECTION AS PER LOCAL CODE REQUIREMENTS)

- (A) REFER TO PART 3 ARTICLE "PIPING APPLICATIONS" FOR IDENTIFICATION OF SYSTEMS WHERE PIPE AND FITTING MATERIALS SPECIFIED BELOW ARE USED.
- (B) DUCTILE-IRON PIPE AND FITTINGS: MECHANICAL JOINTS, DUCTILE IRON FITTINGS; AWWA C110, DUCTILE OR GRAY-IRON STANDARD PATTERN OR AWWA C153, DUCTILE-IRON COMPACT PATTERN.
1. GLANDS, GASKETS AND BOLTS: AWWA C111 DUCTILE- OR GRAY-IRON GLANDS, RUBBER GASKETS AND STEEL BOLTS.
- (C) STEEL PIPE: ASTM A 53, SCHEDULE 40 IN SIZES 6-INCH AND SMALLER AND SCHEDULE 30 IN SIZES 8-INCH AND LARGER, BLACK AND GALVANIZED, PLAIN AND THREADED ENDS, FOR WELDED, THREADED, CUT-GROOVE, AND ROLLED-GROOVE JOINTS.
- (D) STEEL PIPE: ASTM A 135, SCHEDULE 10 THROUGH 5-INCH SIZES AND NFPA 13 SPECIFIED WALL THICKNESS FOR 6-INCH THROUGH 10-INCH SIZES, WITH PLAIN ENDS, BLACK AND GALVANIZED, FOR ROLLED-GROOVE AND WELDED JOINTS.
- (E) GALVANIZED STEEL PIPE: ASTM A 53/A 53M, SCHEDULE 40 STANDARD WEIGHT, PLAIN AND THREADED ENDS.
- (F) GALVANIZED-STEEL PIPE: ASTM A 135 OR ASTM A 795/A 795M, SCHEDULE 10, PLAIN OR THREADED ENDS.
- (G) GALVANIZED STEEL PIPE: ASTM 53/A 53M, SCHEDULE 40 STANDARD WEIGHT, PLAIN AND THREADED.
- (H) GALVANIZED-STEEL PIPE: ASTM A 135 OR ASTM A 795/A 795M, SCHEDULE 10, PLAIN OR THREADED ENDS.
- (I) STEEL PIPE: ASTM A 135, THREADABLE LIGHTWALL, BLACK AND GALVANIZED, FOR THREADED JOINTS.
- (J) STEEL PIPE: ASTM A 795, BLACK AND GALVANIZED, FOR JOINTS LISTED AND FOR USE WITH FITTINGS FOR PLAIN-END STEEL PIPE.
1. TYPE: STANDARD-WEIGHT PIPE, SCHEDULES 40, FOR CUT-GROOVE, ROLLED-GROOVE, THREADED, AND WELDING JOINTS.
2. TYPE: LIGHTWEIGHT PIPE, SCHEDULE 10, FOR ROLLED-GROOVE AND WELDING JOINTS.
- (K) COPPER TUBE: ASTM B 88, TYPES L AND M, WATER TUBE, DRAWN TEMPER.
- (L) CHLORINATED POLYVINYL CHLORIDE (CPVC) PLASTIC PIPE: ASTM F 442, UL-LISTED, 175 PSIG RATING, MADE IN NPS FOR SPRINKLER SERVICE. INCLUDE LOGOS OF "LISTING AGENCY", "LISTED" AND "CPVC SPRINKLER PIPE" MARKS ON PIPE.

2.04 PIPE AND TUBE FITTINGS

- (A) ALL GROOVED JOINT COUPLINGS AND FITTINGS SHALL BE THE PRODUCTS OF A SINGLE MANUFACTURER. GROOVING TOOLS SHALL BE OF THE SAME MANUFACTURER AS THE GROOVED COMPONENTS.
- (B) CAST-IRON THREADED FLANGES: ASME B16.1, CLASS 150, RAISED GROUND FACE, BOLT HOLES SPOT FACED.
- (C) DUCTILE-IRON AND GRAY-IRON FLANGED FITTINGS: AWWA C110, 250 PSIG MINIMUM PRESSURE RATING, WITH AWWA C 104 CEMENT-MORTAR LINING.

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- (D) DUCTILE-IRON THREADED FITTINGS: ANSI B16.3, CLASS 150, STANDARD PATTERN, WITH NPT OR BSPT THREADS.
- (E) CAST-IRON THREADED FITTINGS: ASME B16.4, CLASS 150, STANDARD PATTERN, WITH THREADS ACCORDING TO ASME B 1.20.1.
- (F) MALLEABLE-IRON THREADED FITTINGS: ASME B16.3, CLASS 150, STANDARD PATTERN, WITH THREADS ACCORDING TO ASME B1.20.1.
- (G) GROOVED-END FITTINGS FOR DUCTILE-IRON PIPE: ASTM A 536 DUCTILE-IRON, AWWA PIPE-SIZE, DESIGNED TO ACCEPT AWWA C 606 GROOVED COUPLINGS. INCLUDE CEMENT LINING OR FOOD AND DRUG ADMINISTRATION (FDA)-APPROVED INTERIOR COATING.
- (H) STEEL FITTINGS: ASTM A 234, SEAMLESS OR WELDED; ASME B16.9, BUTTWELDING; OR ASME B16.11, SOCKET-WELDING TYPE FOR WELDED JOINTS.
- (I) STEEL FLANGES AND FLANGED FITTINGS: ASME B16.5.
- (J) GROOVED-END FITTINGS FOR STEEL PIPE: UL-LISTED AND FM-APPROVED, ASTM A 536, GRADE 65-45-12 DUCTILE-IRON, WITH GROOVES OR SHOULDERS DESIGNED TO ACCEPT GROOVED COUPLINGS.
 - 1. BASIS OF DESIGN: INSTALLATION-READY™ FITTINGS FOR SCHEDULE [40] [10] GROOVED END STEEL PIPING IN FIRE PROTECTION APPLICATIONS SIZES 1-1/4 THRU 2-1/2-INCH. FITTINGS SHALL CONSIST OF A DUCTILE IRON HOUSING CONFORMING TO ASTM A-536, GRADE 65-45-12, WITH INSTALLATION-READY™ ENDS, [ORANGE ENAMEL COATED] [RED ENAMEL COATED] [GALVANIZED]. FITTINGS COMPLETE WITH PRE-LUBRICATED GRADE E" EPDM TYPE 'A' GASKET; AND ASTM A449 ELECTROPLATED STEEL BOLTS AND NUTS. UL LISTED FOR WORKING PRESSURE OF 300 PSI AND FM APPROVED FOR WORKING PRESSURE TO 365 PSI.
- (K) GALVANIZED, GROOVED-END FITTINGS FOR STEEL PIPING: ASTM A 536, DUCTILE-IRON CASTING; WITH DIMENSIONS MATCHING STEEL PIPE. IN APPLICABLE SIZES, FITTINGS SHALL BE SHORT PATTERN, WITH FLOW EQUAL TO STANDARD PATTERN FITTINGS. BASIS OF DESIGN: VICTAULIC FIRELOCK.
- (L) WROUGHT-COPPER FITTINGS: ASME B16.22, STREAMLINED PATTERN.
- (M) CAST-BRONZE FLANGES: ASME B16.24, CLASS 300, RAISED GROUND FACE, BOLT HOLES SPOT FACED.
- (N) GROOVED-END FITTINGS FOR COPPER TUBE: UL-LISTED, ASME B16.22 WROUGHT COPPER AND ASTM B 75, COPPER TUBE OR ASME B16.18 AND ASTM B 584 BRONZE CASTINGS, DESIGNED FOR GROOVED-END COUPLINGS. MANUFACTURED TO COPPER-TUBE DIMENSIONS. FLARING OF TUBE OR FITTING ENDS TO ACCOMMODATE ALTERNATE SIZED COUPLINGS IS NOT PERMITTED. BASIS OF DESIGN: VICTAULIC COPPER-CONNECTION.
- (O) GALVANIZED-STEEL PIPING NIPPLES: ASTM A 733, MADE OF ASTM A 53/A 53M, STANDARD WEIGHT SEAMLESS STEEL PIPE WITH THREADED ENDS.
- (P) GALVANIZED, STEEL COUPLINGS: ASTM A 865, THREADED.
- (Q) GALVANIZED, GRAY-IRON THREADED FITTINGS: ASME B16.4, CLASS 125, STANDARD PATTERN.
- (R) CHLORINATED POLYVINYL CHLORIDE (CPVC) PLASTIC PIPE FITTINGS: ASTM F 438 FOR 3/4 INCH TO 1 1/2-INCH SCHEDULE 40, SOCKET TYPE; ATM F 439 FOR 2-INCH TO 3-INCH SCHEDULE 80, SOCKET TYPE; UL LISTED; 175 PSIG RATED AT 150°F MADE IN NPS FOR SPRINKLER SERVICE. INCLUDE "LISTED" AND "CPVC SPRINKLER FITTING" MARKS ON FITTINGS.

(S) CPVC-TO-METAL TRANSITION FITTINGS: CPVC, ONE PIECE, WITH DIMENSIONS EQUIVALENT TO PIPE; ONE END WITH THREADED BRASS INSERT, AND ONE SOCKET END.

(T) CPVC-TO-METAL TRANSITION UNIONS: CPVC, WITH DIMENSIONS EQUIVALENT TO PIPE; ONE END WITH THREADED BRASS INSERT, AND ONE SOCKET END.

2.05 JOINING MATERIALS

(A) FLANGED JOINTS FOR DUCTILE-IRON PIPE AND DUCTILE-IRON OR CAST-IRON FITTINGS: AWWA C 115 DUCTILE-IRON OR GRAY-IRON PIPE FLANGES, RUBBER GASKETS, AND HIGH-STRENGTH STEEL BOLTS AND NUTS.

(B) BRAZING FILLER METALS: AWS A5.8, CLASSIFICATION BCUP-3 OR BCUP-4.

(C) COUPLINGS FOR GROOVED-END STEEL PIPE AND GROOVED-END FERROUS FITTINGS: UL 213, AWWA C 606, ASTM A 536 DUCTILE-IRON HOUSING, WITH ENAMEL FINISH. INCLUDE SYNTHETIC-RUBBER GASKET WITH CENTRAL-CAVITY, PRESSURE-RESPONSIVE DESIGN; ASTM A449 OR A183 CARBON-STEEL BOLTS AND NUTS TO SECURE GROOVED PIPE AND FITTINGS.

1. RIGID TYPE: HOUSINGS CAST WITH OFFSETTING, ANGLE-PATTERN, BOLT PADS TO PROVIDE SYSTEM RIGIDITY AND SUPPORT AND HANGING IN ACCORDANCE WITH NFPA 13, FULLY INSTALLED AT VISUAL PAD-TO-PAD OFFSET CONTACT. INSTALLATION-READY FOR COMPLETE INSTALLATION WITHOUT FIELD DISASSEMBLY. BASIS OF DESIGN: VICTAULIC STYLE 009-EZ AND 107N.

2. FLEXIBLE TYPE: FOR USE IN LOCATIONS WHERE VIBRATION ATTENUATION AND STRESS RELIEF ARE REQUIRED. BASIS OF DESIGN: VICTAULIC INSTALLATION-READY STYLE 177 OR STYLE 77.

(D) COUPLINGS FOR GROOVED-END DUCTILE-IRON PIPE AND FITTINGS: UL 213, AWWA C 606, ASTM A 536 DUCTILE-IRON HOUSING, WITH ENAMEL FINISH. INCLUDE FLUSHSEAL® SYNTHETIC-RUBBER GASKET WITH CENTRAL-CAVITY, PRESSURE-RESPONSIVE DESIGN, AND ASTM A 449 AND A 183 CARBON-STEEL BOLTS AND NUTS TO SECURE GROOVED PIPE AND FITTINGS. BASIS OF DESIGN: VICTAULIC STYLE 31.

1. FOR DIRECT CONNECTION BETWEEN IPS/STEEL PIPE AND AWWA/DUCTILE IRON PIPE, VICTAULIC STYLE 307 TRANSITION COUPLING, OR APPROVED EQUAL.

(E) COUPLINGS FOR GROOVED-END COPPER TUBE AND GROOVED-END COPPER FITTINGS: UL 213, ASTM A 536 DUCTILE-IRON HOUSING, WITH COPPER-COLORED ENAMEL FINISH. INCLUDE SYNTHETIC-RUBBER GASKET WITH CENTRAL-CAVITY, PRESSURE-RESPONSIVE DESIGN, AND ASTM A 449 AND A 183 CARBON-STEEL BOLTS AND NUTS. INSTALLATION-READY FOR COMPLETE INSTALLATION WITHOUT FIELD DISASSEMBLY. BASIS OF DESIGN: VICTAULIC STYLE 607H.

(F) CPVC CEMENT: PRIMER AND SOLVENT CEMENT MADE BY PIPE AND FITTING MANUFACTURER FOR JOINING SPRINKLER PIPING.

2.06 FIRE PROTECTION SERVICE VALVES

(A) GENERAL: UL-LISTED AND FM-APPROVED, WITH 175 PSIG NON-SHOCK MINIMUM WORKING PRESSURE RATING.

1. OPTION: VALVES FOR USE WITH GROOVED PIPING MAY BE GROOVED TYPE.

(B) GATE VALVES, 2-INCH AND SMALLER: UL 262, CAST-BRONZE, THREADED ENDS, SOLID WEDGE, OUTSIDE SCREW AND YOKE, RISING STEM.

(C) INDICATING VALVES:

1. 2-INCH AND SMALLER: BUTTERFLY OR BALL TYPE, BRONZE BODY WITH THREADED OR GROOVED ENDS, AND INTEGRAL INDICATING DEVICE. BASIS OF DESIGN: VICTAULIC SERIES 728.
2. 2-1/2-INCH AND LARGER: DUCTILE IRON, ELECTROLESS-NICKEL PLATED DUCTILE IRON DISC, PRESSURE-RESPONSIVE EPDM SEAT, AND STAINLESS STEEL STEM, GROOVED ENDS AND EXTENDED NECK. BASIS OF DESIGN: VICTAULIC SERIES 705.

(D) GATE VALVES, 2-1/2-INCH AND LARGER: UL 262, IRON BODY, BRONZE MOUNTED, TAPER WEDGE, OUTSIDE SCREW AND YOKE, RISING STEM. INCLUDE REPLACEABLE, BRONZE, WEDGE FACING RINGS AND GROOVED OR FLANGED ENDS. BASIS OF DESIGN: VICTAULIC SERIES 771.

(E) SPRING-ASSISTED SWING CHECK VALVES, 2-INCH AND LARGER: UL 312; CAST DUCTILE-IRON BODY AND BOLTED CAP; WITH BRONZE, STAINLESS STEEL, OR ELASTOMER-COATED DUCTILE-IRON DISC; WITH STAINLESS STEEL SPRING AND SHAFT FOR VERTICAL OR HORIZONTAL INSTALLATION; AND GROOVED OR FLANGED ENDS. BASIS OF DESIGN: VICTAULIC SERIES 717.

(F) BUTTERFLY CHECK VALVES, 4-INCH AND LARGER: UL 213, SPLIT-CLAPPER STYLE, CAST-IRON BODY WITH RUBBER SEAL, BRONZE ALLOY DISCS, STAINLESS-STEEL SPRING AND HINGE PIN.

2.07 SPECIALTY VALVES

(A) BACKFLOW PREVENTER VALVE: PROVIDE DOUBLE CHECK BACKFLOW PREVENTERS. BACKFLOW PREVENTERS SHALL MEET THE REQUIREMENTS OF A.S.S.E. STD. 1015; AWWA STD. C506-78 OR USCFCCL MANUAL FOR CROSS CONNECTION CONTROL. WATTS REGULATOR COMPANY SERIES 709 OR EQUAL.

2.08 SPRINKLERS

(A) AUTOMATIC SPRINKLERS: WITH HEAT-RESPONSIVE ELEMENT CONFORMING TO:

1. UL 199, FOR APPLICATIONS EXCEPT RESIDENTIAL.
2. UL 1626, FOR RESIDENTIAL APPLICATIONS.
3. UL 1767, FOR EARLY-SUPPRESSION, FAST-RESPONSE APPLICATIONS.

(B) SPRINKLERS SHALL BE GLASS BULB TYPE, WITH HEX-SHAPED WRENCH BOSS INTEGRALLY CAST INTO THE SPRINKLER BODY TO REDUCE THE RISK OF DAMAGE DURING INSTALLATION.

1. WRENCHES SHALL BE PROVIDED BY THE SPRINKLER MANUFACTURER THAT DIRECTLY ENGAGE THE HEX-SHAPED WRENCH BOSS INTEGRALLY CAST INTO THE SPRINKLER BODY.

(C) SPRINKLER TYPES AND CATEGORIES ARE AS INDICATED AND AS REQUIRED BY APPLICATION. FURNISH AUTOMATIC SPRINKLERS WITH NOMINAL 1/2-INCH ORIFICE FOR "ORDINARY" TEMPERATURE CLASSIFICATION RATING EXCEPT WHERE OTHERWISE INDICATED AND REQUIRED BY APPLICATION.....

(D) SPRINKLER FINISHES:

1. SPRINKLERS IN FINISHED CEILING AREAS SHALL BE INSTALLED WITHIN 3-INCHES OF CENTER OF CEILING TILE AND SHALL BE CONCEALED STYLE WITH WHITE FACTORY FINISH UNLESS OTHERWISE NOTED ON DRAWINGS.

2. SPRINKLERS IN EXPOSED CONSTRUCTION AREAS SHALL HAVE FACTORY WHITE FINISH WHERE PIPING IS NOTED TO BE PAINTED WHITE ON PLANS OTHERWISE, THEY SHALL HAVE BRASS FINISH.
- (E) SPRINKLER CABINET AND WRENCHES: FINISHED STEEL CABINET SUITABLE FOR WALL MOUNTING WITH HINGED COVER AND SPACE FOR QUANTITY OF SUPPLIED SPARE SPRINKLERS PLUS SPRINKLER WRENCHES. PROVIDE EXTRA CABINETS AS NECESSARY TO MEET THE STORAGE REQUIREMENTS OF NFPA 13.
- (F) ESCUTCHEONS AND GUARDS SHALL BE LISTED, SUPPLIED, AND APPROVED FOR USE WITH THE SPRINKLER BY THE SPRINKLER MANUFACTURER.

2.09 FLEXIBLE HOSE COMMERCIAL SPRINKLER CONNECTIONS

- (A) FLEXIBLE STAINLESS STEEL HOSE ASSEMBLIES AND ELBOW HOSE ASSEMBLIES CONSISTING OF LENGTHS FROM 2 FEET TO 6 FEET AS REQUIRED FOR PROJECT CONDITIONS. HANGERS NOT REQUIRED FOR UP TO 6 FEET OF HOSE ASSEMBLY. SPRINKLER DROP SYSTEM, BRAIDED, LEAK-TESTED WITH MINIMUM 1 INCH INTERNAL CORRUGATED HOSE DIAMETER FABRICATED WITH 304 STAINLESS STEEL, INCLUDING END FITTINGS. THE DROP SHALL INCLUDE A UL APPROVED BRAIDED RADIUS TO 2-INCHES TO ALLOW FOR PROPER INSTALLATION IN CONFINED SPACES. COMPLETE SYSTEM SHALL ALLOW FOR A TOTAL OF 270° TOTAL BENDING PER FLEXIBLE DROP UNLESS LISTED FOR MORE BENDS. FLEXIBLE ASSEMBLIES SHALL BE UL LISTED AND FM APPROVED. UNION JOINTS SHALL BE PROVIDED FOR EASE OF INSTALLATION. THE FLEXIBLE DROP SHALL ATTACH TO THE CEILING GRID USING A ONE-PIECE OPEN GATE BRACKET LISTED FOR USE WITH THE FLEXIBLE DROP. THE BRACKET SHALL ALLOW INSTALLATION BEFORE THE CEILING TILE IS IN PLACE. BASIS OF DESIGN: VICFLEX MODEL AH2/AH2CC WITH AB1 OR AB2 BRACKET.
1. OUTLET CONNECTION: 1/2 OR 3/4 INCH.
2. MAXIMUM RATED PRESSURE: 175 PSI.
- (B) SYSTEM SHALL ONLY BE AUTHORIZED FOR INSTALLATION IN LIGHT HAZARD AND ORDINARY HAZARD OCCUPANCIES.
- (C) DIRECT ATTACHMENT FLEXIBLE HOSE CEILING BRACKET WITH INTEGRATED SNAP-ON CLIP OR SCREW-FASTENED ENDS POSITIVELY ATTACHED TO THE CEILING USING TAMPER-RESISTANT SCREWS AND REMOVABLE ATTACHMENT HUB OR OPEN GATE CLAMP WITH SET SCREW FOR ATTACHING AND ADJUSTING FLEXIBLE HOSE.
- (D) FLEXIBLE HOSE SHALL BE INSTALLED WITH A MAXIMUM OF THREE (3) 90 DEGREE BENDS, REGARDLESS OF MANUFACTURER'S LISTING UNLESS VICFLEX IS USED AND IS EQUIPPED WITH THE IDENTIFICATION LABEL THAT IS VISIBLE FROM GROUND LEVEL.

2.10 FIRE DEPARTMENT CONNECTIONS

- (A) WALL TYPE INLET CONNECTIONS: POLISHED CAST BRASS, FLUSH WALL TYPE, WITH WALL ESCUTCHEON AND TWO-WAY CONNECTIONS. CONNECTION SIZES SHALL BE ONE (1) 4-INCH OUTLET AND TWO (2) 2-1/2-INCH (65MM) FEMALE INLETS, HAVING THREADS COMPATIBLE WITH THE LOCAL FIRE DEPARTMENT EQUIPMENT, FOR THE CONNECTION SIZE INDICATED, AS SPECIFIED IN NFPA 1963. EACH INLET SHALL HAVE A CLAPPER VALVE, AND PLUG AND CHAIN. UNIT SHALL HAVE WALL ESCUTCHEON OF CAST BRASS, FINISH TO MATCH CONNECTIONS, WITH WORDS "AUTO SPKR - FIRE DEPT CONNECTION" IN RAISED LETTERS. NOTE, SMALLER PIPE SIZE AND A SINGLE 2-1/2-INCH FEMALE INLET MAY BE USED WHEN NFPA 13 GUIDELINES PERMIT SMALLER SIZE. FIRE DEPARTMENT CONNECTION SHALL BE LIKE POTTER ROEMER MODEL 5021.

2.11 ALARM DEVICES

- (A) ALARM DEVICES: TYPES AND SIZES THAT WILL MATCH PIPING AND EQUIPMENT CONNECTIONS.

- (B) ELECTRICALLY OPERATED ALARM BELLS: UL LISTED EXTERIOR, WEATHERPROOF, WALL MOUNTED COMBINATION BELL/STROBE/SIGN, ELECTRIC FIRE ALARM BELLS. PROVIDE ALL CONDUIT AND WIRING NECESSARY FOR ELECTRICAL CONNECTION. SIZE WIRING ACCORDING TO MANUFACTURER'S RECOMMENDATIONS. OUTSIDE DEVICE SHALL BE SASH SERIES BY POTTER ELECTRIC SIGNAL COMPANY, OR APPROVED EQUAL.
- (C) WATERFLOW INDICATORS: UL 346, ELECTRICAL-SUPERVISION TYPE, VANE-TYPE WATERFLOW DETECTOR, RATED TO 250 PSIG AND DESIGNED FOR HORIZONTAL OR VERTICAL INSTALLATION. INCLUDE TWO (2) SPDT (SINGLE-POLE, DOUBLE-THROW) CIRCUIT SWITCHES TO PROVIDE ISOLATED ALARM AND AUXILIARY CONTACTS, 7 A, 120-VAC AND 0.25 A, 24-VDC. COMPLETE WITH FACTORY-SET, FIELD-ADJUSTABLE RETARD ELEMENT TO PREVENT FALSE SIGNALS AND TAMPER-PROOF COVER THAT SENDS A SIGNAL WHEN COVER IS REMOVED.
- (D) SUPERVISORY SWITCHES: UL 753, FOR VALVES, ELECTRICAL-SUPERVISION TYPE, SPDT, NORMALLY CLOSED CONTACTS, DESIGNED TO SIGNAL CONTROLLED VALVE IN OTHER THAN FULL OPEN POSITION.
- (E) SUPERVISORY SWITCHES: UL 753, FOR INDICATOR POSTS, ELECTRICAL-SUPERVISION TYPE, SPDT, NORMALLY CLOSED CONTACTS, DESIGNED TO SIGNAL CONTROLLED VALVE IN OTHER THAN FULL OPEN POSITION.

2.12 PRESSURE GAUGES

- (A) PRESSURE GAUGES: UL 393, 3-1/2 TO 4-1/2 INCHES DIAMETER DIAL WITH DIAL RANGE OF 0-250 PSIG.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) EXAMINE AREAS AND CONDITIONS UNDER WHICH FIRE PROTECTION MATERIALS AND PRODUCTS ARE TO BE INSTALLED. DO NOT PROCEED UNTIL SATISFACTORY CONDITIONS HAVE BEEN CORRECTED.

3.02 PIPE APPLICATIONS

(A) ABOVEGROUND PIPE:

1. BLACK STEEL PIPE: INSTALL SCHEDULE 40 FOR LESS THAN 8-INCH; SCHEDULE 30 FOR 8-INCH AND LARGER; CLASS 150, CAST-IRON THREADED FITTINGS, THREADED JOINTS.
2. BLACK STEEL PIPE: INSTALL SCHEDULE 40 FOR LESS THAN 8-INCH; SCHEDULE 30 FOR 8-INCH AND LARGER; MECHANICAL GROOVED PIPE COUPLINGS AND FITTINGS; CUT-GROOVE TYPE.
3. BLACK STEEL PIPE: INSTALL SCHEDULE 10 FOR 5-INCH AND SMALLER; 0.134-INCH WALL THICKNESS FOR 6-INCH; AND 0.188-INCH WALL THICKNESS FOR 8-INCH AND 10-INCH; WROUGHT-STEEL BUTTWELDING FITTINGS, WELDED JOINTS.
4. BLACK STEEL PIPE: INSTALL SCHEDULE 10 FOR 5-INCH AND SMALLER; 0.134-INCH WALL THICKNESS FOR 6-INCH; AND 0.188-INCH WALL THICKNESS FOR 8-INCH AND 10-INCH MECHANICAL GROOVED PIPE COUPLINGS AND FITTINGS; ROLL-GROOVE OR MECHANICAL LOCKING TYPE.
5. CHLORINATED POLYVINYL CHLORIDE (CPVC) PLASTIC PIPE: INSTALL AS ALLOWED BY NFPA 13 FOR 3-INCH AND SMALLER SPRINKLER PIPING; SOLVENT WELD FITTINGS.

(B) UNDERGROUND PIPE:

1. INSTALL DUCTILE-IRON, WATER-SERVICE PIPING ACCORDING TO AWWA C600 AND AWWA M41.
 - A. INSTALL ENCASEMENT FOR PIPING ACCORDING TO ASTM A 674 OR AWWA C105.

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2. INSTALL UNDERGROUND PIPING WITH RESTRAINED JOINTS AT HORIZONTAL AND VERTICAL CHANGES IN DIRECTION. USE RESTRAINED-JOINT PIPING, ANCHORS AND OTHER SUPPORTS.
3. UNDERGROUND FIRE-SUPPRESSION WATER-SERVICE PIPING NPS 3 (DN 80) SHALL BE THE FOLLOWING:
 - A. MECHANICAL-JOINT, DUCTILE-IRON PIPE; MECHANICAL-JOINT, DUCTILE- OR GRAY-IRON, STANDARD-PATTERN FITTINGS; GLANDS, GASKETS, AND BOLTS; AND GASKETED JOINTS.
4. UNDERGROUND FIRE-SUPPRESSION WATER-SERVICE PIPING NPS 4 (DN 100) SHALL BE THE FOLLOWING:
 - A. MECHANICAL-JOINT, DUCTILE-IRON PIPE; MECHANICAL-JOINT, DUCTILE- OR GRAY-IRON, STANDARD-PATTERN FITTINGS; GLANDS, GASKETS, AND BOLTS; AND GASKETED JOINTS.
5. UNDERGROUND FIRE-SUPPRESSION WATER-SERVICE PIPING NPS 6 TO NPS 12 (DN 150 TO DN 300) SHALL BE THE FOLLOWING:
 - A. MECHANICAL-JOINT, DUCTILE-IRON PIPE; MECHANICAL-JOINT, DUCTILE- OR GRAY-IRON, STANDARD-PATTERN FITTINGS; GLANDS, GASKETS, AND BOLTS; AND GASKETED JOINTS.

3.03 PIPING INSTALLATIONS

- (A) EXTREME CARE SHALL BE EXERCISED BY THE CONTRACTOR TO PREVENT DIRT AND OTHER FOREIGN MATTER FROM ENTERING PIPE OR COMPONENTS OF SYSTEM DURING CONSTRUCTION. PIPE STORED ON PROJECT SHALL HAVE OPEN ENDS CAPPED AND EQUIPMENT SHALL HAVE ALL OPENINGS FULLY PROTECTED. BEFORE ERECTION, EACH PIECE OF PIPE, FITTING OR VALVE SHALL BE VISUALLY EXAMINED AND ALL DIRT REMOVED.
- (B) LOCATIONS AND ARRANGEMENTS: DRAWINGS (PLANS, SCHEMATICS, AND DIAGRAMS) INDICATE THE GENERAL LOCATION AND ARRANGEMENT OF PIPING SYSTEMS. SO FAR AS PRACTICAL, INSTALL PIPING AS INDICATED.
 1. DEVIATIONS FROM APPROVED "WORKING PLANS" FOR SPRINKLER PIPING REQUIRE WRITTEN APPROVAL OF THE AUTHORITY HAVING JURISDICTION. WRITTEN APPROVAL SHALL BE ON FILE WITH THE ARCHITECT PRIOR TO DEVIATING FROM THE APPROVED "WORKING PLANS."
- (C) INSTALL SPRINKLER PIPING TO PROVIDE FOR SYSTEM DRAINAGE IN ACCORDANCE WITH NFPA 13.
- (D) USE APPROVED FITTINGS TO MAKE ALL CHANGES IN DIRECTION, BRANCH TAKEOFFS FROM MAINS, AND REDUCTIONS IN PIPE SIZES. REDUCING FLANGES SHALL NOT BE USED. WHEN PIPE REDUCTION IS REQUIRED, PROVIDE A CONCENTRIC REDUCER OR OTHER APPROVED FITTING SUCH AS A REDUCING ELBOW.
- (E) INSTALL UNIONS IN PIPES 2-INCH AND SMALLER, ADJACENT TO EACH VALVE. UNIONS ARE NOT REQUIRED ON FLANGED DEVICES OR IN PIPING INSTALLATIONS USING GROOVED MECHANICAL COUPLINGS.
- (F) INSTALL FLANGES OR FLANGE ADAPTERS ON VALVES, APPARATUS, AND EQUIPMENT HAVING 2-1/2-INCH AND LARGER CONNECTIONS.
- (G) HANGERS AND SUPPORTS: COMPLY WITH THE REQUIREMENTS OF NFPA 13 AND NFPA 14. HANGER AND SUPPORT SPACING AND LOCATIONS FOR PIPING JOINED WITH GROOVED MECHANICAL COUPLINGS SHALL BE IN ACCORDANCE WITH THE GROOVED MECHANICAL COUPLING MANUFACTURER'S WRITTEN INSTRUCTIONS, FOR RIGID SYSTEMS. PROVIDE PROTECTION FROM DAMAGE WHERE SUBJECT TO EARTHQUAKE IN ACCORDANCE WITH NFPA 13.

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- (H) MAKE CONNECTIONS BETWEEN UNDERGROUND AND ABOVE-GROUND PIPING USING AN APPROVED TRANSITION PIECE STRAPPED OR FASTENED TO PREVENT SEPARATION.
- (I) INSTALL MECHANICAL SLEEVE SEAL AT PIPE PENETRATIONS IN BASEMENT AND FOUNDATION WALLS.
- (J) INSTALL TEST CONNECTIONS SIZED AND LOCATED IN ACCORDANCE WITH NFPA 13 COMPLETE WITH SHUTOFF VALVE. TEST CONNECTIONS MAY ALSO SERVE AS DRAIN PIPES.
- (K) INSTALL PRESSURE GAUGE ON THE RISER OR FEED MAIN AND AT OR NEAR EACH TEST CONNECTION. PROVIDE GAUGE WITH A CONNECTION NOT LESS THAN 1/4-INCH AND HAVING A SOFT METAL SEATED GLOBE VALVE, ARRANGED FOR DRAINING PIPE BETWEEN GAUGE AND VALVE. INSTALL GAUGES TO PERMIT REMOVAL, AND WHERE THEY WILL NOT BE SUBJECT TO FREEZING.
- (L) INSTALL AUTOMATIC (BALL DRIP) DRAIN VALVES TO DRAIN PIPING BETWEEN FIRE-DEPARTMENT CONNECTIONS AND CHECK VALVES. DRAIN TO FLOOR DRAIN OR TO OUTSIDE BUILDING.
- (M) INSTALL PRESSURE VENTING IN ACCORDANCE WITH CURRENT ED OF NFPA 13.
- (N) INSTALL ALARM DEVICES IN PIPING SYSTEMS.
- (O) INSTALL HANGERS AND SUPPORTS FOR SPRINKLER SYSTEM PIPING ACCORDING TO NFPA 13. COMPLY WITH REQUIREMENTS IN NFPA 13 FOR HANGER MATERIALS.
- (P) INSTALL SLEEVE SEALS FOR PIPING PENETRATIONS OF CONCRETE WALLS AND SLABS.
- (Q) INSTALL ESCUTCHEONS FOR PIPING PENETRATIONS OF WALLS, CEILINGS AND FLOORS.
- (R) DO NOT INSTALL CPVC PIPING EXPOSED.
- (S) CPVC PIPING SHALL ONLY BE USED TO SERVE LIGHT HAZARD OCCUPANCY DESIGN AREAS.

3.04 PIPE JOINT CONSTRUCTION

(A) ABOVEGROUND PIPING:

- 1. WELDED JOINTS: AWS D10.9, LEVEL AR-3.
- 2. THREADED JOINTS: CONFORM TO ANSI B1.20.1, TAPERED PIPE THREADS FOR FIELD CUT THREADS. JOIN PIPE, FITTINGS, AND VALVES AS FOLLOWS:
 - A. NOTE THE INTERNAL LENGTH OF THREADS IN FITTINGS OR VALVE ENDS, AND PROXIMITY OF INTERNAL SEAT OR WALL, TO DETERMINE HOW FAR PIPE SHOULD BE THREADED INTO JOINT.
 - B. ALIGN THREADS AT POINT OF ASSEMBLY.
 - C. APPLY APPROPRIATE TAPE OR THREAD COMPOUND TO THE EXTERNAL PIPE THREADS.
 - D. ASSEMBLE JOINT TO APPROPRIATE THREAD DEPTH. WHEN USING A WRENCH ON VALVES PLACE THE WRENCH ON THE VALVE END INTO WHICH THE PIPE IS BEING THREADED.
 - E. DAMAGED THREADS: DO NOT USE PIPE WITH THREADS WHICH ARE STRIPPED, CHIPPED, CORRODED, OR OTHERWISE DAMAGED. IF A WELD OPENS DURING CUTTING OR THREADING OPERATIONS, THAT PORTION OF PIPE SHALL NOT BE USED.

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3. FLANGED JOINTS: ALIGN FLANGES SURFACES PARALLEL. ASSEMBLE JOINTS BY SEQUENCING BOLT TIGHTENING TO MAKE INITIAL CONTACT OF FLANGES AND GASKETS AS FLAT AND PARALLEL AS POSSIBLE. USE SUITABLE LUBRICANTS ON BOLT THREADS. TIGHTEN BOLTS GRADUALLY AND UNIFORMLY TO APPROPRIATE TORQUE SPECIFIED BY THE BOLT MANUFACTURER.
4. MECHANICAL GROOVED JOINTS: CUT OR ROLL GROOVES ON PIPE ENDS DIMENSIONALLY COMPATIBLE WITH THE COUPLINGS. GROOVED JOINTS SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S LATEST PUBLISHED INSTRUCTIONS. THE GASKET STYLE AND ELASTOMERIC MATERIAL SHALL BE VERIFIED AS SUITABLE FOR THE INTENDED SERVICE. GASKETS SHALL BE MOLDED AND PRODUCED BY THE GROOVED COUPLING MANUFACTURER. GROOVED ENDS SHALL BE CLEAN AND FREE FROM INDENTATION, PROJECTIONS, AND ROLL MARKS IN THE AREA FROM PIPE END TO GROOVE. GROOVED COUPLING MANUFACTURER'S FACTORY TRAINED FIELD REPRESENTATIVE SHALL PROVIDE ON-SITE TRAINING FOR A CONTRACTOR'S FIELD PERSONNEL IN THE PROPER USE OF GROOVING TOOLS, APPLICATION OF GROOVE, AND INSTALLATION OF GROOVED PIPING PRODUCTS. FACTORY TRAINED REPRESENTATIVE SHALL PERIODICALLY INSPECT THE PRODUCT INSTALLATION. CONTRACTOR SHALL REMOVE AND REPLACE ANY IMPROPERLY INSTALLED PRODUCTS.
5. END TREATMENT: AFTER CUTTING PIPE LENGTHS, REMOVE BURRS AND FINIS FROM PIPE ENDS.

(B) UNDERGROUND PIPING:

1. INSTALL COUPLINGS, FLANGES, FLANGED FITTINGS, UNIONS, NIPPLES, AND TRANSITION AND SPECIAL FITTINGS THAT HAVE FINISH AND PRESSURE RATING SAME AS OR HIGHER THAN SYSTEMS PRESSURE RATING FOR ABOVEGROUND APPLICATIONS UNLESS OTHERWISE INDICATED.
2. INSTALL FLANGES, FLANGE ADAPTORS, OR COUPLINGS FOR GROOVED-END PIPING ON VALVES, APPARATUS, AND EQUIPMENT HAVING NPS 2-1/2 (DN 65) AND LARGER END CONNECTIONS.
3. REAM ENDS OF TUBES AND REMOVE BURRS.
4. REMOVE SCALE, SLAG, DIRT, AND DEBRIS FROM OUTSIDE AND INSIDE OF PIPES, TUBES, AND FITTINGS BEFORE ASSEMBLY.
5. DUCTILE-IRON PIPING, GASKETED JOINTS FOR FIRE-SERVICE-MAIN PIPING: UL 194.
6. FLANGED JOINTS: SELECT APPROPRIATE GASKET MATERIAL IN SIZE, TYPE, AND THICKNESS SUITABLE FOR WATER SERVICE. JOIN FLANGES WITH BOLTS ACCORDING TO ASME B31.9.

3.05 VALVE INSTALLATIONS

- (A) GENERAL: INSTALL FIRE PROTECTION SPECIALTY VALVES, FITTINGS, AND SPECIALTIES IN ACCORDANCE WITH THE MANUFACTURER'S WRITTEN INSTRUCTIONS, NFPA 13, AND THE AUTHORITY HAVING JURISDICTION.
- (B) GATE VALVES: INSTALL SUPERVISED-OPEN GATE VALVES SO LOCATED TO CONTROL ALL SOURCES OF WATER SUPPLY EXCEPT FIRE DEPARTMENT CONNECTIONS. WHERE THERE IS MORE THAN ONE CONTROL VALVE, PROVIDE PERMANENTLY MARKED IDENTIFICATION SIGNS INDICATING THE PORTION OF THE SYSTEM CONTROLLED BY EACH VALVE. PROVIDE TAMPER SWITCH CONNECTED TO BUILDING FIRE ALARM SYSTEM ON ALL CONTROL VALVES THAT, WHEN CLOSED, WILL PREVENT THE FLOW OF WATER TO A SPRINKLER.
- (C) INSTALL DOUBLE CHECK BACKFLOW PREVENTION DEVICE IN EACH WATER SUPPLY CONNECTION. INSTALL IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS AND ALL LOCAL CODE REQUIREMENTS.

3.06 SPRINKLER INSTALLATIONS

- (A) USE PROPER TOOLS TO PREVENT DAMAGE DURING INSTALLATIONS.
- (B) DO NOT INSTALL SPRINKLERS THAT HAVE BEEN DROPPED, DAMAGED, SHOW A VISIBLE LOSS OF FLUID, OR A CRACKED BULB.
- (C) THE SPRINKLER BULB PROTECTOR SHALL BE REMOVED BY HAND, WITHOUT TOOLS OR DEVICES THAT MAY DAMAGE THE BULB.
- (D) THE SPRINKLER BULB PROTECTOR SHALL REMAIN IN PLACE UNTIL SYSTEM IS READY TO BE TESTED AND PLACED INTO SERVICE.

3.07 UNDERGROUND PIPING ANCHORAGE INSTALLATION

- (A) ANCHORAGE, GENERAL: INSTALL WATER-DISTRIBUTION PIPING WITH RESTRAINED JOINTS. ANCHORAGES AND RESTRAINED-JOINT TYPES THAT MAY BE USED INCLUDE THE FOLLOWING:
 - 1. LOCKING MECHANICAL JOINTS.
 - 2. BOLTED FLANGED JOINTS.
- (B) INSTALL ANCHORAGES FOR TEES, PLUGS AND CAPS, BENDS, CROSSES, VALVES, AND HYDRANT BRANCHES IN FIRE-SUPPRESSION WATER-SERVICE PIPING ACCORDING TO NFPA 24 AND THE FOLLOWING:
 - 1. GASKETED-JOINT, DUCTILE-IRON, WATER-SERVICE PIPING: ACCORDING TO AWWA C600.
 - 2. GASKETED-JOINT: ACCORDING TO AWWA M23.
 - 3. BONDED-JOINT FIBERGLASS, WATER-SERVICE PIPING: ACCORDING TO AWWA M45.
- (C) APPLY FULL COAT OF ASPHALT OR OTHER ACCEPTABLE CORROSION-RESISTANT MATERIAL TO SURFACES OF INSTALLED FERROUS ANCHORAGE DEVICES ON BURIED PORTION OF PIPE.

3.08 FLEXIBLE HOSE COMMERCIAL SPRINKLER INSTALLATIONS

- (A) LIMIT STAINLESS STEEL HOSE ASSEMBLIES AND ELBOW HOSE ASSEMBLIES TO NO GREATER THAN 270° TOTAL BENDING PER EACH DROP REGARDLESS OF MANUFACTURER'S LISTING. FOR FM-APPROVED SYSTEMS MAXIMUM BEND RADIUS SHALL NOT EXCEED 7 TIMES BRAIDED HOSE DIAMETER.
- (B) MANUFACTURER SHALL PROVIDE WRITTEN PROCEDURES FOR PROPER INSTALLATION OF FLEXIBLE HOSE SPRINKLER SYSTEMS.

3.09 FIRE DEPARTMENT CONNECTION INSTALLATIONS

- (A) INSTALL AUTOMATIC DRIP VALVES AT THE CHECK VALVE ON THE FIRE DEPARTMENT CONNECTION TO THE MAINS.
- (B) INSTALL MECHANICAL SLEEVE SEAL AT PIPE PENETRATION IN OUTSIDE WALLS.

3.10 IDENTIFICATION

- (A) INSTALL LABELING AND PIPE MARKERS ON EQUIPMENT AND PIPING ACCORDING TO REQUIREMENTS IN NFPA 13.

- (B) IDENTIFY SYSTEM COMPONENTS, WIRING, CABLING, AND TERMINALS. COMPLY WITH REQUIREMENTS FOR IDENTIFICATION SPECIFIED IN DIVISION 26 SECTION IDENTIFICATION FOR ELECTRICAL SYSTEMS.

3.11 FIRE SPRINKLER SYSTEM COORDINATION AND WARRANTY

- (A) THE GENERAL CONTRACTOR AND SPRINKLER SUBCONTRACTOR SHALL MEET WITH THE ARCHITECT/ENGINEER TO COORDINATE ROUTING OF ALL PIPING AND SPRINKLER PLACEMENT IN EXPOSED AREAS PRIOR TO SUBMITTAL OF SHOP DRAWINGS TO ASCERTAIN THE AESTHETIC REQUIREMENTS IN SUCH AREAS.
- (B) THE GENERAL CONTRACTOR SHALL TAKE FULL RESPONSIBILITY FOR LOCATING ALL FIRE SPRINKLER PIPING AND SPRINKLERS WITHIN THE BUILDING AT LOCATIONS NOT SUBJECT TO FREEZING CONDITIONS. FOR AREAS OF THE BUILDING WHERE THAT IS NOT DEEMED POSSIBLE, A "DRY" SYSTEM SHALL BE SUBSTITUTED. THE CONTRACTOR, IN LOCATING SUCH PIPING AND SPRINKLER, SHALL TAKE INTO ACCOUNT THE POSSIBILITY THAT THE INTERIOR SPACE TEMPERATURE MAY BE REDUCED TO APPROXIMATELY 60°F THROUGH THE OWNER'S OFF-HOURS TEMPERATURE CONTROL SETBACK.
- (C) IN AREAS WHERE CONCEALMENT OF THE SPRINKLER IS REQUIRED, IF THE GENERAL CONTRACTOR AND/OR SPRINKLER CONTRACTOR DETERMINE THAT ADDITIONAL CHASES, BULKHEADS AND OTHER ARCHITECTURAL MODIFICATIONS ARE REQUIRED IN ORDER TO CONCEAL THE PIPING WHILE COMPLYING WITH THE ABOVE FREEZE PROTECTION REQUIREMENTS, THEY SHALL COORDINATE SUCH CONCERNS WITH THE ARCHITECT/ENGINEER PRIOR TO SUBMITTAL OF SHOP DRAWINGS.
- (D) ALL ENTRY VESTIBULES AND OTHER MINIMALLY CONDITIONED SPACES, WHERE SYSTEM PIPING, SPRINKLERS AND/OR DROP NIPPLES ARE SUBJECT TO FREEZING, DRY STYLE SPRINKLERS SHALL BE USED.
- (E) THE GENERAL CONTRACTOR SHALL COORDINATE INSTALLATION OF THE FIRE SPRINKLER SYSTEM WITH THE INSULATION CHARACTERISTICS OF THE BUILDING AND WARRANT THE FIRE SPRINKLER SYSTEM AGAINST FREEZING FOR A PERIOD OF TWO (2) YEARS FROM DATE OF SUBSTANTIAL COMPLETION. SUCH WARRANTY SHALL COVER THE COST OF REPAIR INCLUDING DAMAGED BUILDING MATERIALS. SUCH WARRANTY SHALL NOT COVER FREEZING IN THE EVENT OF A LOSS OF HEAT DUE TO MALFUNCTION OR SHUT DOWN OF MECHANICAL HEATING SYSTEM BEYOND NORMAL SETBACKS PREVIOUSLY STATED.

3.12 FIELD QUALITY CONTROL

- (A) FLUSH, TEST, AND INSPECT BOTH UNDERGROUND FIRE MAIN AND ABOVEGROUND SPRINKLER PIPING SYSTEMS IN ACCORDANCE WITH NFPA 13 AND NFPA 24. PROVIDE CERTIFICATION OF BOTH UNDERGROUND AND ABOVE GROUND FLUSHING. INCLUDE COPIES OF BOTH CERTIFICATES IN THE PROJECT O&M MANUAL.
- (B) REPLACE PIPING SYSTEM COMPONENTS WHICH DO NOT PASS THE TEST PROCEDURES SPECIFIED, AND RETEST REPAIRED PORTION OF THE SYSTEM.
- (C) PROVIDE A PLASTIC POUCH ATTACHED TO SYSTEM RISER LARGE ENOUGH TO HOUSE THE FOLLOWING: COPY OF UNDERGROUND FLUSHING CERTIFICATION, ABOVEGROUND FLUSHING CERTIFICATION, COPY OF "AS-BUILT" DRAWINGS, A COPY OF 2-HOUR PRESSURE TEST AND SYSTEM CERTIFICATION AND A COPY OF NFPA 25.
- (D) PROVIDE COPIES OF ALL TESTING AND CERTIFICATION DOCUMENTS/REPORTS, WARRANTIES, HYDRAULIC CALCULATIONS, PRODUCT DATA AND A COPY OF "AS-BUILT" DRAWINGS IN THE PROJECT O & M MANUAL. O&M MANUAL SHALL ALSO INCLUDE A PARTS LIST AT THE BEGINNING OF THE MANUAL.
- (E) MAINTAIN A CONTRACTOR MARKED UP SET OF RECORD DRAWINGS AT THE PROJECT SITE. CONTRACTOR SHALL KEEP RECORD DRAWING CURRENT WITH ALL FIELD CHANGES MADE TO A/E AND AHJ REVIEWED SET OF PLANS. UPON COMPLETION OF PROJECT, CONTRACTOR SHALL DELIVER MARKED-UP SET OF PLANS TO A/E.

END OF SECTION 21 05 00 – FIRE PROTECTION

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FIRE PROTECTION
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SECTION 21 13 13 – PACKAGED FIRE PUMP ASSEMBLY WITH HOUSE ENCLOSURE

PART 1 - GENERAL

1.01 WORK INCLUDED

- (A) THIS SECTION INCLUDES PROVISION, DELIVERY, INSTALLATION AND STARTUP OF ONE PACKAGED ASSEMBLY COMPLETE WITH HOUSING UNIT, (1) ELECTRIC-DRIVEN FIRE PUMP WITH DRIVE AND ASSOCIATED CONTROLLER, ONE (1) ELECTRIC DRIVEN JOCKEY PUMP EACH WITH DRIVE AND ASSOCIATED CONTROLLER WITH INTERCONNECTING PIPING AND WIRING FOR INSTALLATION AT PROJECT LOCATION. PACKAGED ASSEMBLY SHALL BE FACTORY MANUFACTURED AS A COMPLETE SYSTEM AND BE LABELED FOR ITS INTENDED USE.

1.02 QUALITY ASSURANCE

- (A) COMPLY WITH NFPA 20, CURRENT EDITION.
- (B) SYSTEM SHALL BEAR THE ETL LABEL FOR PACKAGED FIRE PUMP SYSTEMS BASED ON NFPA 20.
- (C) ALL EQUIPMENT OR COMPONENTS OF THIS SPECIFICATION SECTION SHALL MEET OR EXCEED THE REQUIREMENTS AND QUALITY OF THE ITEMS HEREIN SPECIFIED OR DENOTED ON THE DRAWINGS.
- (D) THE FIRE PUMP PACKAGED ASSEMBLY COMPLETE WITH HOUSING UNIT SHALL BE ASSEMBLED BY THE PUMP MANUFACTURER. AN ASSEMBLER OF FIRE PUMP SKIDS NOT ENGAGED IN THE DESIGN AND CONSTRUCTION OF FIRE PUMPS SHALL NOT BE CONSIDERED AS A FIRE PUMP MANUFACTURER. THE MANUFACTURER SHALL ASSUME "SINGLE SOURCE RESPONSIBILITY" FOR THE COMPLETE PACKAGED FIRE PUMP SYSTEM. BASIS OF DESIGN IS BY AC FIRE PUMP.
- (E) FIRE PUMP SYSTEM COMPONENTS ASSEMBLED AND AFFIXED ONTO A STRUCTURAL STEEL FRAMING ASSEMBLY AS DESIGNED UNDER DIRECTION OF A QUALIFIED PROFESSIONAL ENGINEER, FABRICATED BY WELDERS QUALIFIED IN ACCORDANCE WITH ASME BPVC CODE SECTION IX AND AWS SECTION D1.1, AND ASSEMBLED AT A LISTED AND APPROVED MANUFACTURING FACILITY. AFTER COMPLETION, THE ASSEMBLY IS SHIPPED AS A UNIT TO THE INSTALLATION SITE. THE PACKAGED FIRE PUMP ASSEMBLY MAY BE ASSEMBLED ONTO THE STRUCTURAL STEEL FRAMING ASSEMBLY EITHER WITH OR WITHOUT AN ENVIRONMENTAL ENCLOSURE CONSTRUCTED FROM NON-FLAMMABLE MATERIALS.
- (F) TEST FIRE PUMPS AT THE FACTORY TO ENSURE THE PERFORMANCE AS SPECIFIED AND AS REQUIRED BY NFPA 20. COPIES OF CERTIFIED FACTORY TEST DATA SHALL BE AVAILABLE FOR COMPARISON DURING FIELD ACCEPTANCE TESTS. SYSTEM SHALL BE HYDROSTATICALLY TESTED AS A COMPLETE UNIT AT THE FACTORY AFTER FABRICATION AND BEFORE SHIPPING. ALL TEST RESULTS SHALL BE RECORDED AND SENT TO THE BUYER FOR THEIR RECORDS.
- (G) THE MANUFACTURER SHALL CARRY A MINIMUM PRODUCT LIABILITY INSURANCE OF \$2,000,000 PER OCCURRENCE WITH AN AGGREGATE PRODUCT LIABILITY OF \$6,000,000.
- (H) TEST ALL ELECTRICAL COMPONENTS FOR PROPER INSTALLATION, CONNECTION AND OPERABILITY.
- (I) FURNISH ALL MATERIAL THAT IS NEW AND UNUSED AND FREE FROM CRACKS AND IMPERFECTIONS.
- (J) MANUFACTURER'S QUALIFICATIONS:
1. PUMP MANUFACTURER AND SYSTEM ASSEMBLER SHALL BE THE SAME.

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PACKAGED FIRE PUMP
ASSEMBLY WITH HOUSE
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2. MINIMUM OF 25 YEARS OF EXPERIENCE IN PRODUCTION AND ASSEMBLY OF FIRE PUMPS AND FIRE PUMP SYSTEMS.
- (K) PROVIDE SERVICES OF QUALIFIED MANUFACTURER'S REPRESENTATIVE TO ASSIST IN THE INSTALLATION AND COMPLETE CHECKOUT AND STARTUP OF EQUIPMENT.
- (L) MANUFACTURER OR SUPPLIER SHALL HAVE THE CAPABILITY TO PROVIDE REPAIR, MAINTENANCE AND PARTS SUPPLY SERVICE FOR ALL FURNISHED COMPONENTS.
- (M) DO NOT COMMENCE FABRICATION AND ASSEMBLY OF PACKAGED SYSTEM UNTIL REVIEW OF ALL SUBMITTAL DATA BY OWNERS REPRESENTATIVES IS COMPLETED AND WRITTEN RELEASE TO PRODUCTION IS RECEIVED.
- (N) A/E AND OWNERS REPRESENTATIVE SHALL BE ABLE TO INSPECT CONSTRUCTION OF PACKAGED PUMP SYSTEM AT THE MANUFACTURER'S FACILITY WITH 72 HOUR NOTICE.

1.03 SUBMITTALS

- (A) SUBMIT EACH ITEM IN THIS ARTICLE ACCORDING TO THE CONDITIONS OF THE CONTRACT AND SPECIFICATIONS SECTIONS.
- (B) SUBMIT MANUFACTURER'S INSTALLATION INSTRUCTIONS UNDER PROVISIONS OF GENERAL CONDITIONS.
- (C) PRODUCT DATA INCLUDING CERTIFIED PERFORMANCE CURVES AND RELATED CAPACITIES OF SELECTED MODELS, WEIGHTS, FURNISHED SPECIALTIES AND ACCESSORIES. INDICATE PUMPS OPERATING POINT ON CURVES.
- (D) SUBMITTAL PACKAGE SHALL INCLUDE AT A MINIMUM:
1. MECHANICAL GENERAL ARRANGEMENT DRAWING OF COMPLETE FIRE PUMP PACKAGE.
 2. PROJECT SPECIFIC ELECTRICAL SCHEMATICS FOR ALL SYSTEM WIRING INCLUDING CONTROLLERS, PANELS, LIGHTING, WIRING DEVICES, ETC.
 3. MANUFACTURERS' EQUIPMENT SUBMITTAL DATASHEETS FOR ALL CONTROLLERS, FUEL TANK, VALVES, AND SPECIALTIES.
 4. PROCESS AND INSTRUMENTATION DIAGRAM FOR COMPLETE ASSEMBLED SYSTEM.
- (E) ALL SUBMITTAL INFORMATION SHALL BE IN AN ELECTRONIC FORMAT AND A HARD COPY SHALL BE MADE AVAILABLE IF REQUESTED.

1.04 DELIVERY, STORAGE AND HANDLING

- (A) PROTECT ALL EQUIPMENT, CONNECTION SURFACES, PIPING, WIRING, FLUID PASSAGES AND WORKING PARTS FROM DAMAGE DURING SHIPMENT, HANDLING AND STORAGE.
- (B) THE PACKAGED PUMPING SYSTEM SHALL BE FACTORY ASSEMBLED AND SHIPPED AS A COMPLETE HOUSING UNIT UNLESS SHIPMENT IN SECTIONS IS ABSOLUTELY REQUIRED OR UNLESS SHIPPING RESTRICTIONS OR EQUIPMENT LIMITATIONS DICTATE THAT SMALLER PORTIONS MUST BE SHIPPED.
- (C) DELIVER EQUIPMENT AND ACCESSORIES TO THE SPECIFIED LOCATION FOR UNLOADING.

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(D) STORE MATERIAL IN A CLEAN, DRY PLACE AND PROTECT FROM WEATHER AND CONSTRUCTION TRAFFIC. HANDLE CAREFULLY TO AVOID DAMAGE.

(E) REPAIR OR REPLACE ALL ITEMS DAMAGED DURING SHIPMENT AND DELIVERY.

1.05 WARRANTY

(A) WARRANT THAT ALL SUPPLIED COMPONENTS WILL FUNCTION AS SPECIFIED AND AS A COMPLETE FUNCTIONAL SYSTEM IN ACCORDANCE WITH ALL APPLICABLE CODES AND FREE FROM DEFECTS IN DESIGN, ASSEMBLY, MANUFACTURE AND WORKMANSHIP FOR A MINIMUM OF TWELVE (12) MONTHS AFTER STARTUP OR EIGHTEEN (18) MONTHS AFTER SHIPMENT WHICHEVER OCCURS FIRST.

PART 2 - PRODUCTS

2.01 SYSTEM COMPONENTS

(A) FIRE PUMP:

1. QUANTITY: ONE ELECTRIC MOTOR(S) DRIVEN.
2. DESIGN: PUMPS SHALL FURNISH NOT LESS THAN 150 PERCENT OF RATED CAPACITY AT NOT LESS THAN 65 PERCENT OF TOTAL RATED HEAD.
3. MAXIMUM SHUTOFF HEAD: THE SHUTOFF HEAD SHALL NOT EXCEED 140 PERCENT OF RATED HEAD.
4. OPERATING CONDITIONS:
 - A. CAPACITY 750 GPM.
 - B. RATED PRESSURE: 90 PSI.
 - C. WORKING PRESSURE: 200 PSI.
 - D. VOLTAGE 230.
5. PUMP TYPE (BASIS OF DESIGN):
 - A. A-C MODEL 8100 SERIES, HORIZONTALLY SPLIT CASE, BASE MOUNTED IN A PREFABRICATED ENVIRONMENTAL ENCLOSURE.
6. PUMP MATERIALS:
 - A. CASING: CAST IRON.
 - B. IMPELLER: BRONZE.
 - C. SHAFT: STEEL.
 - D. STUFFING BOX PACKING: NON-ASBESTOS.
 - E. SHAFT SLEEVE: BRONZE.

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- F. SEAL TUBING: INTEGRAL WITH CASTING, BRASS.
 - G. CONNECTIONS: FLANGED CLASS 125, ASME B16.1.
 - H. BEARINGS: STEEL.
7. PROVIDE FIRE PUMP ACCESSORIES IN ACCORDANCE WITH NFPA 20 INCLUDING BUT NOT LIMITED TO:
- A. ONE CASING RELIEF VALVE.
 - B. ONE AUTOMATIC AIR RELEASE VALVE.
 - C. ONE PUMP DISCHARGE GAUGE, RANGE (0-300 WITH SHUTOFF COCK) (0-600 WITH SHUTOFF COCK).
 - D. ONE COMPOUND PUMP SUCTION GAUGE, RANGE -30-0-200 WITH SHUTOFF COCK.
 - E. COMMON RIGID STRUCTURAL STEEL BASEPLATE (ELEVATED AS REQUIRED) FOR EACH PUMP AND ITS ASSOCIATED DRIVE.
 - F. FLEXIBLE DRIVE COUPLING, WITH OSHA APPROVED GUARD.
 - G. ONE MANUFACTURER'S NAMEPLATE FOR PUMP, STATING:
 - (1) PUMP CAPACITY
 - (2) TOTAL HEAD
 - (3) PUMP RPM
 - (4) MANUFACTURER'S MODEL AND SERIAL NUMBER
 - (5) CASING WORKING PRESSURE
8. ACCEPTABLE MANUFACTURERS: A-C FIRE PUMP, OR APPROVED EQUAL.
9. PUMP DESIGN AND CONSTRUCTION: PUMP SHALL BE UL LISTED AND FM APPROVED.
- (B) JOCKEY (PRESSURE MAINTENANCE) PUMP:
- 1. QUANTITY: ONE
 - 2. TYPE: VERTICAL IN-LINE MULTI-STAGE, DIRECT DRIVE BY ELECTRIC MOTOR.
 - 3. MATERIALS:
 - A. CASING: CAST IRON AND STAINLESS STEEL.
 - B. SHAFT: STEEL
 - C. TRIM AND IMPELLER: BRONZE OR STAINLESS STEEL.

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4. OPERATING CONDITIONS:

- A.** CAPACITY: 7.5 GPM.
- B.** TOTAL HEAD (TDH): 100 PSIG.
- C.** SPEED: 3500 RPM MAXIMUM.
- D.** VOLTAGE: 230.

5. PROVIDE ACCESSORIES INCLUDING BUT NOT NECESSARILY LIMITED TO:

- A.** COMMON STRUCTURAL STEEL BASEPLATE FOR PUMP AND DRIVE ELEVATED AS REQUIRED.
- B.** MOTOR: TEFC, PREMIUM EFFICIENT, 1.15 SERVICE FACTOR, NEMA DESIGN B, 208-230/3/60.

6. MANUFACTURER'S NAMEPLATE STATING:

- A.** PUMP CAPACITY.
- B.** TOTAL HEAD.
- C.** MANUFACTURE'S MODEL NUMBER AND SERIAL NUMBER.

7. ACCEPTABLE MANUFACTURERS: A-C FIRE PUMP, OR APPROVED EQUAL.

(C) ELECTRIC MOTOR DRIVE:

- 1.** QUANTITY: ONE
- 2.** ALL MOTORS SHALL COMPLY WITH NEMA MG-1, SHALL BE MARKED AS COMPLYING WITH NEMA DESIGN B STANDARDS AND SHALL BE SPECIFICALLY LISTED FOR FIRE PUMP SERVICE.
- 3.** MOTOR SHALL HAVE A 1.15 SERVICE FACTOR.
- 4.** FIRE PUMP MOTOR SHALL HAVE THE HORSEPOWER, VOLTAGE, PHASE, FREQUENCY RATING SHOWN ON THE PLANS AND DRAWINGS.

(D) ELECTRIC FIRE PUMP CONTROLLER:

- 1.** CONTROLLER SHALL BE UL LISTED IN ACCORDANCE WITH UL218 (STANDARD FOR FIRE PUMP CONTROLLERS) AND FM APPROVED AS WELL AS NEMA AND NFPA 20.
- 2.** THE CONTROLLER SHALL BE OF THE COMBINED MANUAL AND AUTOMATIC TYPE AND DESIGNED FOR :
 - A.** WYE-DELTA (STAR-DELTA) CLOSED TRANSITION STARTING.
- 3.** THE CONTROLLER SHALL HAVE A WITHSTAND RATING OF 100,000 RMS SYMMETRICAL AMPERES.

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4. ENCLOSURE SHALL BE NEMA 2, DRIP PROOF.
5. THE CONTROLLER SHALL HAVE ENGLISH AS A STANDARD LANGUAGE.
6. A SOLID STATE PRESSURE TRANSDUCER SHALL BE RATED FOR 600 PSI WITH +/- 1.5% ACCURACY. START AND STOP POINTS SHALL BE ADJUSTABLE IN INCREMENTS OF (1) PSI.
7. TWO (2) SETS OF FORM-C CONTACTS SHALL BE PROVIDED FOR EACH OF THE FOLLOWING:
 - A. PHASE REVERSAL.
 - B. PHASE FAILURE.
 - C. CONTROLLER CONNECTED TO ALTERNATE SOURCE (AUTOMATIC TRANSFER SWITCH).
 - D. PUMP RUN.
 - E. THE COMMON ALARM AND PHASE FAILURE SHALL BE ENERGIZED UNDER NORMAL CONDITIONS.
 - F. AUTOMATIC TRANSFER SWITCH LISTED FOR FIRE PROTECTION SERVICE. PERFORM AUTOMATIC TRANSFER FROM NORMAL TO ALTERNATE SOURCE WHEN VOLTAGE DROPS TO 85% OF NORMAL OR LOSS OF ANY PHASE AND/OR PHASE REVERSAL.

(E) JOCKEY PUMP CONTROLLER

1. JOCKEY PUMP CONTROLLER SHALL BE UL LISTED AND FM APPROVED.
2. THE JOCKEY PUMP CONTROLLER SHALL BE OF THE FULL VOLTAGE STARTING TYPE.
3. THE CONTROLLER SHALL BE RATED NEMA 1.
4. THE JOCKEY PUMP SHALL HAVE AS A MINIMUM BUT NOT LIMITED TO THE FOLLOWING ALARMS:
 - A. POWER FAILURE.
 - B. PHASE REVERSAL.
 - C. PUMP RUNNING.
5. THE JOCKEY PUMP SHALL HAVE AS A MINIMUM BUT NOT LIMITED TO THE FOLLOWING STANDARD FEATURES:
 - A. HORSEPOWER RATED DISCONNECT SWITCH, FUSE BLOCK AND FUSES.
 - B. HORSEPOWER RATED MOTOR CONTACTOR AND OVERLOAD RELAY.
 - C. MINIMUM RUN TIMER TO PREVENT SHORT CYCLING OF PUMP.
 - D. HAND-OFF-AUTO SELECTOR SWITCH TO ALLOW MANUAL OPERATION OF THE PUMP.
 - E. 0-300 PSI PRESSURE SWITCH SUITABLE FOR FRESHWATER APPLICATIONS.

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(F) PIPING

1. ALL PIPING SHALL BE CONSTRUCTED FROM ASTM A53 STANDARD WEIGHT PIPE. THE PACKAGE PIPING SHALL CONSIST OF FABRICATED WELDED STEEL AND / OR CAST IRON FITTINGS IN AND OUT OF PUMPS. ALL PIPING SHALL BE SIZED PER NFPA 20. ALL WELDED PRESSURE BEARING PIPING MUST BE FABRICATED WITH FULL PENETRATION WELDS. USE OF BACKING RINGS WILL NOT BE PERMITTED. QUALIFICATION OF THE WELDING PROCEDURES AND PERFORMANCE OF THE WELDERS SHALL COMPLY WITH THE REQUIREMENTS OF ASME CODE, SECTION IX. ALL PIPING VALVES AND FITTINGS SHALL BE IN ACCORDANCE WITH NFPA 20. SUPPORTS SHALL BE PROVIDED FOR ALL SUCTION AND DISCHARGE PIPING. ALL PIPE SUPPORTS SHALL BE DESIGNED TO ALLOW FOR THE REMOVAL OF ANY INDIVIDUAL SECTIONS WITHOUT ADDING ADDITIONAL STRESS TO ADJOINING SECTIONS.

(G) FIRE PUMP FITTINGS

1. FIRE PUMP FITTINGS SHALL INCLUDE AT A MINIMUM THE FOLLOWING: AN AUTOMATIC AIR RELEASE VALVE, COMPOUND SUCTION AND DISCHARGE GAUGES (MINIMUM 3.5 INCH DIALS) AND A CASING RELIEF VALVE SUPPLIED AND SIZED PER NFPA 20.
2. VALVES SHALL BE UL LISTED AND FM APPROVED, WITH 175-PSIG MINIMUM PRESSURE RATING. VALVES SHALL HAVE APPROPRIATE PRESSURE RATING IF INTENDED FOR USE IN A HIGH PRESSURE SYSTEM.
3. WHERE THE SUCTION PIPE AND PUMP SUCTION FLANGE ARE NOT OF THE SAME SIZE THEY SHALL BE CONNECTED BY AN ECCENTRIC TAPERED REDUCER OR INCREASER INSTALLED IN SUCH A WAY AS TO PREVENT AIR POCKETS.
4. A LISTED OS&Y GATE VALVE WITH TAMPER SWITCH SHALL BE INSTALLED IN THE SUCTION PIPING. THE OS&Y VALVE SHALL BE RATED FOR THE MAXIMUM WORKING WATER PRESSURE OF THE SYSTEM. VALVE SHALL BE MANUFACTURED OUT OF ASTM A126 CLASS B CAST IRON AND HAVE FLANGED ENDS. VALVE SHALL HAVE OUTSIDE STEM & YOKE, FULL FLOW PORT, REPLACEABLE DISC.
5. A LISTED CHECK VALVE SHALL BE INSTALLED IN THE DISCHARGE PIPING. VALVE SHALL COMPLY WITH UL 312 UNLESS NOTED. CHECK VALVE SHALL BE GROOVED OR FLANGED CONSTRUCTION, SINGLE OR DOUBLE DISC SWING TYPE LISTED FOR USE IN FIRE PROTECTION SYSTEMS.
6. A LISTED INDICATING BUTTERFLY VALVE SHALL BE INSTALLED ON THE FIRE PROTECTION SIDE OF THE PUMP DISCHARGE CHECK VALVE. THE BUTTERFLY VALVE SHALL BE GROOVED BODY STYLE AND COMPLY WITH UL 1090 WITH INTEGRAL INDICATING DEVICE. GEAR OPERATOR SHALL BE INDOOR/OUTDOOR RATED AND ENDS SHALL MATCH CONNECTING PIPING WITH MOLDED IN SEAT. NORMALLY OPEN AND NORMALLY CLOSED TAMPER SWITCH CONNECTIONS SHALL BE PROVIDED FOR MONITORING.
7. ALL DRAINS SHALL BE PIPED TO A COMMON POINT FOR CONNECTION TO A BUYER SUPPLIED FLOOR DRAIN PER NFPA 20.

(H) FIRE PUMP ACCESSORIES

1. HOSE VALVE HEADER: SYSTEM SHALL BE EQUIPPED WITH HOSE VALVE HEADER AND VALVES. THE HOSE VALVE HEADER SHALL BE SIZED PER NFPA 20 2016 EDITION TABLE 4.26(A). HOSE VALVE HEADER SHALL BE MANUFACTURED FROM CAST IRON OR FABRICATED FROM ASTM A105 OR ASTM A53 STANDARD WEIGHT PIPE. THE TEST HEADER SHALL BE EQUIPPED WITH

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LISTED VALVES THE NUMBER AND SIZE OF HOSE VALVES FOR TESTING SHALL BE AS SPECIFIED IN TABLE 4.26(A). HOSE VALVES SHALL BE LISTED, 2-1/2" NATIONAL STANDARD THREAD, EQUIPPED WITH CAPS AND CHAINS UNLESS OTHERWISE SPECIFIED. THE HOSE VALVE HEADER SHALL BE EQUIPPED WITH AND LISTED ISOLATION VALVE AND A MINIMUM 3/4" DRAIN PIPED TO A COMMON POINT.

2. FLOW METER LOOP: SYSTEM SHALL BE EQUIPPED WITH A FLOW METER LOOP SIZED IN ACCORDANCE WITH NFPA 20 2016 EDITION TABLE 4.26(A). THE METERING DEVICE SHALL BE OF THE VENTURI TYPE WITH GROOVED CONNECTIONS AND INSTALLED PER MANUFACTURES DIRECTIONS. THE FLOW METER LOOP SHALL BE COMPLETE WITH METER CONTROL AND METER THROTTLE VALVES. VALVES SHALL BE OF THE UL LISTED, FM APPROVED INDICATING BUTTERFLY TYPE.
3. FIRE DEPARTMENT CONNECTION: SYSTEM SHALL BE EQUIPPED WITH A 4" FIRE DEPARTMENT CONNECTION. THE FDC SHALL BE EQUIPPED WITH A LISTED CHECK VALVE. THE FIRE DEPARTMENT CONNECTION SHALL HAVE TWO 2-1/2" THREADED CONNECTIONS WITH THREADS TO MATCH RESPONDING FIRE DEPARTMENT REQUIREMENTS.
4. SUCTION CONTROL VALVE: THE FIRE PUMP SUCTION CONTROL VALVE SHALL MODULATE TO MAINTAIN A MINIMUM PRESSURE AT THE PUMP SUCTION REGARDLESS OF DEMAND. IT SHALL CONTROL THE PUMP DISCHARGE IN RELATION TO THE SUCTION HEAD AVAILABLE AND NOT ALLOW SUCTION HEAD TO FALL BELOW A PRE-SET MINIMUM. THE MAIN VALVE SHALL BE HYDRAULICALLY-OPERATED, PILOT CONTROLLED, DIAPHRAGM-TYPE, GLOBE OR ANGLE PATTERN. THE VALVE SHALL HAVE FLANGED ENDS AND BE RATED FOR CWP CLASS 150. THE PILOT CONTROL SHALL BE DIRECT-ACTING, ADJUSTABLE, SPRING LOADED, DIAPHRAGM-TYPE VALVE DESIGNED FOR MODULATING SERVICE TO PERMIT FLOW WHEN CONTROLLING PRESSURE EXCEEDS SPRING SETTING. REMOTE SENSING LINE SHALL BE PIPED FROM VALVE BODY TO SUCTION SUPPLY. THE VALVE SHALL BE DESIGNED TO ALLOW FOR REPAIR AND SERVICING WITHOUT REMOVING THE VALVE BODY FROM THE LINE. THE VALVE SHALL BE FM APPROVED.
5. BACKFLOW PREVENTION: A DOUBLE CHECK DETECTOR ASSEMBLY SHALL BE INSTALLED ON THE FIRE PUMP SYSTEM WHEN CONNECTED TO A POTABLE WATER SUPPLY. THE UNIT SHALL BE A COMPLETE ASSEMBLY INCLUDING EPOXY COATED BODY, RESILIENT SEATED OS&Y SHUT OFF VALVES AND COCKS. THE UNIT SHALL BE UL LISTED/FM APPROVED WITH UL/FM OS&Y SHUTOFF VALVES. THE AUXILIARY LINE SHALL CONSIST OF AN APPROVED BACKFLOW PREVENTER AND WATER METER.
6. FLOOR DRAIN: THE SYSTEM SHALL BE PROVIDED WITH A FLOOR DRAIN PER NFPA 20 2016 EDITION. THE DRAIN SHALL BE INSTALLED FLUSH WITH THE FLOOR LEVEL AND ROUTED THROUGH THE SKID PERIPHERAL STRUCTURAL MEMBERS AND TERMINATED WITHIN 4 INCHES OF THE SKID.
7. SYSTEM RISER PER CONTRACT DRAWINGS.

(I) PAINTING:

AFTER FABRICATION AND BEFORE SHIPPING PAINT ALL SURFACES INCLUDING BUT NOT LIMITED TO THE MAIN PIPING AND STRUCTURAL MEMBERS, EXCLUDING THE FUEL LINES, ENCLOSURE FIRE SPRINKLER LINES AND JOCKEY PUMP PIPING AS FOLLOWS:

1. XYLEM WI-00067 STANDARD PAINT SPECIFICATION

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PROJECT NO. H IH BLAC 19100

- A. THIS COATING SYSTEM DISPLAYS HIGH GLOSS AND EXCELLENT COLOR RETENTION DURING EXTENDED SERVICE PERIODS.
- B. COATING SYSTEM IS A HIGH-SOLIDS, HIGH-BUILD COATING WITH LOW VOC.
- C. COATING SYSTEM SHOULD NOT BE SELECTED FOR SUBMERGED STEEL OR FOR EQUIPMENT INSTALLED BELOW THE SPLASH ZONE IN MARINE ENVIRONMENTS.
- D. THIS COATING SYSTEM CAN ONLY BE APPLIED TO EQUIPMENT OPERATING LESS THAN 200 DEGREES F CONTINUOUS.
- E. THIS COATING SYSTEM WILL NOT BE APPLIED TO FIRE PUMP CONTROLLERS OR DIESEL ENGINES.
- F. PRE-PAINTING PREPARATION
 - (1) ALL SHARP EDGES, FILLETS AND CORNERS SHOULD BE ROUNDED TO A MINIMUM RADIUS OF 1/8".
 - (2) THE EQUIPMENT TO BE COATED SHOULD BE DEGREASED IN ACCORDANCE WITH SSPC - SP-1.
- G. ALL COATINGS SHOULD BE APPLIED WITHIN THE FOLLOWING ENVIRONMENTAL CONDITIONS:
 - (1) AIR TEMPERATURE 40 - 120 DEGREES F
 - (2) SURFACE TEMPERATURE 40 - 120 DEGREES F
 - (3) SURFACE TEMPERATURE MUST BE AT LEAST 5 DEGREES F ABOVE THE DEW POINT TO PREVENT CONDENSATION.
- H. COATING SYSTEM
 - (1) THE COATING SYSTEM WILL BE A DIRECT TO METAL APPLICATION APPLIED IN ACCORDANCE WITH THE MANUFACTURES APPLICATION INSTRUCTIONS.
 - (2) PAINT: FINISHES UNLIMITED INC., RED WATER REDUCIBLE AIR DRY ENAMEL.
 - (3) COLOR: FIRE RED.

(J) TESTING:

- 1. THE FIRE PUMP WILL BE FACTORY PERFORMANCE TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF NFPA, UL AND FM. THE FIRE PUMP AND JOCKEY PUMP CONTROLLERS WILL BE ELECTRICALLY TESTED PRIOR TO SHIPMENT. ADDITIONALLY, THE ENTIRE PACKAGE SYSTEM WILL BE HYDROSTATICALLY TESTED AT THE FACTORY AT A PRESSURE RATING PER NFPA 20 SECTION 11-1.1 FOR A MINIMUM OF 2 HOURS. A COPY OF THE TEST PROCEDURES SHALL BE PROVIDED UPON REQUEST.

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PART 3 - ENCLOSURE

3.01 SYSTEM ENCLOSURE

- (A) THE ENTIRE FIRE PUMP SYSTEM SHALL BE ENCLOSED IN A SINGLE MODULE. THE MODULE SHALL BE COMPLETE AS SPECIFIED HEREIN INCLUDING SHOP WIRING AND PIPING OF THE EQUIPMENT FURNISHED UNDER THESE EQUIPMENT SPECIFICATIONS. THE MODULE SHALL BE MOUNTED ON A CONCRETE FOUNDATION PROVIDED BY THE GENERAL CONTRACTOR.
- (B) STRUCTURAL DESIGN: THE MODULE SHALL BE THE MANUFACTURER'S STANDARD DESIGN THAT MEETS OR EXCEEDS THE SITE DESIGN CONDITIONS. THE FLOOR SHALL BE FRAMED WITH STRUCTURAL MEMBERS WITH PROVISIONS FOR BOLTING TO THE CONCRETE FOUNDATION. A MEANS SHALL FOR LIFTING SHALL BE PROVIDED THE ASSEMBLED MODULE WITHOUT DAMAGE USING OVERHEAD RIGGING.
- (C) ARRANGEMENT: THE MANUFACTURER SHALL ARRANGE THE EQUIPMENT FURNISHED UNDER THESE EQUIPMENT SPECIFICATIONS TO ALLOW PROPER ACCESS TO THE COMPONENTS FOR OPERATION AND MAINTENANCE. THE MINIMUM HEADROOM IN ALL WALKWAYS SHALL BE 7'-0" THE MODULE SHALL BE COMPLETELY ASSEMBLED AT THE SELLERS ASSEMBLY PLANT, WITH ALL THE ACCESSORIES LISTED IN THIS SPECIFICATION FULLY INSTALLED, WIRED, AND TESTED PRIOR TO SHIPPING TO THE JOB SITE, INCLUDING THE FIRE PUMP EQUIPMENT, DISCONNECT SWITCHES, PANEL BOARD(S) AND TRANSFORMER(S), LIGHTING, LIGHT SWITCHES AND RECEPTACLES REQUIRED TO MAKE A COMPLETE OPERATING SYSTEM.
- (D) DESIGN CRITERIA:
1. ALL ENCLOSURES SHALL BE DESIGNED IN ACCORDANCE WITH THE APPLICABLE SECTIONS OF THE LATEST EDITION OF THE INTERNATIONAL BUILDING CODE AND CONFORM TO ASCE (AMERICAN SOCIETY OF CIVIL ENGINEERS) "MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES".
 2. EACH ENCLOSURE SHALL BE DESIGNED FOR THE FOLLOWING LOADS, IN ADDITION TO THE STATIONARY WEIGHT OF THE ENCLOSURE. REDUCTION OF LOADS DUE TO TRIBUTARY LOADED AREAS WILL NOT BE PERMITTED.
 3. THE VERTICAL LIVE LOAD OF THE ENCLOSURE SHALL NOT BE LESS THAN 40 POUNDS PER SQUARE FOOT APPLIED ON THE ROOF.
 4. THE HORIZONTAL WIND LOAD OF THE ENCLOSURE SHALL NOT BE LESS THAN 110 MPH AND SHALL BE DISTRIBUTED AND APPLIED IN ACCORDANCE WITH THE APPLICABLE EDITION OF THE INTERNATIONAL BUILDING CODE AND ASCE.
 5. THE ENCLOSURE SHALL BE DESIGNED TO RESIST THE EFFECTS OF SEISMIC GROUND MOTIONS WHICH MAY BE EXPECTED IN SEISMIC ZONE 4.
 6. ALL COMBINING AND DISTRIBUTING OF AUXILIARY EQUIPMENT LOADS IMPOSED ON THE ENCLOSURE SYSTEM SHALL BE DONE IN ACCORDANCE WITH THE APPLICABLE SECTION OF THE ASCE.
 7. UPON REQUEST, THE SELECTED ENCLOSURE MANUFACTURER SHALL PROVIDE THE ENCLOSURE PURCHASER WITH A COMPLETE DESIGN CERTIFICATION SIGNED AND SEALED BY A REGISTERED PROFESSIONAL ENGINEER.

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(E) MODULAR PANEL CONSTRUCTION:

1. ALL ENCLOSURES SHALL BE CONSTRUCTED WITH PREFABRICATED WALL AND CEILING PANELS FORMED TO EXACT SIZE. ALL PANELS TO BE CONSTRUCTED WITH DIE-FORMED INTERIOR AND EXTERIOR METAL PANS SECURELY FASTENED TO A PERIMETER FRAME OF KILN DRIED SPRUCE-PINE-FIR (SPF) SPECIE, #2 GRADE LUMBER. PERIMETER FRAME TO FEATURE TONGUE AND GROOVE PROFILE FOR POSITIVE ALIGNMENT AND SEALING AND SHALL UTILIZE PRESSURE TREATED LUMBER. PANELS SHALL BE FILLED WITH POURED-IN-PLACE URETHANE, WHICH SECURELY BONDS TO METAL PANS AND PERIMETER FRAME CREATING A RIGID STRUCTURAL PANEL WITH A TOUGH, RESILIENT, SHOCK-RESISTING SURFACE. STANDARD PANELS SHALL BE INTERCHANGEABLE FOR EASE OF ASSEMBLY. SPECIAL PANELS (IF REQUIRED) SHALL BE MANUFACTURED TO THE SIZE REQUIRED TO OBTAIN A SPECIFIED BUILDING SIZE.

(F) PANEL FASTENERS:

1. CAM-LOCK FASTENERS SHALL PROVIDE A TIGHT AND POSITIVE SEAL. THESE FASTENERS REDUCE ON-THE-JOB INSTALLATION TIME TO A MINIMUM. FASTENER MATERIAL SHALL BE STEEL HOUSING, HOOK AND PIN WITH HIGH-PRESSURE DIE-CAST ZINC CAM. HARDENED STEEL HEXAGONAL WRENCH IS PROVIDED TO TIGHTEN PANEL FASTENERS. THE HOOK OF THE FASTENER SHALL ENGAGE OVER THE PIN WHEN ROTATING THE WRENCH AND WITH CAM-ACTION, DRAW THE PANELS TIGHTLY TOGETHER. POLYETHYLENE SNAP-IN CAPS COVER THE WRENCH HOLES. LOCK SPACING SHALL NOT EXCEED 48" ON CENTER.

(G) PANEL GASKETS:

1. EACH JOINT SHALL EXHIBIT A POLYVINYL CHLORIDE (PVC) BULB TYPE; COMPRESSION GASKET TO ELIMINATE WATER VAPOR PERMEABILITY. ALL GASKETS ARE FACTORY INSTALLED AND REQUIRE NO ADDITIONAL HANDLING. GASKETS SHALL BE RESISTANT TO CHEMICAL CORROSION AND ULTRAVIOLET RADIATION. GASKET OPERATING TEMPERATURE SHALL BE -34 DEGREES C TO +71 DEGREES C (-30 DEGREES F TO +160 DEGREES F).

(H) INSULATION:

1. INSULATION SHALL BE 100% RIGID URETHANE WITH A CONDUCTIVITY FACTOR (K FACTOR) NOT TO EXCEED 0.128 BTU/HR. URETHANE IS TO BE POURED IN PLACE WITH A DENSITY OF 2.2 POUNDS PER CUBIC FOOT. OVERALL COEFFICIENT OF HEAT TRANSFER (U FACTOR) AND R VALUE TO BE AS FOLLOWS:

	THICKNESS	"U" FACTOR	"R" VALUE
WALL PANELS	3 - 1/2"	.036	28
ROOF PANELS	5"	.025	40

THIS INSULATION SHALL BE A LISTED URETHANE WITH A RATING OF NO MORE THAN 25 FOR FLAME SPREAD AND 450 FOR SMOKE DEVELOPED PER ASTM E84. THIS URETHANE WILL ALSO MEET THE IGNITION PROPERTIES REQUIREMENTS OF ASTM D-1929.

(I) PANEL FINISHES:

1. INTERIOR AND EXTERIOR METAL PANS SHALL BE NOMINAL 24 GAUGE GALVANIZED STEEL CONFORMING TO ASTM A-653 SPECIFICATIONS WITH THE GALVANIZED COATING CONFORMING TO G60 STANDARDS. MINIMUM YIELD STRENGTH OF THE PANEL MATERIAL SHALL BE 50,000 PSI. THE INTERIOR FINISH SHALL BE WHITE EMBOSSED AND THE EXTERIOR FINISH SHALL BE TAN EMBOSSED WITH MESA PROFILE. PANEL FINISH SHALL BE FACTORY APPLIED COATING OF

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0.9 TO 1.1 MILS OF DRY FILM THICKNESS. ALTERNATE COLORS ARE AVAILABLE BY SPECIAL ORDER.

2. THE FINISH COAT SHALL BE A BAKED-ON SILICONIZED POLYESTER FORMULATION THAT WILL MEET THE FOLLOWING PERFORMANCE STANDARDS AFTER 10 YEARS CONTINUOUS EXPOSURE IN "NORMAL" ATMOSPHERIC CONDITIONS NOT CONTAINING CORROSIVE FUMES SUCH AS CHEMICALS OR SALT SPRAY.
 - A. PANEL FINISH SHALL SHOW NO EVIDENCE OF BLISTERING, PEELING, OR CHIPPING.
 - B. PANEL FINISH SHALL NOT SHOW SURFACE CHALKING IN EXCESS OF THE NO. 4 RATING D659 AS ESTABLISHED BY THE AMERICAN SOCIETY OF TESTING MATERIALS (ASTM).
3. PANEL FINISH AFTER CLEANING, SHALL NOT SHOW COLOR CHANGE IN EXCESS OF 7 NBS UNITS WHEN MEASURED IN ACCORDANCE WITH THE ASTM D-2244 STANDARD.
4. THE ABOVE PERFORMANCE STANDARDS SHALL NOT APPLY WHERE PANELS HAVE BEEN DAMAGED BY FIRE, RADIATION OR OTHER PHYSICAL DAMAGE.

(J) ROOF SYSTEM:

1. A PREFABRICATED ROOF SYSTEM SHALL BE PROVIDED FOR THE ENCLOSURE TO PROVIDE A WATERPROOF COVERING FOR INSULATED CEILING PANELS.
2. THE ROOF SYSTEM SHALL BE A GALVANIZED STANDING SEAM, 22 GAUGE, 16 INCHES WIDE, SHEET METAL OVER CEILING PANELS WITH A SLOPE OF 1/4" PER FOOT. FASTENERS SHALL BE CORROSION RESISTANT RUBBER WASHERED TEK SCREWS WITH LENGTH AND STRENGTH REQUIRED FOR METAL TO BE FASTENED.

(K) WALL PANEL DESIGN:

1. EXTERIOR WALL PANELS OF THE ENCLOSURE SHALL BE A SINGLE CONTINUOUS LENGTH FROM THE STEEL SKID TO THE ROOF PANEL OF THE ENCLOSURE AND AT THE SIDE WALLS AND THE END WALLS OF THE ENCLOSURE EXCEPT WHERE INTERRUPTED BY WALL OPENINGS.
2. WALL PANELS SHALL BE FASTENED FROM THE INTERIOR THROUGH A STEEL PLATE IN THE SKID WITH 3/8" DIAMETER ELECTRO-GALVANIZED LAG BOLTS. THE FASTENING SYSTEM SHALL BE DESIGNED SO THAT NO WALL FASTENERS ARE EXPOSED ON THE EXTERIOR SURFACE OF THE WALLS.

(L) ENCLOSURE TYPE:

1. EACH ENCLOSURE ROOF SHALL HAVE 1/4" PITCH IN ENCLOSURE WIDTH. ROOF PANELS SHALL HAVE INTERLOCKING TONGUE AND GROOVE AND ATTACHED TO THE WALL THROUGH FACTORY PRE-DRILLED HOLES WITH 3/8" CORROSION RESISTANT FASTENERS AND AN INTERIOR ANGLE FASTENED TO WALLS AND TOP PANELS. THE ROOF SYSTEM SHALL INCLUDE FACTORY MANUFACTURED "J" RAIL AT THE LOW SIDE WALL. THE "J" RAIL SHALL BE NOMINAL 18 GAUGE GALVANIZED STEEL.
2. TRANSMISSION OF HORIZONTAL WIND LOADS ACROSS THE ENCLOSURE SHALL BE MADE THROUGH THE PANEL ROOF SYSTEM AND NO SEPARATE ROOF OR WALL DIAGONAL BRACING SHALL BE REQUIRED.

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3. STRUCTURAL FRAME WIND BELTS AND WIND BENTS SHALL NOT BE REQUIRED FOR PROPER TRANSMISSION OF LATERAL WINDS LOADS.

(M) HOLLOW METAL DOORS:

1. ALL DOORS SHALL BE 1-3/4" THICK FLUSH-TYPE. DOOR PANELS SHALL BE NOMINAL 18 GAUGE COLD ROLLED STEEL REINFORCED BY LAMINATION TO A POLYSTYRENE CORE ENCLOSED WITH 16 GAUGE END CHANNEL. THE HINGE REINFORCEMENTS SHALL BE NOMINAL 7 GAUGE AND THE LOCK REINFORCEMENTS SHALL BE NOMINAL 16 GAUGE.
2. DOOR FRAMES SHALL BE 4-3/4" DEEP DOUBLE RABBETED TYPE OF NOMINAL 16 GAUGE COLD ROLLED STEEL.
3. DOOR AND FRAMES SHALL BE FACTORY PAINTED WITH ONE COAT OF BAKED ON PRIMER. ALL DOORS SHALL BE PRE-ASSEMBLED IN THEIR FRAMES AND HARDWARE INSTALLED AND TESTED PRIOR TO SHIPMENT. FIELD INSTALLATION OF SINGLE LEAF DOOR UNITS SHALL NOT REQUIRE ANY FRAME ASSEMBLY OR DOOR HANGING.

(N) DOOR HARDWARE:

1. DOOR HARDWARE SHALL CONSIST OF:
 - A. 3- 4-1/2" X 4-1/2" STANDARD WEIGHT, PLAIN BEARING HINGES PER ANSI A5133 630 STAINLESS STEEL FINISH WITH NON-RISING PINS.
 - B. 3-1/2" WIDE X 1" HIGH EXTRUDED ALUMINUM THRESHOLD (OUT SWING).
 - C. 3/16" X 5/16" SILICONE RUBBER WEATHER-STRIPPING.
2. CAL-ROYAL DEADBOLT LOCKSET PER ANSI GRADE 3, LSD-01 SERIES, STAINLESS STEEL FINISH.
3. CAL-ROYAL BA-30 KEYLESS PASSAGE SET, GRADE 2, ANSI F75-2, STAINLESS STEEL FINISH.
4. DOOR CLOSER IS CERTIFIED TO CONFORM TO ANSI 156.4 GRADE 1 AND MEETS EXTERIOR BARRIER FREE CODES IN 689 ALUMINUM POWDER COAT FINISH.
5. RIM TYPE "CROSS BAR" PANIC DEVICE PER ANSI A156.3, TYPE 1, GRADE 1, FUNCTION 08, WITH POWDER COATED ALUMINUM FINISH OR RIM TYPE "PUSH PAD" PANIC DEVICE BUILT TO ANSI A156.3, TYPE 1, GRADE 2, FUNCTION 08 WITH POWDER COAT ALUMINUM FINISH ARE AVAILABLE AS AN OPTION.

3.02 ENCLOSURE ACCESSORIES

(A) ELECTRICAL:

1. ALL WIRING SHALL BE INSTALLED IN SURFACE MOUNTED EMT CONDUIT INSTALLED PER NFPA 20 CURRENT EDITION AND THE LATEST EDITION OF NEC. ALL CONDUIT INSTALLED BELOW GRADE SHALL BE HOT DIPPED RIGID CONDUIT. FLEXIBLE LIQUID-TITE CONDUIT 18" MAXIMUM LENGTH SHALL BE PERMITTED AT EQUIPMENT AND ENCLOSURE CONNECTIONS.
2. POWER SUPPLY: THE PUMP STATION MANUFACTURER SHALL PROVIDE A DISTRIBUTION PANEL SIZED TO SUPPORT ALL BUILDING LOADS WITHOUT OVERLOADING.

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3. LIGHTING: THE MODULE SHALL BE EQUIPPED INTERIOR, EXTERIOR AND EMERGENCY LIGHTING PER NFPA 20 AND INSTALLED PER THE LATEST EDITION OF THE NEC.
 - A. INTERIOR LIGHTING: THE ENCLOSURE SHALL BE EQUIPPED WITH A MINIMUM OF TWO LED WRAP AROUND TYPE FIXTURES. THE LIGHTING LEVELS SHALL BE AS RECOMMENDED BY THE I.E.S.(ILLUMINATING ENGINEERING SOCIETY). THE FIXTURE SHALL BE UL LISTED.
 - B. EXTERIOR LIGHTING: THE ENCLOSURE SHALL BE EQUIPPED WITH A MINIMUM OF ONE EXTERIOR LIGHTING FIXTURE PER DOOR. THE FIXTURE SHALL BE LED TYPE WITH PHOTOELECTRIC CONTROL. THE FIXTURE SHALL BE UL LISTED.
 - C. EMERGENCY LIGHTING: THE ENCLOSURE SHALL BE EQUIPPED WITH EMERGENCY LIGHTING. THE FIXTURE SHALL PROVIDE A MINIMUM OF 90 MINUTES OF ILLUMINATION AND BE POWERED BY A MAINTENANCE FREE LEAD-CALCIUM BATTERY.
4. RECEPTACLES: THE MANUFACTURER SHALL FURNISH AND INSTALL 120 VOLT WALL MOUNTED CONVENIENCE OUTLETS. THE OUTLETS SHALL BE LOCATED IN AN ACCESSIBLE AREA ON EACH WALL OF THE ENCLOSURE. THE OUTLETS SHALL BE OF THE GFCI (GROUND FAULT CIRCUIT INTERRUPTING) TYPE. THE OUTLETS SHALL BE UL LISTED.
5. ALL ELECTRICAL COMPONENTS AND INSTALLATION SHALL MEET 2017 NEC.

(B) HEATING AND VENTILATING:

1. THE ENCLOSURE SHALL BE EQUIPPED THERMOSTAT CONTROLLED ELECTRIC SPACE HEATER CAPABLE OF MAINTAINING A MINIMUM OF 40 DEG F PER NFPA 20 CURRENT EDITION. THE HEATER SHALL BE WALL OR CEILING MOUNTED, FAN FORCED WITH ADJUSTABLE OUTLET LOUVERS.
2. VENTILATION SHALL BE PROVIDED FOR THE FOLLOWING FUNCTIONS:
 - A. TO CONTROL THE MAXIMUM TEMPERATURE TO 120 DEG F (49C) AT THE COMBUSTION AIR CLEANER INLET WITH THE ENGINE RUNNING AT RATED LOAD.
 - B. TO SUPPLY AIR FOR ENGINE COMBUSTION.
 - C. TO REMOVE ANY HAZARDOUS VAPORS.
 - D. TO SUPPLY AND EXHAUST AIR AS NECESSARY FOR RADIATOR COOLING OF THE ENGINE WHEN REQUIRED.
3. EXHAUST FAN: THE ENCLOSURE SHALL BE EQUIPPED WITH A HIGH CAPACITY, DIRECT DRIVE PROPELLER WALL MOUNTED FAN. FAN SHALL COME COMPLETE WITH WALL COLLAR, REAR GUARD AND EXHAUST DAMPER. THE FAN SHALL BE CONTROLLED BY A WALL MOUNTED THERMOSTAT. THE FAN SHALL MEET NFPA 20 AND BE UL LISTED AND OSHA COMPLIANT.
4. INLET LOUVER: THE ENCLOSURE SHALL BE EQUIPPED WITH ELECTRIC ACTUATED, CENTER PIVOT DAMPER WITH BUG SCREEN MOUNTED ON THE ENCLOSURE EXTERIOR. THE LOUVER SHALL BE 120/1/60V POWERED CLOSED, SPRING OPEN AND FAIL IN THE OPEN POSITION, FAST ACTING, TWO POSITION AND BE UL LISTED AND OSHA COMPLIANT.
5. HEATING SHALL BE PLACED ON THE EMERGENCY CIRCUIT.

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**PACKAGED FIRE PUMP
ASSEMBLY WITH HOUSE
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(C) TESTING:

1. THE FIRE PUMP WILL BE FACTORY PERFORMANCE TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF NFPA, UL AND FM. THE FIRE PUMP AND JOCKEY PUMP CONTROLLERS WILL BE ELECTRICALLY TESTED PRIOR TO SHIPMENT. ADDITIONALLY, THE ENTIRE PACKAGE SYSTEM WILL BE HYDROSTATICALLY TESTED AT THE FACTORY AT A PRESSURE RATING PER NFPA 20 SECTION 11-1.1 FOR A MINIMUM OF 2 HOURS. A COPY OF THE TEST PROCEDURES SHALL BE PROVIDED UPON REQUEST.

PART 4 - EXECUTION

4.01 INSTALLATION

- (A) PLACE, ASSEMBLE, INSTALL AND PLACE INTO OPERATIONAL READINESS COMPLETE PUMPING SYSTEM AND BUILDING AS SPECIFIED IN THIS SECTION, IN ACCORDANCE WITH MANUFACTURER'S LISTED RECOMMENDATION, FM AND NFPA 20.

1. FIELD QUALITY CONTROL

- A. MANUFACTURER'S FIELD REPRESENTATIVE SHALL SUPERVISE INSTALLATION OF ALL ITEMS AND EQUIPMENT AS SPECIFIED IN THIS SECTION
- B. MANUFACTURER'S FIELD REPRESENTATIVE AND/OR CONTRACTOR SHALL INSPECT JOB SITE CONDITIONS 72 HOURS BEFORE SHIPMENT OF PACKAGED PUMP MODULE TO ASSURE FIELD CONDITIONS COMPATIBLE WITH SYSTEM LAYOUT.
- C. MANUFACTURER'S FIELD REPRESENTATIVE SHALL CONDUCT AND DOCUMENT ACCEPTANCE TESTS AND STARTUP OF EQUIPMENT SPECIFIED IN THIS SECTION AND SHALL ENSURE CONFORMANCE TO ACCEPTANCE REQUIREMENTS OF NFPA 20 AND FM DATA SHEET 3-7N/13-4N.
- D. MANUFACTURER'S REPRESENTATIVE SHALL INSTRUCT OWNERS PERSONNEL IN PROPER SYSTEM OPERATION AND MAINTENANCE.
- E. MANUFACTURER'S REPRESENTATIVE SHALL COMMISSION EQUIPMENT AND CERTIFY TO OWNER IN WRITING THAT ALL INSTALLATION, MAINTENANCE INSTRUCTION, TESTS, ADJUSTMENTS, REPAIRS AND STARTUP ARE COMPLETE AND THAT ALL COMPONENTS ARE READY FOR CONTINUOUS OPERATION.

4.02 START UP AND COMMISSIONING

- (A) THE SYSTEM MANUFACTURER OR HIS REPRESENTATIVE SHALL PROVIDE COMMISSIONING OF THE COMPLETE PACKAGED PUMPING SYSTEM. THE COMMISSIONING SHALL INCLUDE A CHECK OF PROPER INSTALLATION BY THE INSTALLING CONTRACTOR, SYSTEM CHECK OUT, ADJUSTMENT AND COMPLETE START-UP. THE COMMISSIONING WILL OCCUR ONLY WHEN ALL HOOK-UPS, TIE-INS AND TERMINATIONS HAVE BEEN COMPLETED AND SIGNED OFF ON THE MANUFACTURERS START-UP REQUEST FORM BY THE INSTALLER.
- (B) THE COMMISSIONING WILL REQUIRE THE SYSTEM MANUFACTURER OR HIS REPRESENTATIVE TO PROVIDE ON-SITE TRAINING FOR THE OWNERS PERSONNEL ON THE OPERATION AND MAINTENANCE OF THE PACKAGED PUMPING SYSTEM.

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PACKAGED FIRE PUMP
ASSEMBLY WITH HOUSE
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4.03 TRAINING

- (A) SYSTEM MANUFACTURER OR HIS REPRESENTATIVE SHALL BE AVAILABLE FOR SITE INSTRUCTIONAL TRAINING.
- (B) PROVIDE TRAINING, OPERATION, MAINTENANCE AND TROUBLE SHOOTING OF UNIT.
- (C) PROVIDE INSTRUCTION FOR A MINIMUM OF () HOURS.
- (D) PROVIDE REQUIRED EDUCATIONAL MATERIALS FOR A MINIMUM OF THREE (3) PERSONNEL.
- (E) PROVIDE MINIMUM 10-DAY NOTICE OF START-UP AND TRAINING.

END OF SECTION 21 13 13 – PACKAGED FIRE PUMP ASSEMBLY WITH HOUSE ENCLOSURE

SECTION 22 00 00 - PLUMBING GENERAL PROVISIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This section includes general requirements for plumbing systems.

1.03 CONTRACT DOCUMENT COORDINATION

- (A) Contract Drawings are diagrammatic in showing certain physical relationships between architectural, structural, plumbing, mechanical and electrical work.

1. Verification and coordination of these relationships is the responsibility of the Contractor.
2. Verify all existing conditions before starting work.
3. Floor plan drawings do not necessarily indicate all required offsets, fittings, valves, etc.
4. Provide all necessary piping, fittings, valves, offsets, and other specialties required without additional cost to the Owner.

- (B) Should Contract Document requirements appear to make it impossible in providing a complete and operational system, or should discrepancies appear among Contract Documents, Contractor shall request clarification before proceeding with work.

1.04 QUALITY ASSURANCE

- (A) Comply with all State, and local codes and ordinances.
- (B) Obtain and pay for all required permits, fees and certificates of inspection of the work.
- (C) Install equipment and devices to provide required access for servicing and maintenance.
- (D) Comply with applicable portions of Local, City, and State Plumbing Code pertaining to plumbing materials construction and installation of products.
- (E) Fabricate and install potable water and natural gas systems in accordance with Local Utility Company requirements.
- (F) Do not interrupt plumbing services to occupied facilities without written permission from Owner and a minimum three (3) days' notice.

1.05 SUBMITTALS

(A) General:

1. See Division 01 Submittal Procedures.
2. Shop Drawing Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information.
3. Shop Drawing Submittals may also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

(B) Submittal Requirements:

1. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
2. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name, specification section and similar information to distinguish it from other submittals.
3. Provide General Contractor's and Subcontractor's stamp, signed or initialed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Contract Documents. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".
4. Items from each specification section shall be prepared as separate submittals, not grouped or bound with other items. Submittals shall clearly indicate the applicable specification section.

(C) Alternate Equipment Submittal by Contractor:

1. Equipment of greater or larger dimensions, weight, capacity, or rated performance than that which is specified may be submitted provided all connecting mechanical and electrical services, including ductwork and piping connections, circuit breakers, electrical conduit and conductors, motors, equipment supports, building structure, and equipment spaces are modified as required by the proposed equipment. If performance ratings or efficiencies of the equipment are specified, the equipment must meet or exceed these design requirements as well as any specified commissioning requirements. **NO ADDITIONAL COST WILL BE APPROVED FOR ANY SUCH CHANGES RELATED TO THE ALTERNATE EQUIPMENT.**
2. Should proposed alternate equipment involve rearrangement of other designed equipment, a complete layout of the area involved shall be submitted by the Contractor along with the alternate equipment submittal and shall be approved in writing by the Architect/Engineer prior to ordering, purchasing, delivery or installation of any such items of equipment.

3. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL ADDITIONAL EXPENSE AND COORDINATION WITH OTHER TRADES RESULTING FROM THE SUBSTITUTION OF EQUIPMENT OTHER THAN THAT SPECIFIED IN THE CONTRACT DOCUMENTS.

(D) Submittal Review:

1. Review of submittal data is only for general conformance with the design concept of the Project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications.
2. Review of submittal data does not release the Contractor from further satisfactory equipment operating responsibilities. Equipment shall be approved for final acceptance when installation is completed and all equipment and systems have been operated, tested and adjusted in compliance with the contract documents.
3. Re-submittals: When revised for resubmission, clearly indicate all changes since previous submission. Only those items required to be resubmitted shall be included.

(E) Operation and Maintenance (O&M) Manuals:

1. Prepare and submit three copies of operation and maintenance instructions for all Division 22 equipment and fixtures furnished.
 - A. Provide individual 3-ring binders with a table of contents and tabbed sections for each specification section.
 - B. Identify equipment and fixtures included in the manuals by the equipment or fixture mark used in the contract drawings.
 - C. Include emergency instructions, spare parts listing, copies of warranties, wiring diagrams, shop drawings, product data, signed letters of certification of inspection and similar information.
 - D. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner's representative(s) present, date and time of training.
 - E. Provide a list of manufacturer's representatives for each item of equipment including company name, address and phone number.
 - F. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.
2. All information contained in equipment and fixture manufacturer's operation and maintenance manual shall be specific to equipment and fixtures provided. Contractor shall mark out or not include all unrelated information.
3. Electronic O&M Manuals: Provide electronic version of project O&M Manuals in pdf format in addition to hardcopy version of the manuals.

- (F) Contractor shall be responsible for all additional expense and coordination with other trades resulting from the substitution of equipment to that specified in the Contract Documents.

- (G) Review of shop drawings does not release the Contractor from further satisfactory operating responsibilities. Material and equipment shall be approved for final acceptance when construction is completed and all equipment and systems have been operated, tested, adjusted and balanced to the satisfaction of the Architect/Engineer. Should proposed approved alternate equipment involve rearrangement of designed equipment, a complete layout of the area involved shall be submitted by the Contractor and shall be approved in writing before installation of any such items of equipment.
- (H) Required Submittals List:
1. Shop Drawings shall be submitted for the items listed in each section of the specifications. Submittals in addition to those listed may be required by the Architect/Engineer.
- 1.06 RECORD DRAWINGS
- (A) See Division 01 "Project Record Documents".
- (B) Provide a set of plumbing drawings marked-up with actual as-built conditions for Division 22 work. Record drawings shall include all addenda and change orders.
- 1.07 UTILITY CONNECTION CHARGES AND UTILITY COSTS
- (A) Contractor shall pay for all utility connection charges (water, sanitary sewer, storm sewer and gas) and utility cost for services to the building required. Capital facilities utility service charges will be paid directly by the Owner and are not part of the Construction Contract.
- 1.08 CONTRACT DRAWING FILE REQUESTS
- (A) As an instrument of service to aid in Shop Drawing Submittals, Farris Engineering (FEI) will provide AutoCAD drawing files upon request. The files will be sent upon return receipt of the "Request for Drawings" agreement signed by an officer of the requesting firm. FEI does not assure that the drawings represent all changes, addenda items, change orders or modifications that may have occurred. The drawings are simply a tool for use in producing shop drawing submittals. The drawing files will be "cleaned-up" by having the FEI logo, Professional Engineer seal, and all extraneous notes and details removed. FEI must be compensated for this additional service by the requesting firm. A minimum fee of \$400.00 for up to eight (8) sheets and \$50.00 per sheet for each additional requested drawing will be invoiced to the requesting firm once the signed agreement is received.
- 1.09 PLUMBING/ELECTRICAL COORDINATION
- (A) See Division 01 "Multiple Contract Summary".
- (B) Plumbing Contractor shall coordinate with Electrical Contractor and verify that proper electrical power connections to plumbing equipment which requires electrical power is provided. Unless specifically shown otherwise Electrical Contractor shall provide power connections to the equipment and Plumbing Contractor shall provide wiring required for start-stop, control and safety interlock functions.
- (C) If plumbing contractor has proposed alternate equipment to that specified in the contract documents, and such alternate equipment requires modified electrical power connections, mechanical contractor shall coordinate these requirements with electrical contractor prior to ordering, purchasing, delivery or installation of any electrical conduits, conductors, circuit breakers and other electrical devices serving the alternate equipment.

(D) Types of work, normally recognized as electrical but provided as plumbing include but are not necessarily limited to the following:

1. Motors for plumbing equipment.
2. Starters for motors of plumbing equipment, but only where specifically indicated to be furnished integrally with equipment.
3. Wiring from motors to disconnect switches or junction boxes for motors of plumbing equipment, when specifically indicated to be furnished integrally with equipment.
4. Electrical power connections for plumbing equipment and fixtures that are not indicated on the electrical drawings.

(E) Emergency Shutdown Switches: Plumbing Contractor shall coordinate with Electrical Contractor and verify that required shutdown switches to equipment which requires emergency shutdown is provided. Types of equipment provided by plumbing, kitchen or foodservice equipment suppliers that may require emergency shutdown include but is not necessarily limited to the following:

1. Domestic Water Heaters.
2. Electric steam generators.
3. Steam Kettles.
4. Science lab/classroom gas service.

1.10 CLEANING AND PROTECTION

(A) During the construction period the Plumbing Contractor shall clean and protect work in progress and adjoining work on a basis of perpetual maintenance.

1.11 FINAL COMPLETION

(A) The Plumbing Contractor shall not call for a final completion check until Plumbing Systems have been installed, adjusted, tested and in full and complete satisfactory operation and the following certifications of inspection from equipment suppliers have been completed. Certifications of Inspection are required on the following equipment:

1. Domestic Water Mixing Valves.
2. Plumbing Pumps.
3. Domestic Water Softeners.
4. Sensor Operated Flush Valves and Faucets.
5. Domestic Water Heaters.

(B) The Certifications shall consist of letters signed by Factory-Trained and -Authorized Service Personnel stating the following:

1. They have inspected their equipment on the project.

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2. They approve the condition of the equipment and its installation.
 3. They have checked its operation and certify that it is operating properly.
 4. They have noted any problems, conditions or objections that could lead to future operating problems.
- (C) Documentation of the signed letters of Certification of Inspection shall be furnished in the Operations and Maintenance Manuals, included with the associated equipment.

1.12 GUARANTEE

- (A) The one year guarantee period shall not start until the project is completed and the Contractor has received the Final Payment and Certificate of Completion.
- (B) Equipment and work shall be guaranteed, parts and labor, for one full year from the date of the Certificate of Completion. Repairs made during this period shall be fully guaranteed for an additional one year period from the date of repairs.
- (C) Plumbing Contractor has the responsibility to guarantee equipment and work and shall assume responsibility to repair any equipment at his cost that the manufacturer refuses to guarantee.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 ELECTRICAL WORK PROVIDED BY PLUMBING CONTRACTOR

- (A) Electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of the equipment manufacturer, this Section, and Division 26.

3.02 PIPE HANGING AND SUPPORT

- (A) Piping systems shall be supported from building structural systems capable of supporting the applied load.
- (B) Piping shall not be supported from metal roof decking.

3.03 PAINTING AND FINISHING

- (A) Painting of exposed plumbing work is specified and performed under other divisions of these specifications, or as indicated on the drawings.
- (B) Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.

3.04 REBATES

- (A) Contractor shall assist the Owner with filing of applicable forms to obtain rebates. This shall include but not be limited to determination of qualifying equipment, fixtures and materials and furnishing invoices for equipment, fixtures and materials as required to support the rebate application.

END OF SECTION 22 00 00 – PLUMBING GENERAL PROVISIONS

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SECTION 22 00 10 - PLUMBING SUBMITTALS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 GENERAL

- (A) Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information not in standard printed form for general application to a range of similar projects.
- (B) Submittals shall also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

1.03 SUBMITTAL REQUIREMENTS

- (A) Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
- (B) Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name and similar information to distinguish it from other submittals. Show Contractor's executed review and approval marking and providing space for Architect's/Engineer's "Action" marking. Package each submittal appropriately for transmittal and handling. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".
- (C) Provide Contractor's certification on form, ready for execution, stating that information submitted complies with requirements of contract documents.
- (D) The Contractor shall be responsible for and bear any expense of alterations to the building or its appurtenances resulting from the substitution of equipment to that specified in the Contract Documents.
- (E) Review of submittals does not release the Contractor from further satisfactory operating responsibilities. Material and equipment shall be approved for final acceptance when construction is completed and all units and systems have been operated, tested, adjusted and balanced to the satisfaction of the Architect/Engineer. Should proposed approved alternate equipment involve rearrangement of designed equipment, a complete layout of the area involved shall be submitted by the Contractor and shall be approved in writing before installation of any such items of equipment. Any additional expense involved shall be a Contractor-borne expense.
- (F) Electronic Submittals: All submittals for shop drawings, O & M Manuals and Record Drawings shall be in electronic PDF format. Identify and incorporate information in each electronic submittal file as follows:

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PLUMBING SUBMITTALS

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PROJECT NO. H IH BLAC 19100

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
 - A. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., IHS BLACKFEET-22 05 00). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., IHS BLACKFEET-22 05 00-A).
3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect and/or Construction Manager.
4. Transmittal Form for Electronic Submittals: Use software-generated form from electronic project management software acceptable to Architect, Engineer and Owner, containing the following information:
 - A. Project name.
 - B. Date.
 - C. Name and address of Architect.
 - D. Name of Construction Manager.
 - E. Name of Contractor.
 - F. Name of firm or entity that prepared submittal.
 - G. Names of subcontractor, manufacturer, and supplier.
 - H. Category and type of submittal.
 - I. Submittal purpose and description.
 - J. Specification Section number and title.
 - K. Specification paragraph number or drawing designation and generic name for each of multiple items.
 - L. Drawing number and detail references, as appropriate.
 - M. Location(s) where product is to be installed, as appropriate.
 - N. Related physical samples submitted directly.
 - O. Indication of full or partial submittal.
 - P. Transmittal number, numbered consecutively.
 - Q. Submittal and transmittal distribution record.

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PLUMBING SUBMITTALS

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R. Other necessary identification.

S. Remarks.

1.04 SUBMITTAL LIST

- (A) Submittals shall be submitted for, but not limited to, the items listed in each section of the specifications. Submittals, in addition to those listed, may be required by the Architect/Engineer. The following submittal register is a summary list of submittals required for the project.

SUBMITTAL REGISTER	
SECTION	ITEM
22 00 00	O&M Manuals
22 00 00	Record Drawings
22 00 00	Certification of Inspection
22 05 00	Plumbing Pipe and Fittings
22 05 00	Plumbing Valves and Specialties
22 05 00	Meters and Gauges
22 05 00	Plumbing Support and Anchors
22 05 00	Plumbing Identification
22 05 00	Plumbing Access Panels
22 05 00	Joint Sealants
22 07 00	Plumbing Insulation Product Data & Installation Instructions
22 11 16	Pipe and Fittings
22 11 16	Plumbing Valves, Meters, Mixing Valves, Trap Primers, Interceptors
22 11 16	Natural Gas Piping and Fittings
22 11 16	Natural Gas Valves and Emergency Shutoff Controls
22 11 19	Plumbing Specialties
22 11 23	Plumbing Pumps
22 11 25	Domestic Water Packaged Booster Pumps
22 31 00	Domestic Water Softener Equipment
22 33 00	Domestic Water Heaters and Accessories
22 40 00	Plumbing Fixtures

END OF SECTION 22 00 10 – PLUMBING SUBMITTALS

SECTION 22 05 00 - COMMON PLUMBING MATERIALS AND REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes the following common plumbing materials and requirements.

1. Valves:
 - A. Gate
 - B. Ball
 - C. Plug
 - D. Globe
 - E. Butterfly
 - F. Check
2. Valve Tags and Schedules.
3. Piping Specialties:
 - A. Pipe escutcheons
 - B. Pipeline strainers
 - C. Pipe sleeves
 - D. Dielectric fittings
 - E. Transition fittings
4. Meters and Gauges:
 - A. Thermometers
 - B. Pressure gauges
5. Supports and Anchors:
 - A. Piping hangers and supports

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COMMON PLUMBING
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- B. Saddles and shields
 - 6. Plumbing Identification.
 - 7. Vibration Control:
 - A. Spring Isolators
 - B. Isolation hangers
 - C. Flexible pipe connectors
 - 8. Access Panels.
 - 9. Nonshrink grout for equipment installations.
 - 10. Joint sealers for sealing around plumbing materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - 11. Installation requirements common to piping and equipment specification Sections.
 - 12. Concrete equipment base construction requirements.
 - 13. Plumbing demolition.
 - 14. Excavation and backfill.
 - 15. Cutting and patching.
 - 16. Piping tests.
- 1.03 DEFINITIONS
- (A) Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.
 - (B) Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below the roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
 - (C) Exposed Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
 - (D) Exposed Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
 - (E) Concealed Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
 - (F) Concealed Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

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COMMON PLUMBING
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1.04 SUBMITTALS

(A) Submittals:

1. General: Submit the following according to the Conditions of the Contract.
2. Product data for following piping specialties:
 - A. Valves.
 - B. Mechanical sleeve seals.
 - C. Thermometers.
 - D. Pressure gauges.
 - E. Identification materials and devices.
 - F. Vibration Isolators.
 - G. Access panels.
3. Coordination drawings for access panel and access door locations.

1.05 QUALITY ASSURANCE

- (A) All plumbing piping, fixtures, specialties, equipment and connections shall be installed per requirements of the applicable code.
- (B) Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions of ASME B31 Series "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.
- (C) MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions."
- (D) ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves."
- (E) FCI Compliance: Test and rate Y-type strainers in accordance with FCI 73-1 "Pressure Rating Standard for Y-type strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than Y-type".
- (F) UL and FM Compliance: Provide meters, gauges, and supports which are UL-listed and FM approved.
- (G) MSS Standard Compliance: Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

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COMMON PLUMBING
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(H) ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

(I) Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements. No additional cost will be approved for any such changes.

1.06 DELIVERY, STORAGE, AND HANDLING

(A) Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

(B) Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

(C) Protect flanges, fittings, and piping specialties from moisture and dirt.

(D) Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.

1.07 SEQUENCING AND SCHEDULING

(A) Coordinate plumbing fixture and equipment installation with other building components.

(B) Arrange for chases, slots, and openings in building structure during progress of construction to allow for plumbing installations.

(C) Coordinate the installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

(D) Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

(E) Coordinate connection of electrical services.

(F) Coordinate connection of plumbing systems with exterior site utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

(G) Coordinate requirements for access panels and doors where plumbing items requiring access are concealed behind finished surfaces.

(H) Perform demolition and new plumbing work in phases as indicated.

1.08 PROJECT CONDITIONS

(A) Conditions Affecting Selective Demolition:

1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.

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2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

(B) Conditions Affecting Excavations:

1. Maintain and protect existing building services which transit the area affected by excavations.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
4. Remove existing underground utilities indicated to be removed.
 - A. Uncharted or Incorrectly Charted Utilities: Contact Utility Owner immediately for instructions.
 - B. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Owner and Engineer prior to utility interruption.
5. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.01 PIPE AND PIPE FITTINGS

- (A) For pipe and fitting materials and joining methods refer to plumbing piping system specification sections.

2.02 PIPING SPECIALTIES

(A) Pipe Escutcheons:

1. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated.
 - A. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension.
 - B. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

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(B) Low Pressure Pipeline Strainers:

1. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 PSI working pressure, with Type 304 stainless steel screens, with 3/64-inch perforations at 233 per square inch.
2. Threaded Ends, 2-inches and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.
3. Threaded Ends, 2-1/2-inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
4. Flanged Ends, 2-1/2-inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
5. Butt Welded Ends, 2-1/2-inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.
6. Grooved Ends, 2-1/2-inches and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

(C) Dielectric Fittings:

1. Description: Assembly of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.
 - A. Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.
 - B. Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure and temperature.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions: Factory-fabricated, union assembly for 250 PSIG minimum working pressure at a 180°F temperature.
4. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150 or 300 PSIG minimum pressure to suit system pressures.
5. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - A. Provide separate companion flanges and steel bolts and nuts for 150 or 300 PSIG minimum working pressure to suit system pressures.
6. Dielectric Couplings: Galvanized-steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300 PSIG minimum working pressure at 225°F temperature.

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7. Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300 PSIG working pressure at 225°F temperature.
- (D) Mechanical Sleeve Seals: Modular, watertight mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.
- (E) Sleeves: The following materials are for wall, floor, slab, and roof penetrations:
1. Steel Sheet-Metal: 24-gauge or heavier galvanized sheet metal, round tube closed with welded longitudinal joint.
 2. Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, galvanized, plain ends.
 3. Cast-Iron: Cast or fabricated wall pipe equivalent to ductile-iron pressure pipe, having plain ends and integral water stop, except where other features are specified.
- (F) Transition Fittings
1. General Requirements:
 - A. Same size as pipes to be joined.
 - B. Pressure rating at least equal to pipes to be joined.
 - C. End connections compatible with pipes to be joined.

2.03 VALVES

- (A) General: Provide factory-fabricated valves recommended by Manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with Installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.
- (B) Gate Valves: Comply with the following requirements:
1. Gate Valves - 2-Inches and Smaller:
 - A. MSS SP-80.
 - B. Class 125, body and bonnet of ASTM B 62 cast bronze.
 - C. Threaded or solder ends,
 - D. Solid disc.
 - E. Copper-silicon alloy stem.
 - F. Brass packing gland, "Teflon" impregnated packing.
 - G. Malleable iron handwheel.

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H. Class 150 valves meeting the above shall be used where pressure requires.

2. Gate Valves - 2-Inches and Smaller:

- A. MSS SP-80.
- B. Class 150, body and union bonnet as ASTM B 62 cast bronze.
- C. Threaded or solder ends.
- D. Solid disc.
- E. Copper-silicon alloy stem.
- F. Brass packing gland, "Teflon" impregnated packing.
- G. Malleable iron handwheel.

3. Gate Valves - 2-1/2-Inches and Larger:

- A. MSS SP-70
- B. Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B.
- C. Flanged ends,
- D. Teflon impregnated packing and two-piece backing gland assembly.

(C) Ball Valves: Comply with the following requirements:

1. Ball valves - 1-inch and Smaller:

- A. Rated for 150 PSI SWP pressure, 600 PSI non-shock WOG pressure;
- B. 2-piece construction, bronze body conforming to ASTM B 584 or B61, full port,
- C. 316 stainless steel ball
- D. Reinforced "Teflon" or "TFE" seats and seals
- E. Blowout proof stem
- F. Vinyl-covered steel handle.
- G. Extended solder ends for domestic hot and cold water service.
- H. 2-inch extended handles of non-thermal conductive material. Valve pressure ratings shall be cast into the body of the valve.

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2. Ball Valves - 1-1/4-Inches to 2-Inches:
 - A. Rated for 150 PSI SWP pressure, 600 PSI non-shock WOG pressure.
 - B. 2-piece construction, bronze body conforming to ASTM B 584 or B61, full port.
 - C. 316 stainless steel ball.
 - D. reinforced and replaceable "Teflon" or "TFE" seats and seals.
 - E. Blowout proof stem.
 - F. Vinyl-covered steel handle.
 - G. Extended solder ends for domestic hot and cold water service.
 - H. 2-inch extended handles of non-thermal conductive material.
 - I. Valve pressure ratings shall be cast into the body of the valve.

(D) Plug Valves: Comply with the following requirements:

1. Plug Valves - 2-Inches and Smaller:
 - A. 150 PSI WOG
 - B. Bronze body
 - C. Straightaway pattern
 - D. Square head
 - E. Threaded ends.
2. Plug Valves - 2-1/2-Inches and Larger:
 - A. MSS SP-78; 175 PSI WOG.
 - B. Lubricated plug type.
 - C. Semi-steel body.
 - D. Single gland.
 - E. Wrench operated.
 - F. Flanged ends.

(E) Globe Valves: Comply with the following requirements:

1. Globe Valves - 2-Inches and Smaller:
 - A. MSS SP-80.
 - B. Class 125, body and screwed bonnet of ASTM B 62 cast bronze.
 - C. Threaded or solder ends.
 - D. Brass or replaceable composition disc.
 - E. Copper-silicon alloy stem.
 - F. Brass packing gland, "Teflon" impregnated packing.
 - G. Malleable iron handwheel.
 - H. Class 150 valves meeting the above shall be used where pressure requires.
2. Globe Valves - 2-1/2-Inches and Larger:
 - A. MSS SP-85.
 - B. Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B.
 - C. Outside screw and yoke.
 - D. Bronze-mounted, flanged ends.
 - E. Teflon impregnated packing and two-piece backing gland assembly.

(F) Butterfly Valves: Comply with the following requirements:

1. Butterfly Valves - 2-1/2-Inches and Larger:
 - A. MSS SP-67;
 - B. 200 non-shock PSI, cast iron body conforming to ASTM A 126, Class B.
 - C. Replaceable EPDM sleeve, with aluminum bronze disc.
 - D. 400 Series stainless steel stem, and EPDM O-ring stem seals.
 - E. Sizes 2-1/2-inch through 6-inches shall have 10-position lever operators with locks.
 - F. Wafer type valve.
 - G. Drill and tap valves on dead-end service or requiring additional body strength. Valve shall be capable of bi-directional dead end service with downstream flange removed at full-rated pressure.

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(G) Check Valves: Comply with the following requirements:

1. Swing Check Valves - 2-Inches and Smaller:
 - A. MSS SP-80.
 - B. Class 125, cast bronze body and cap conforming to ASTM B 62.
 - C. Horizontal swing, Y-pattern, with a bronze disc,
 - D. Threaded or solder ends.
 - E. Valve capable of being reground while the valve remains in the line.
 - F. Class 150 valves meeting the above specifications may be used with threaded end connections where pressure requires or Class 125 valves are not available.
2. Swing Check Valves - 2-1/2-Inches and Larger:
 - A. MSS SP-71
 - B. Class 125 (Class 175 FM approved for fire protection piping systems).
 - C. Cast iron body and bolted cap conforming to ASTM A 126, Class B.
 - D. Horizontal swing, with a bronze disc or cast iron disc with bronze disc ring
 - E. Flanged ends.
 - F. Valve capable of being refitted while the valve remains in the line.

2.04 NATURAL GAS VALVES & STOPS

(A) Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 PSIG.
2. Body: Cast iron with bronze plug, straight away pattern, square head, tapered-plug type.
3. Threaded Ends: Comply with ASME B1.20.1.
4. Dryseal Threaded on Flare Ends: Comply with ASME B1.20.3.
5. Tamperproof Feature: Locking (tamperproof).
6. Service Mark: Valves 1-1/4-inches to NPS 2 with initials "WOG" permanently marked on valve body.

(B) Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 PDIG.

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2. Body: Cast iron with bronze plug, straight away pattern, square head, tapered-plug type.
3. Flanged Ends: Comply with ASME B16.5 for steel flanges.
4. Tamperproof Feature: Locking (tamperproof).
5. Service Mark: Valves 1-1/4-inches to NPS 2 with initials "WOG" permanently marked on valve body.

(C) Two-Piece, Full Port, Bronze Ball Valves and Bronze Trim" MSS SP-110.

1. Body: Bronze, complying with ASTM B 584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. CWP Rating: 600 PSIG.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

(D) Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Body: Cast iron, complying with ASTM A 126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural gas.
5. Ends: Threaded for flanged.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125 PSIG
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

(E) Bronze Plug Valves: MSS SP-78.

1. Body: Bronze, complying with ASTM B 584.
2. Plug: Bronze.
3. Ends: Threaded, socket or flanged.
4. Operator: Square head or lug type with tamper proof feature.

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5. Pressure Class: 125 PSIG.

6. Service: Suitable for natural gas with "WDG" indicated on valve body.

(F) Gas Valves and Stops:

1. Gas Stops, 2-Inch and Smaller: CSA-certified design for 2 PSIG or less natural gas, with CSA stamp.

A. Body: Plug or ball type, bronze body.

B. Stem: Bronze plug or chrome-plated brass ball.

C. Operator: Flat head, square head, or lever handle. Include locking (tamperproof) feature.

D. Ends: Threaded ends.

2.05 VALVE TAGS

(A) Brass Valve Tags: Provide 19-gauge polished brass valve tags for all valves with stamp-engraved piping system abbreviation in 1/4-inch high letters and sequenced valve numbers 1/2-inch high, and with 5/32-inch hole for fastener.

1. Provide 1-1/2-inch diameter tags, except as otherwise indicated.

2. Fill tag engraving with black enamel.

(B) Valve Tag Fasteners: Manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

2.06 VALVE SCHEDULES

(A) General: Provide a valve schedule for each piping system in electronic form and printed out on standard size bond paper for inclusion in Operation and Maintenance manual.

1. Schedule shall include valve identification number, piping system, size and location of valve, normal operating position and additional remarks as required.

2. Identify valve use for emergency shutoff or similar special use.

2.07 METERS AND GAUGES

(A) Glass Thermometers:

1. General: Provide thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

2. Case: Die cast aluminum finished in baked epoxy enamel or hard powder coat finish, glass or acrylic front, 9-inches long.

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3. Adjustable Joint: Die cast aluminum, finished to match case, 180° adjustment in vertical plane, 360° adjustment in horizontal plane, with locking device.
4. Tube and Capillary: Blue organic-liquid filled, magnifying lens, ± 1 scale division accuracy, shock mounted.
5. Scale: Satin faced, non-reflective white aluminum, permanently etched black markings.
6. Stem: Copper-plated steel, brass or die-cast aluminum, for separable socket, length to suit installation.
7. Range: Conform to the following:
 - A. Domestic Hot Water: 30°F to 180°F with 2°F scale divisions.

(B) Light Powered Thermometers:

1. Manufacturers:
 - A. Cole Palmer.
 - B. Terice, H. O. Co.
 - C. Weiss Instruments, Inc.
 - D. Winters Instruments - U.S.
2. Type: Light powered digital.
3. Case, Industrial Style: Aluminum or ABS.
4. Readout: Minimum 1/2-inch high LCD digits at up to 10 second intervals.
5. Light Rating: 10-20 Lux.
6. Range: -50 to 300 degrees with °F/°C switch.
7. Sensing Element: Glass passivated thermistor.
8. Stem: Stainless, aluminum, or brass for thermowell installation and of length to suit installation.
 - A. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches with ASME B1.1 screw threads. Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
10. Accuracy: Plus or minus 1% of range or one scale division, to maximum of 1.5% of range.

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(C) Pressure Gauges:

1. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Type: General use, $\pm 1\%$ accuracy, ANSI B 40.1 Grade 1A, phosphor bronze bourdon type, bottom connection.
3. Case: Stainless steel, glass or acrylic lens, 4-1/2-inch diameter.
4. Connector: Brass, lower mount with 1/4-inch male NPT.
5. Scale: White coated aluminum, with permanently etched black markings.
6. Accessories:
 - A. Provide each gauge with a shut-off needle valve.
 - B. Provide pressure snubber where spikes may be present.
7. Range: Conform to the following:
 - A. Vacuum: 30-inch Hg - 15 PSI.
 - B. Water: 0-100 PSI.

2.08 SUPPORTS AND ANCHORS

(A) Horizontal-Piping Hangers and Supports:

1. General: Provide factory-fabricated horizontal-piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information.
2. Adjustable Steel Clevis Hangers: MSS Type 1.
3. Yoke Type Pipe Clamps: MSS Type 2.
4. Steel Double Bolt Pipe Clamps: MSS Type 3.
5. Steel Pipe Clamps: MSS Type 4.
6. Pipe Hangers: MSS Type 5.
7. Trapeze type with horizontal angle iron.
8. Use only one type by one manufacturer for each piping service.
9. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping.
10. Provide copper-plated hangers and supports for copper-piping systems.

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(B) Saddles and Shields:

1. General: Provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
4. Thermal Hanger Shields: Constructed of 360 degree insert of high density, 100 PSI, water-proofed calcium silicate, encased in 360 degree sheet metal shield. Provide assembly of same thickness as adjoining insulation.

(C) Roof Equipment Supports:

1. General: Construct roof equipment supports using minimum 18-gauge galvanized steel with fully mitered and welded corners, 3-inch cant, internal bulkhead reinforcing, integral base plates, pressure treated wood nailer, and 18-gauge galvanized steel counterflashing.
2. Configuration: Construct to sizes as indicated, compensate for slope in roof so top of support is dead level.

2.09 PLUMBING IDENTIFICATION

(A) Equipment Markers:

1. General: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive or fasteners to mount on equipment.
2. Terminology: Match drawing schedules as closely as possible unless directed otherwise by Owner.
3. Data Required:
 - A. Equipment Description, (i.e. Domestic Water Heater).
 - B. Schedule Mark, (i.e. DWH-1).
4. Marker Size: 2-1/2- by 4-inches for main control valves; 4-1/2- by 6-inches for equipment.

(B) Plastic Pipe Markers:

1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.
2. Small Pipes: For external diameters less than 6-inches (including insulation if any), provide full-band pipe markers, extending 360° around pipe at each location, fastened by the following method:

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- A. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4-inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2-inches.
3. Large Pipes: For external diameters of 6-inch and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than three times letter height (and of required length), fastened by one of the following methods:
- A. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2-inches wide, full circle at both ends of pipe marker, tape lapped 3 inches.
4. Lettering: Comply with piping system nomenclature as specified, scheduled or shown on drawings, and abbreviate only as necessary for each application length.
- A. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
- (C) Plastic Tape:
1. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick, complying with ANSI A13.1.
2. Width: Provide 1-1/2-inch wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6-inches, 2-1/2-inch wide tape for larger pipes.
- (D) Color Scheme: Comply with ANSI A13.1, or as scheduled below:
- | <u>PIPE CONTENTS</u> | <u>COLOR SCHEME</u> |
|-------------------------------------|----------------------|
| Domestic Cold Water | White text on Green |
| Domestic Hot and Recirculated Water | Black text on Yellow |
| Natural Gas | Black text on Yellow |
| Non-Potable Water | Black text on Yellow |

2.10 VIBRATION CONTROL

- (A) Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.
1. Include holes in bottom plate for bolting unit to substrate as indicated.
- (B) Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for three times rated loading of units. Fabricate units to accept misalignment of 15° off center in any direction before contacting hanger box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.
1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.
2. Provide neoprene element, with minimum deflection of 0.35-inches, securely retained in hanger box.

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3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
 4. Provide hangers, pre-compressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.
- (C) Flexible Pipe Connectors: Provide neoprene or EDPM construction consisting of multiple plies of nylon tire cord fabric and elastomer molded and cured in hydraulic rubber presses. Provide straight or elbow connector as indicated, rated at 125 PSI at 220°F.

2.11 ACCESS PANELS

- (A) Panels MILCOR, Style "M" for masonry, Style A for acoustical tile, and Style K for plaster; except that Fire Rated UL 1-1/2 hour and "B" label access panels furnished in fire-rated walls and ceilings as indicated on the Drawings.
- (B) Access doors 12-inch x 12-inch minimum size for valves and water hammer arrestors and 24-inch x 36-inch minimum size for access to equipment.

2.12 GROUT

- (A) Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, non-staining, non-corrosive, non-gaseous, and recommended for interior and exterior applications.
 2. Design Mix: 5000 PSI, 28 day compressive strength.
 3. Packaging: Premixed and factory-packaged.

2.13 JOINT SEALERS

- (A) General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
- (B) Colors: As selected by the Architect from manufacturer's standard colors.
- (C) Elastomeric Joint Sealers: Provide the following types:
1. One-part, non-acid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
 2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and non-porous joint substrates; formulated with fungicide; intended for sealing interior joints with non-porous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.

- (D) Acrylic-Emulsion Sealants: One-part, nonsag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5%.
- (E) Fire-Resistant Joint Sealers: Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors. Sealants and accessories shall have fire-resistant ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.01 PIPING SYSTEMS-COMMON REQUIREMENTS

- (A) General: Install piping as described below, except where system Sections specify otherwise.
- (B) General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, except where deviations to layout are approved on coordination drawings.
- (C) Install piping at indicated slope.
- (D) Install components having pressure rating equal to or greater than system operating pressure.
- (E) Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.
- (F) Install piping free of sags and bends.
- (G) Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.
- (H) Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.
- (I) Install piping to allow application of insulation plus 1-inch clearance around insulation.
- (J) Locate groups of pipes parallel to each other, spaced to permit valve servicing.
- (K) Install fittings for changes in direction and branch connections.
- (L) Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:
 - 1. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons, where required, for existing piping.
 - 2. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.
 - 3. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.

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4. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.
 5. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.
- (M) Sleeves are not required for core drilled holes.
- (N) Install sleeves for pipes passing through concrete and masonry walls, concrete floor and roof slabs, and where indicated.
1. Cut sleeves to length for mounting flush with both surfaces.
 - A. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2-inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring where specified.
 2. Build sleeves into new walls and slabs as work progresses.
 3. Install large enough sleeves to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - A. Steel Pipe Sleeves: For pipes smaller than 6-inches.
 - B. Steel Sheet Metal Sleeves: For pipes 6-inches and larger that penetrate gypsum-board partitions.
 - C. Cast-Iron Sleeve Fittings: For floors having membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2-inches above finished floor level.
 4. Except for below-grade wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants.
 5. Install sleeves for piping penetrations of walls, ceilings, and floors.
 6. Install sleeve seals for piping penetrations of concrete walls and slabs.
- (O) Transition Fitting Installation:
1. Install transition couplings at joints of dissimilar piping.
 2. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.
 - A. Dielectric Fitting Installation:
 - (1) Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - (2) Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.

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(3) Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

(4) Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

(P) Above Grade, Exterior Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.

1. Install steel pipe for sleeves smaller than 6-inch.
2. Install cast-iron wall pipes for sleeves 6-inch and larger.
3. Assemble and install mechanical seals according to manufacturer's printed instructions.

(Q) Below Grade, Exterior Wall, Pipe Penetrations: Install cast-iron wall pipes for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.

(R) Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material.

(S) Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."
4. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:
 - A. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 - B. Apply appropriate tape or thread compound to external pipe threads (except where dry seal threading is specified).
 - C. Align threads at point of assembly.
 - D. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
 - E. Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
5. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to the "Quality Assurance" Article.

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6. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
 7. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:
 - A. Comply with ASTM F 402 for safe handling of solvent-cement and primers.
 - B. Chlorinated Polyvinylchloride (CPVC): ASTM D 2846 and ASTM F 493.
 - C. Polyvinylchloride (PVC) Pressure Application: ASTM D 2672.
 - D. Polyvinylchloride (PVC) Non-Pressure Application: ASTM D 2855.
 8. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.
 - A. Plain-End Pipe and Fittings: Butt joining.
 - B. Plain-End Pipe and Socket-Type Fittings: Socket joining.
- (T) Piping Connections: Except as otherwise indicated, make piping connections as specified below.
1. Install unions in piping 2-inch and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch or smaller threaded pipe connection.
 2. Install flanges in piping 2-1/2-inches and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
 3. Dry Piping Systems (Gas, Compressed Air, and Vacuum): Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 4. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
 5. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces.
 6. Install isolation valves upstream of all dielectric unions and flanges.
- (U) Escutcheons: Install for piping penetrations of walls, ceilings, floors, cabinetry and case work.
- (V) Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

3.02 EQUIPMENT INSTALLATION-COMMON REQUIREMENTS

- (A) Install equipment to provide the maximum possible headroom where mounting heights are not indicated.
- (B) Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.
- (C) Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, except where otherwise indicated.
- (D) Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
- (E) Install equipment giving right-of-way to piping systems installed at a required slope.

3.03 VALVE INSTALLATIONS

- (A) General Application: Use ball and butterfly valves for shut-off duty; globe, ball, and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.
- (B) Locate valves for easy access and provide separate support where necessary.
- (C) Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
- (D) Install shutoff valve, hose-end drain valve, strainer, pressure gauge, and test tee with valve, inside the building at each domestic water service entrance.
- (E) Install shutoff valve immediately upstream of each dielectric fitting.
- (F) Locate valves for easy access.
- (G) Install 3-valve bypass around each pressure reducing valve using throttling type valves.
- (H) Install valves in horizontal piping with stem at or above the center of the pipe, and to allow full stem movement.
- (I) Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- (J) Installation of Check Valves: Install for proper direction of flow as follows:
 - 1. Swing Check Valves: Install in horizontal position with hinge pin level.
 - 2. Lift Check Valve: Install in piping line with stem upright and plumb.
- (K) Valve Locations:
 - 1. Plumbing Piping:

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- A. Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves two or more plumbing fixtures or equipment connections, and elsewhere as indicated.
- B. Shut-off Valves: Install on inlet of each plumbing equipment item, and on inlet of each plumbing fixture, and elsewhere as indicated.
- C. Throttling Valves: As required on plans.

2. Valve Tags:

- A. Provide valve tags for all valves and list on Valve Schedule.
- B. Install tags on valves in piping systems, except check valves, valves within factory-fabricated equipment units and plumbing fixture supply stops.

(L) Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.

(M) Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

- 1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
- 2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

3.04 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

<u>VALVES 2-INCHES AND SMALLER</u>				
<u>SERVICE</u>	<u>GATE</u>	<u>GLOBE</u>	<u>BALL</u>	<u>CHECK</u>
Domestic Hot & Cold Water	125	125	150	125
<u>VALVES 2-1/2-INCHES AND LARGER</u>				
<u>SERVICE</u>	<u>GATE</u>	<u>GLOBE</u>	<u>BUTTERFLY</u>	<u>CHECK</u>
Domestic Hot & Cold Water	125	125	200	125

3.05 DOMESTIC WATER VALVE SCHEDULE

(A) Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

- 1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
- 2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
- 3. Hot-Water Circulation Piping, Balancing Duty: Automatic flow control valves.
- 4. Drain Duty: Hose-end drain valves.

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- (B) Use check valves to maintain correct direction of domestic water flow to and from equipment.
- (C) PVC, PP, CPVC, and PVDF valves matching piping materials may be used.

3.06 NATURAL GAS VALVE SCHEDULE

- (A) Valves for pipe sizes NPS 2 and smaller shall be one (1) of the following:

- 1. Bronze ball valve with bronze trim.
- 2. Bronze plug valve.

- (B) Valves for pipe sizes NPS 2-1/2 and larger shall be one (1) of the following:

- 1. Bronze ball valves with bronze trim.
- 2. Bronze plug valve.
- 3. Cast-iron, nonlubricated plug valve.

- (C) Valves in branch piping for single appliance shall be one (1) of the following:

- 1. Bronze ball valve with bronze trim.
- 2. Bronze plug valve.

3.07 PIPING SPECIALTIES INSTALLATION

- (A) Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shut-off valve in strainer blow-down connection, full size of connection, except for strainers 2-inch and smaller. Where indicated, provide drain line from shut-off valve to plumbing drain, full size of blow-down connection.

- 1. Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:
 - A. Pumps.
 - B. Temperature control valves.
 - C. Pressure reducing valves.
 - D. Temperature or pressure regulating valves.
 - E. Automatic flow control valves.

- (B) Dielectric Unions: Install at each piping joint between ferrous and nonferrous piping. Comply with manufacturer's installation instructions.

- 1. Install isolation valves on each side of all dielectric unions.

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3.08 METERS AND GAUGES INSTALLATION

(A) Thermometers:

1. General: Install in vertical upright position, and tilted to be easily read by observer standing on floor.
2. Locations: Install in the following locations, and elsewhere as indicated:
 - A. At outlet of each domestic water heater.
 - B. At outlet of each thermostatic mixing valve.
3. Install thermometers in hot-water circulation piping.
4. Install thermometers on outlet piping from each water heater.
5. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
6. Connect branch piping from top or side of horizontal piping.

(B) Pressure Gauges:

1. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.
2. Locations: Install in the following locations, and elsewhere as indicated:
 - A. Across suction and discharge of each pump.
 - B. At discharge of each pressure reducing valve.
 - C. At domestic water service entrance.
3. Install pressure gauges on suction and discharge piping from each plumbing pump and packaged booster pump.

3.09 SUPPORTS AND ANCHORS INSTALLATION

(A) Hangers and Supports:

1. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69.
 - A. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69.
 - B. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe.

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- C. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
 - D. Do not support piping from bottom cord of bar joist or from metal roof deck, unless approved by Structural Engineer.
 - E. Piping may be supported at panel points of bar joists.
- 2. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. For exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent and similar piping.
 - 3. Use powder-actuated fasteners only for installation where load will be applied perpendicular to the fasteners. Do not use powder-actuated fasteners where load will be applied axially to the fasteners.
 - 4. Support fire-water piping independently of other piping.
 - 5. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.
- (B) Saddles and Shields:
- 1. Insulated Piping: Comply with the following installation requirements:
 - A. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold water piping, install coated protective shields. For pipe 8-inch and over, install wood insulation saddles.
 - B. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.
- (C) Pipe hanger and support products.
- 1. Individual, Straight, Horizontal Piping Runs:
 - A. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - B. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - C. Longer Than 100 Feet Requiring Vibration Isolation: MSS Type 49, spring cushion rolls.
 - 2. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 3. Vertical Piping: MSS Type 8 or 42, clamps.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- (D) Support vertical piping and tubing at base and at each floor.

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- (E) Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8-inch.
- (F) Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 and Smaller: 60-inches with 3/8-inch rod.
 2. NPS 1 and NPS 1-1/4: 72-inches with 3/8-inch rod.
 3. NPS 1-1/2 and NPS 2: 96-inches with 3/8-inch rod.
 4. NPS 2-1/2: 108-inches with 1/2-inch rod.
 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 6. NPS 6: 10 feet with 5/8-inch rod.
 7. NPS 8: 10 feet with 3/4-inch rod.
- (G) Install supports for vertical copper tubing every 10 feet.
- (H) Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 and Smaller: 84-inches with 3/8-inch rod.
 2. NPS 1-1/2: 108-inches with 3/8-inch rod.
 3. NPS 2: 10 feet with 3/8-inch rod.
 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 5. NPS 3: 12 feet with 1/2-inch rod.
 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 7. NPS 6: 12 feet with 3/4-inch rod.
 8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.
- (I) Install supports for vertical steel piping every 15 feet.
- (J) Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2 and Smaller: 48-inches with 3/8-inch rod.
 2. NPS 2-1/2 to NPS 3: 48-inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 48-inches with 5/8-inch rod.
 4. NPS 6: 48-inches with 3/4-inch rod.

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5. NPS 8: 48-inches with 7/8-inch rod.
- (K) Install supports for vertical PVC piping every 48 inches.
- (L) Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60-inches with 3/8-inch rod.
 2. NPS 3: 60-inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60-inches with 5/8-inch rod.
 4. NPS 6: 60-inches with 3/4-inch rod.
 5. NPS 8 to NPS 12: 60-inches with 7/8-inch rod.
- (M) Install supports for vertical cast-iron soil piping every 15 feet.
- (N) Install vinyl-coated hangers for PEX tubing at 32-inches maximum horizontal spacing with 3/8-inch rod.
- (O) Install supports for vertical PEX tubing every 48-inches.
- (P) Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.
- 3.10 PLUMBING IDENTIFICATION INSTALLATION**
- (A) Install equipment markers with permanent adhesive or appropriate fasteners on or near each major item of mechanical equipment
1. Locate markers where accessible and visible.
 2. Include markers for the following categories of equipment:
 - A. Main control and operating valves.
 - B. Pumps, water heaters, tanks, pressure vessels, humidifiers, water-treatment systems, and similar equipment.
- (B) Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
1. Near each valve and control device.
 2. Near each branch, excluding short take-offs for fixtures; mark each pipe at branch, where there could be question of flow pattern.
 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.

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4. At access doors, manholes and similar access points which permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced intermediately at maximum spacing of 50-feet along each piping run, except reduce spacing to 25-feet in congested areas of piping and equipment.
7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.11 VIBRATION CONTROL INSTALLATION

- (A) General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.
- (B) Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.
- (C) Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
- (D) Locate isolation hangers as near overhead support structure as possible.
- (E) Flexible Pipe Connectors: Install on equipment side of shut-off valves, horizontally and parallel to equipment shafts wherever possible.

3.12 ACCESS PANEL INSTALLATION

- (A) Plumbing Contractor shall locate and furnish for installation by General Contractor, all access panels as required for access to valves and water hammer arresters, and the proper servicing of equipment and piping installed under this Contract.

3.13 CONCRETE BASES

- (A) Construct concrete equipment bases of dimensions indicated, but not less than 4-inches larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 PSI, 28 day compressive strength concrete and reinforcement.

3.14 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- (A) Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- (B) Field Welding: Comply with AWS D1.1 "Structural Welding Code-Steel."

3.15 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- (A) Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

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(B) Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

(C) Attach to substrates as required to support applied loads.

3.16 SELECTIVE DEMOLITION

(A) General: Demolish, remove, demount, and disconnect abandoned plumbing piping, materials and equipment indicated to be removed and not indicated to be salvaged or saved.

(B) Materials and Equipment designated for Salvage: Remove, demount, and disconnect existing plumbing materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage by Owner.

(C) Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

(D) Plumbing Materials and Equipment: Demolish, remove, demount, and disconnect the following items:

1. Inactive and obsolete piping, fittings and specialties, equipment, controls, fixtures, and insulation.
 - A. Piping embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove materials above accessible ceilings. Drain and cap piping allowed to remain.

3.17 EXCAVATION AND BACKFILL

(A) Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.

(B) Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30-inches below finished grade elevation.

(C) Install sediment and erosion control measures in accordance with local codes and ordinances.

(D) Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

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- (E) Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.
1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
 2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.
- (F) Excavation for Underground Tanks, Basins, and Plumbing Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10-foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.
1. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1-inch in diameter and larger with emulsified asphalt tree paint.
 2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.
- (G) Trenching: Excavate trenches for plumbing installations as follows:
1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6- to 9-inches clearance on both sides of pipe and equipment.
 2. Excavate trenches to depth indicated or required for piping to establish indicated slope and invert elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.
 3. Limit the length of open trench to that in which pipe can be installed, tested, and the trench backfilled within the same day.
 4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of pipe. Provide a minimum of 6-inches of stone or gravel cushion between rock bearing surface and pipe.
 5. Excavate trenches for piping and equipment with bottoms of trench to accurate elevations for support of pipe and equipment on undisturbed soil.
 - A. For pipes or equipment 6-inch or larger in nominal size, shape bottom of trench to fit bottom 1/4 of the circumference. Fill unevenness with tamped sand backfill. At each pipe joint over-excavate to relieve the bell or pipe joint of the pipe of loads, and to ensure continuous bearing of the pipe barrel on the bearing surface.
- (H) Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35°F.
- (I) Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below.
1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.

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2. Under building slabs, use drainage fill materials.
 3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
 4. For piping less than 30-inches below surface of roadways, provide 4-inch thick concrete base slab support. After installation and testing of piping, provide a 4-inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
 5. Other areas, use excavated or borrowed materials.
- (J) Backfill excavation as promptly as work permits, but not until completion of the following:
1. Inspection, testing, approval, and locations of underground utilities have been recorded.
 2. Removal of concrete formwork.
 3. Removal of shoring and bracing, and backfilling of voids.
 4. Removal of trash and debris.
- (K) Placement and Compaction: Place backfill and fill materials in layers of not more than 8-inches in loose depth for material compacted by heavy equipment, and not more than 4-inches in loose depth for material compacted by hand-operated tampers.
- (L) Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
- (M) Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of piping and equipment by carrying material uniformly around them to approximately same elevation in each lift.
- (N) Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below:
1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 698 and not less than the following percentages of relative density, determined in accordance with ASTM D 4253 and ASTM D 4254, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).
 - A. Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12-inches of subgrade and each layer of backfill or fill material to 95% maximum density for cohesive material, or 98% relative density for cohesionless material.
 - B. Areas Under Walkways: Compact top 6-inches of subgrade and each layer of backfill or fill material to 95% maximum density for cohesive material, or 98% relative density for cohesionless material.

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- C. Other Areas: Compact top 6-inches of subgrade and each layer of backfill or fill material to 85% maximum density for cohesive soils, and 90% relative density for cohesionless soils.
2. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.
- (O) Subsidence: Where subsidence occurs at mechanical installation excavations during the period 12 months after Substantial completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.
- 3.18 CUTTING AND PATCHING
- (A) Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for plumbing installations. Perform cutting by skilled mechanics of the trades involved.
- (B) Repair cut surfaces to match adjacent surfaces.
- 3.19 GROUTING
- (A) Install nonmetallic nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.
- (B) Clean surfaces that will come into contact with grout.
- (C) Provide forms for placement of grout, as required.
- (D) Avoid air entrapment when placing grout.
- (E) Place grout to completely fill equipment bases.
- (F) Place grout on concrete bases to provide a smooth bearing surface for equipment.
- (G) Place grout around anchors.
- (H) Cure placed grout according to manufacturer's printed instructions.
- 3.20 PIPING TESTS
- (A) No piping work, fixtures, or equipment shall be concealed or covered until they have been observed by the Engineer's representative, who shall be notified by the Contractor when the work is ready for inspection. All work shall be completely installed, tested as required by this Section and by all applicable local and State Ordinances and Safety Orders, and shall be leak-tight before inspection is requested. All tests shall be repeated upon request to the satisfaction of those making the inspection.
- (B) All domestic water piping shall be flushed, tested and shall be left under pressure of supply main or a minimum of 40 PSI for the balance of the construction period.

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- (C) Piping tests shall be made with the test medium and under test pressures listed in the following table. Use a calibrated Bristol Pressure Recorder, or equal, on all tests. Engineer's representative shall install and remove each chart. Recorder range shall be 0-300 pounds or required range for specific test.

<u>Type of Piping</u>	<u>PIPING TESTS Test Pressure</u>	<u>Test Medium</u>	<u>Test Period</u>
Soil, Waste, Vent and Storm Drainage Piping Within Building	Minimum of 10 foot head on each joint with no loss in head	Water	One Hour
Domestic Water			
1. Pressure Regulated to and including 80 PSI	150 PSIG	Water	Two Hours
2. Non-regulated above 80 PSI	Twice normal static pressure at the service point	Water	Two Hours
Fuel Gas, and Fuel Oil Return	50 PSIG	Air	One Hour

- (D) Test pressure in lbs. per square inch, or inches of vacuum, gauge, are given as an initial pressure to be applied to lines being tested, together with test medium.
- (E) Final pressures at the end of test period shall be no more or less than that caused by expansion or contraction of the test medium due to temperature changes.
- (F) Check of systems during application of test pressures should include visual check for water medium leakage and soap bubble or similar for air and nitrogen medium.
- (G) During heating and cooling cycles, linear expansion shall be checked at all elbows, U-bends, expansion joints, etc., for proper clearance.

END OF SECTION 22 05 00 – COMMON PLUMBING MATERIALS AND REQUIREMENTS

SECTION 22 07 00 - PLUMBING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Plumbing Insulation.
2. Equipment Insulation.
3. Insulation Accessories.

1.03 SUBMITTALS

- (A) Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation and accessory.

1. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

1.04 QUALITY ASSURANCE

- (A) Furnish insulation and materials bearing the manufacturer's label. Only mechanics skilled at such work shall apply materials. Insulation and materials shall be by one of the manufacturers listed. Specialty material shall be of the manufacturer indicated or approved equal. Fire and smoke hazard classification ratings on insulation, jacket, and adhesive shall conform to NFPA 255, ASTM E 84, or UL-723 as follows:

1. Flame Spread Index not exceeding 25.
2. Smoke Developed Index not exceeding 50.

- (B) Certifications: Submit certifications or other data as necessary to show compliance with these specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

1.05 DELIVERY, STORAGE, AND HANDLING

- (A) Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.06 COORDINATION

- (A) Coordinate size and location of supports, hangers, and insulation shields.

(B) Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

(C) Coordinate installation and testing of heat tracing.

1.07 SCHEDULING

(A) Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

(A) Subject to compliance with requirements, provide products by one (1) of the following:

1. Armacell LLC.
2. Dow Chemical Company.
3. Johns-Manville Corp.
4. Keene Corp.
5. Knauf Fiber Glass.
6. Nomaco K-Flex.
7. Owens-Corning Fiberglass Corp.
8. Pittsburg Corning Corp.

2.02 MATERIALS

(A) Thermal Conductivity Average Maximum in Btu-in/hr-ft² at 75°F Mean Temperature:

1. Fiberglass Board = 0.26.
2. Fiberglass Blanket = 0.30.
3. Fiberglass Preformed Pipe Insulation = 0.26.
4. Cellular Glass = 0.30.
5. Flexible Elastomeric Cellular = 0.27.
6. Polyisocyanurate = 0.19.
7. Calcium Silicate = 0.60 @ 500°F.

(B) Vapor retarder film and tape shall have a maximum permeance of 0.030 perm.

- (C) Provide pre-formed fiberglass and elastomeric closed-cell plastic foam pipe insulation with self-adhering and self-sealing overlapping flap.

PART 3 - EXECUTION

3.01 PIPING INSULATION SCHEDULE

(A) Exposed Piping.

1. Pipe insulation exposed in finished areas shall be protected with 0.030-inches thick PVC plastic jacketing covers, Ceel-Co 100 Series or approved equal.
2. Pipe insulation exposed in mechanical and electrical equipment rooms, indoor parking garages and other unfinished areas 8-feet 0-inches or less above finish floor shall be protected with 0.030-inches thick, ultraviolet resistant, PVC plastic jacketing covers, Ceel-Co 300 Series or approved equal.
3. Pipe insulation exposed to weather shall be protected with a pre-fabricated self-adhering and self-sealing sheet type waterproof membrane. Membrane shall be installed according to manufacturer's recommendations for the application at hand. The waterproof membrane shall be Flex-Clad 400 as manufactured by MFM Building Products Corporation of Coshocton, OH or approved equal.

(B) Storm and Storm Overflow Drainage – Aboveground and drain sumps.

1. Fiberglass: 1-inch thick 4-pcf density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1/2-inch thick.
3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(C) Sanitary and Storm Drainage from drains serving cooling coil condensate drainage or ice machine drainage and from refrigerated water coolers - above ground piping within 25 feet of drain and drain sumps.

1. Fiberglass: 1-inch thick 4-pcf density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1/2-inch thick.
3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(D) Domestic Cold Water - 1-1/4-inch and smaller.

1. Fiberglass: 1-inch thick 4-pcf density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1-inch thick.
3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(E) Domestic Cold Water - 1-1/2-inch and larger.

1. Fiberglass: 1-inch thick 4-pcf density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1-inch thick.

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3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- (F) Domestic Hot Water and Recirculated Hot Water.
1. Fiberglass: 1-inch thick 4-pcf density with fire-resistive ASJ vapor barrier jacket.
 2. Elastomeric closed-cell plastic foam: 1-inch thick.
 3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- (G) Vent Piping Within 10 Feet of Roof or Exterior Wall Penetration.
1. Fiberglass: 1-inch thick 4-pcf density with fire-resistive ASJ vapor barrier jacket.
 2. Elastomeric closed-cell plastic foam: 1-inch thick.
 3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- 3.02 EQUIPMENT INSULATION SCHEDULE
- (A) Domestic Water Pumps
1. Elastomeric closed-cell plastic foam: 1-inch thick. Joints shall be carefully filled with seam filler. After insulation has been applied and seams filled, apply two (2) coats of Foster 30-36.
 2. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- (B) Domestic Hot Water Storage Tanks and Storage Tank Heaters
1. Elastomeric closed-cell plastic foam: 1-1/2-inch thick. Joints shall be carefully filled with seam filler. After insulation has been applied and seams filled, apply two (2) coats of Foster 30-36.
- (C) Condensing Water Heater Vent and Air Intake Piping in Unconditioned Space.
1. Elastomeric closed-cell plastic foam: 1-1/2-inch thick.
- 3.03 EXAMINATION
- (A) Examine substrates and condition for compliance with requirements for installation and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.
- 3.04 PREPARATION
- (A) Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- (B) Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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3.05 GENERAL INSTALLATION REQUIREMENTS

- (A) Install insulation products in accordance with manufacturer's written instructions, and in accordance with the MICA National Commercial and Industrial Insulation Standards to ensure that insulation serves its intended purpose.
- (B) Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, and piping including fittings, valves, and specialties.
- (C) Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, and pipe system as specified in insulation system schedules.
- (D) Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- (E) Install insulation with longitudinal seams at top and bottom of horizontal runs.
- (F) Install multiple layers of insulation with longitudinal and end seams staggered.
- (G) Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- (H) Keep insulation materials dry during application and finishing.
- (I) Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- (J) Install insulation with least number of joints practical.
- (K) Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- (L) Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- (M) Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- (N) Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4-inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

(O) For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

(P) Provide neatly beveled edge at interruptions of insulation.

3.06 PENETRATIONS

(A) Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2-inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

(B) Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

(C) Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2-inches.
4. Seal jacket to wall flashing with flashing sealant.

(D) Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

(E) Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.
- (F) Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.
- 3.07 INSTALLATION OF PIPING INSULATION
- (A) Install insulation on pipe systems subsequent to testing and acceptance of tests.
- (B) Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. The appearance of the completed insulation shall be a significant factor in determining the acceptability of the work.
- (C) Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- (D) Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
- (E) Where vapor retarders are specified, elbows and fittings shall be wrapped with vapor retarder tape 3-inches wide or shall have PVC jacketing.
- (F) Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation applied to adjoining pipe run. Install factory-molded, pre-cut or job-fabricated units (at installer's option) except where specific form or type is indicated.
- (G) Insulation of Piping Specialties on Cold Piping Services: Insulate union, flanges, strainers, flexible connections, hoses, and expansion joints on cold piping services with flexible elastomeric cellular insulation. Thickness of flexible elastomeric cellular insulation shall be equivalent to thickness of insulation on the piping service as specified in this Section or as shown on the drawings. Insulation shall be sealed to provide a vapor tight barrier. Cold piping services include domestic cold water systems.
- (H) Piping Insulation Omitted: Omit insulation on exposed plumbing fixture runouts from faces of wall or floor to fixture; on unions, flanges, strainers, flexible connections, and expansion joints.
- (I) Insulated piping systems shall be supported on the exterior of the insulation surface. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation.
- (J) Metal shields: Conform to table below for minimum length of shield:

<u>PIPE SIZE</u>	<u>INSULATION THICKNESS</u>	<u>LENGTH OF SHIELD</u>
Less than 1"	Up to 1"	3"
1"-2"	1"	4-1/2"
2-1/2"-4"	1"	6-1/2"
5" and Larger	1"	13"

- (K) Pipe Hanger, Trapeze, and Roller Support Insulation Inserts: Butt pipe insulation against pipe hanger insulation inserts. Apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3-inch wide vapor barrier tape or band.

3.08 INSTALLATION OF EQUIPMENT INSULATION

- (A) Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.
- (B) Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
- (C) Do not apply insulation to hot equipment.
- (D) Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
- (E) Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
- (F) Cover insulated surfaces with glass cloth jacketing neatly fitted and firmly secured. Lap seams at least 2-inches. Apply over vapor barrier where applicable.
- (G) Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
- (H) Insulation Installation on Pumps: Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. For below ambient services, install a vapor barrier at seams, joints, and penetrations.
- (I) For below ambient services, remove equipment nameplate and re-install on exterior insulation surface or provide duplicate nameplate for field installation on exterior insulation surface.

3.09 PROTECTION AND REPLACEMENT

- (A) Protection: Provide protection for insulation work during remainder of construction period, to avoid damage and deterioration.
- (B) Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

END OF SECTION 22 07 00 – PLUMBING INSULATION

SECTION 22 11 16 - PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes piping tubing and fittings inside building:

1. Domestic water.
2. Sanitary waste.
3. Natural gas.
4. Containment conduit.
5. Connectors.
6. Hangers and supports.

1.03 PERFORMANCE REQUIREMENTS

- (A) Components and installation shall be capable of withstanding the following minimum working pressure:

1. Soil, Waste and Vent Piping: 10-foot head of water.
2. Storm Drainage Piping: 10-foot head of water.
3. Sanitary Sewer and Storm Drainage, Force-Main Piping: 1.5 times working pressure of system.
4. PEX Tubing Systems: Pressure and temperature rating of 160 PSI at 73°F, 100 PSI at 180°F and 80 PSI at 200°F.
5. Natural gas piping, valves and regulators: 100 PSIG minimum unless otherwise indicated.

1.04 SUBMITTALS

- (A) Product Data: For the following products:

1. Pipe
2. Fittings.
3. Connectors.

1.05 QUALITY ASSURANCE

- (A) Piping materials shall bear label, stamp, or other markings of specified testing agency.
- (B) Comply with NSF 14 for plastic piping and components.
- (C) Comply with NSF 61 for potable domestic water piping and components.
- (D) Comply with ASTM F877 for cross-linked polyethylene (PEX) tubing distribution systems.
- (E) Utility Compliance: Comply with requirements of natural gas utility provider for installation of natural gas piping and specialties.

1.06 WARRANTY

- (A) Manufacturer's Warranty for PEX Tubing Systems shall be 25 year non-prorated warranty against failure due to defect in material or workmanship, beginning with the date of installation.

PART 2 - PRODUCTS

2.01 JOINING MATERIALS

- (A) Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, except where thickness or specific material is indicated.
 - A. Full-Face Type: For flat-face, Class 125 cast-iron and cast-bronze flanges.
 - B. Narrow-Face Type: For raised-face, Class 250 cast-iron and steel flanges.
 - 2. ASME B16.20 for grooved, ring-joint, steel flanges.
 - 3. AWWA C110, rubber, flat face, 1/8-inch thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.
- (B) Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.
- (C) Solder Filler Metal: ASTM B 32.
 - 1. Alloy Sn95 or Alloy Sn94: Tin (approximately 95%) and silver (approximately 5%), having 0.10% lead content.
 - 2. Alloy Sn50: Tin (50%) and lead (50%) (for use on nonpotable water systems only).
- (D) Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- (E) Solvent Cements: Manufacturer's standard solvents complying with the following:
 - 1. Chlorinated Polyvinylchloride (CPVC): ASTM F 493.
 - 2. Polyvinylchloride (PVC): ASTM D 2564.

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- (F) Plastic Pipe Seals: ASTM F 477, elastomeric gasket.
- (G) Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.
- (H) Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.
1. Sleeve: ASTM A126, Class B, gray iron.
 2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron.
 3. Gaskets: Rubber.
 4. Bolts and Nuts: AWWA C111.
 5. Finish: Enamel paint.
- (I) Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.
- 2.02 COPPER TUBE AND FITTINGS**
- (A) Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
1. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- (B) Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- 2.03 DUCTILE-IRON PIPE AND FITTINGS**
- (A) Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- (B) Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.
 2. Gaskets: AWWA C111, rubber.

(C) Plain-End, Ductile-Iron Pipe: AWWA C151.

1. Grooved-Joint, Ductile-Iron-Pipe Appurtenances:

- A. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
- B. Grooved-End, Ductile-Iron-Pipe Couplings: AWWA C606 for ductile-iron-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

2.04 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

(A) Pipe and Fittings: ASTM A 888, ASTM A 74 or CISPI 301, Service class.

(B) Gaskets: ASTM C 564, rubber and ASTM C-1563.

(C) Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

(D) Shall bear the collective trademark of the Cast Iron Soil Pipe Institute or have prior written approval of Farris Engineering.

2.05 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

(A) Pipe and Fittings: ASTM A 888, ASTM A 74 or CISPI 301.

(B) Shielded Couplings: ASTM C 1540 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

- 1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

(C) Shall bear the collective trademark of the Cast Iron Soil Pipe Institute or have prior written approval of Farris Engineering.

2.06 STEEL PIPE AND FITTINGS

(A) Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.

(B) Pressure Fittings:

- 1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
- 2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
- 3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
- 4. Cast-Iron Flanges: ASME B16.1, Class 125.
- 5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

(C) Grooved-Joint Systems:

1. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, galvanized, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, galvanized, ductile-iron casting; with dimensions matching steel pipe.
2. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.07 PVC PIPE AND FITTINGS

(A) PVC Pipe: ASTM D 1785, Schedule 40.

1. PVC Socket Fittings: ASTM D 2466 for Schedule 40.
2. PVC Threaded Fittings: ASTM D 2464 for Schedule 80.

(B) Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.08 PEX TUBE AND FITTINGS

(A) PEX Tubing System: ASTM F877, SDR 9 Tubing.

(B) PEX Pre-insulated Tubing System: ASTM F877, SDR 9 Tubing, ½-inch thick, PEX-foam insulation.

1. PEX Tube Fittings:
 - A. ASTM F1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.
 - B. ASTM F2159, plastic-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.

2.09 POLYPROPYLENE (PP) PIPE AND FITTINGS

(A) ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM 4101; with fusion and mechanical joint ends.

(B) Manufacturer: Subject to compliance with requirements, provide products by one (1) of the following:

1. IPEX, Inc.
2. Orion Fittings, Inc.
3. Zurn Plumbing Product Group.

2.10 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

- (A) Special drainage system for corrosive or acid waste shall be manufactured from CPVC Type IV Grade I compounds with a minimum cell classification of 23447. Pipe and Fittings shall conform to ASTM F 2618. Pipe shall be Schedule 40 dimensions. One-Step solvent cement shall be specially formulated for chemical waste applications and conform to ASTM F493. All pipe, fittings and cement shall be supplied as a system by a single manufacturer and shall be certified by NSF International for use in corrosive waste drainage systems and shall bear the mark "NSF-cw".
- (B) Manufacturer: Subject to compliance with requirements, provide products of one (1) of the following:
1. Charlotte Pipe-ChemDrain
 2. Spears – LabWaste

2.11 POLYVINYLIDENE FLUORIDE (PVDF) PIPE AND FITTINGS

- (A) PVDF pipe and fittings shall conform to ASTM F163 and shall be joined using socket fusion or mechanical joints. Pipe and fittings shall meet or exceed Schedule 40 dimensions. PVDF material shall conform to ASTM D3222. Pipe shall be marked to indicate compliance with UL 723 (ASTM #84).
- (B) Manufacturer: Subject to compliance with requirements, provide products by one (1) of the following:
1. IPEX, Inc.
 2. Orion Fittings, Inc.
 3. Zurn Plumbing Products Group

2.12 NATURAL GAS PIPING

- (A) Gas Service Piping:
1. All Pipe Sizes: Black steel pipe; Schedule 40; wrought-steel butt welding fittings.
 - A. Wrapping: Machine wrap pipe using 50% overlap wrap, with polyvinyl chloride tape. Hand wrap fittings using 100% overlap wrap extending 6 inches beyond fitting onto wrapped pipe. Comply with tape manufacturer's installation instructions.
 - B. Cathodic Protection: 17 pound prepackaged magnesium anode with No. 12 wire extension.
 - C. Dielectric Unions: Provide standard products recommended by manufacturer and in accordance with Gas Utility Company requirements for use in service indicated, which effectively isolate underground piping from above ground piping (electrical conductance), to prevent galvanic action, and stop corrosion.
 2. Pipe Sizes 1/2-inch through 12-inch: Thermoplastic gas pressure pipe, tubing, and fittings complying with ASTM D 2513.
 3. Pipe Sizes 2-inch through 12-inch: Reinforced epoxy resin gas pressure pipe and fittings complying with ASTM D 2517.

(B) Building Distribution Pipe and Fittings:

1. Steel Pipe: ASTM A 53, Type E, Electric-Resistance Welded or Type S, Seamless, Grade B, Schedule 40, black.
2. Corrugated Stainless Steel Tubing: ANSI LC-1, complying with Standard for Fuel Gas Piping Using Corrugated Stainless Steel Tubing (CSST), listed by CSA International. Tubing shall be manufactured with Type 304 stainless steel, nominal 0.010-inch wall thickness. Tubing shall be jacketed with UV-resistant polyethylene meeting the requirements of ASTM E84 for flame spread and smoke density.
3. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threads conforming to ASME B1.20.1.
4. Cast-Iron Fittings: ASME B16.1, Classes 125 and 250.
5. Steel Fittings: ASME B16.9, wrought steel, butt-welding type; and ASME B16.11, forged steel.
6. Steel Flanges and Flanged Fittings: ASME B16.5.
7. Unions: ASME B16.39, Class 150, black malleable-iron; female pattern; brass-to-iron seat; ground joint.
8. Corrugated Stainless Steel Fittings: ASTM B16 Type 360 brass fittings, double wall flare seal.

(C) Flexible Connectors: ANSI Z21.24 or ANSI Z21.24a, copper alloy.

2.13 PIPING JOINING MATERIALS

- (A)** Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8-inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
- (B)** Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- (C)** Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- (D)** Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- (E)** Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
1. Solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- (F)** Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.14 FLEXIBLE CONNECTORS

- (A) Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
1. Working-Pressure Rating: Minimum 200 PSIG.
 2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
 3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.
- (B) Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
1. Working-Pressure Rating: Minimum 200 PSIG.
 2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
 3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.01 GENERAL

- (A) Drawing plans, schematics, and diagrams indicate general location and arrangement of plumbing piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

3.02 DOMESTIC WATER, SANITARY AND STORM PIPING INSTALLATION

- (A) Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- (B) Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- (C) Install domestic water piping level and plumb.
- (D) Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- (E) Install piping concealed from view and protected from physical contact by building occupants except in equipment rooms and service areas.
- (F) Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- (G) Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- (H) Install piping adjacent to equipment and specialties to allow service and maintenance.
- (I) Install piping to permit valve servicing.

- (J) Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
- (K) Install piping free of sags and bends.
- (L) Install fittings for changes in direction and branch connections.
- (M) Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- (N) Install escutcheons for piping penetrations of walls, ceilings, floors, cabinetry and casework.
- (O) Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings" (latest edition).
1. Cast-iron piping 5-inch and larger shall be supported and braced at each branch fitting and at each change in direction.
- (P) Make changes in direction for soil and waste drainage, vent and storm drainage piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- (Q) Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- (R) Install sanitary, vent and storm drainage piping at the following minimum slopes, unless otherwise indicated:
1. Building Sanitary and Storm Drain: 2% downward in direction of flow for piping NPS 3 and smaller; 1% downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary and Storm Drain Piping: 2% downward in direction of flow.
3. Vent Piping: 1% down toward vertical fixture vent or toward vent stack.
- (S) Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- (T) Install underground PVC soil and waste drainage piping according to ASTM D 2321.
1. Protect exposed PVC plumbing vents exposed to sunlight with two (2) coats of water-based latex paint
- (U) PEX tubing installation:
1. Install in accordance with tubing manufacturer's recommendations.
2. Install with loop at each change of direction of more than 90 degrees and with slack of 1/8 inch per foot to compensate for expansion and contraction.

3. Do not install PEX tubing within 6-inches of gas appliance vents or within 12-inches of recessed light fixtures.
 4. Do not solder within 18-inches of PEX tubing in same waterline. Install sweat connections prior to installing PEX connections.
 5. Provide grommets at penetrations of PEX tubing through metal studs.
 6. Provide nail plates at PEX tubing penetrations of wall studs.
- (V) Plastic piping installation:
1. Where plastic pipe is used, provide fire stopping at all floor penetrations with firestop collars and firestop sealant, STI SpecSeal or approved equal.
 2. Plastic pipe shall not be installed in Kitchens or Laundry Rooms or in any piping system containing or receiving drainage of liquids at temperatures exceeding 140°F.
 3. Plastic pipe shall not be installed in supply or return air plenums.
- (W) Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- 3.03 NATURAL GAS PIPING INSTALLATION**
- (A) Comply with the International Fuel Gas Code and Gas Utility Company recommendations.
 - (B) Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
 - (C) Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
 - (D) Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 - (E) Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 - (F) Install piping at uniform grade of 2% down toward drip and sediment traps.
 - (G) Install piping free of sags and bends.
 - (H) Install fittings for changes in direction and branch connections.
 - (I) Install escutcheons at penetrations of interior walls, ceilings, and floors.
 - (J) Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.
 - (K) Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

- (L) Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3-inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- (M) Extend relief vent connections for service regulators, line regulators, and overpressure protection devices individually to outdoors and terminate with weatherproof vent cap per requirements of Gas Utility Company.
- (N) Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- (O) Concealed Installations: except as indicated below, install concealed natural –gas piping and piping installed under the building in containment conduit that is sealed water tight. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
1. Above Accessible Ceilings: Piping, fittings, valves and regulators may be installed in accessible spaces without containment conduit.
2. In Floor Channels: Install piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
3. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
4. Prohibited Locations:
- A. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiters or elevator shafts.
- B. Do not install natural gas piping in solid walls or floors.
- (P) Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- (Q) Do not use natural-gas piping as grounding electrode.
- (R) Coordinate painting of natural gas piping with Architect and Division 09 contents.
- (S) Paint piping and fitting installed outdoors above ground see Division 09.
- 3.04 JOINT CONSTRUCTION
- (A) Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- (B) Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- (C) Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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1. Apply appropriate tape or thread compound to external pipe threads.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- (D) Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
- (E) Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- (F) Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.
- (G) Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
- (H) Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
- (I) Welded Joints:
1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 2. Bevel plain ends of steel pipe.
 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- (J) Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
 2. PVC Piping: Join according to ASTM D 2855.
 3. PVC Non-pressure Piping Joints: Join piping according to ASTM D 2665.
- (K) PEX Tubing Joints: Join according to ASTM F1807.
- (L) Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.
- (M) Join cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" (latest edition) for compression joints.
- 3.05 FLEXIBLE CONNECTOR INSTALLATION**
- (A) Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

(B) Install bronze-hose flexible connectors in copper domestic water tubing.

3.06 CONNECTIONS

(A) General:

1. Install piping adjacent to equipment, appliances, fixtures and machines to allow service and maintenance.
2. Use transition fitting to join dissimilar piping materials.

(B) Connect domestic water piping water-service main to exterior water-service piping with shutoff valve.

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

(C) Connect natural gas piping to utility's gas main or gas meter according to utility's procedures and requirements.

1. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
2. Install piping adjacent to appliances to allow service and maintenance of appliances.
3. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72-inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
4. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

(D) Connect storm and sanitary to service mains.

1. Extend to fixtures drains and equipment in sizes indicated, but not smaller than fixture and drain connection sizes.

(E) Connections to equipment and fixtures furnished by others:

1. Provide rough-in connections, P-traps, tailpieces, supplies and stops as required for connection to the plumbing system.
2. Pipes and fittings exposed in finished areas shall be chrome plated.

3.07 FIELD QUALITY CONTROL

(A) Perform tests and inspections.

(B) Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one (1) day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - A. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - B. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

(C) Test domestic water piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 PSIG above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

(D) Test sanitary drainage, vent and storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 6. Prepare reports for tests and required corrective action.
 7. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
- (E) Plumbing piping shall be considered defective if it does not pass tests and inspections.
- (F) Prepare test and inspection reports.
- (G) Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- (H) Connect drainage and vent piping to the following:
1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- (I) Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- (J) Connect storm drainage piping to roof drains and storm drainage specialties.

3.08 ADJUSTING

(A) Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
6. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.09 CLEANING

(A) Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - A. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - B. Fill and isolate system according to either of the following:
 - (1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - (2) Fill system or part thereof with water/chlorine solution with at least 200 PPM of chlorine. Isolate and allow to stand for three hours.
 - C. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - D. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

(B) Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - A. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - B. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
 - (C) Prepare and submit reports of purging and disinfecting activities.
 - (D) Clean interior of piping system. Remove dirt and debris as work progresses.
 - (E) Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
 - (F) Place plugs in ends of uncompleted piping at end of day and when work stops.
- 3.10 PIPING APPLICATIONS
- (A) General:
 1. Pipe material selected shall be in compliance with all applicable codes.
 2. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
 3. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
 4. Fitting Option: Extruded-tee connections with brazed joints may be used on aboveground copper tubing.
 - (B) Domestic Water:
 1. Under-building-slab, domestic water, building service piping, NPS 2-1/2 and smaller, shall be the following:
 - A. Soft copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints.
 2. Under-building-slab, domestic water, building-service piping, NPS 3 to NPS 8 and larger, shall be one of the following:
 - A. Soft copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints.
 - B. Mechanical-joint, ductile-iron pipe with cement mortar lining; standard-pattern mechanical-joint fittings; and mechanical joints.
 - C. Push-on-joint, ductile-iron pipe with cement mortar lining; standard-pattern push-on-joint fittings; and gasketed joints.
 - D. PVC, Schedule 40 pipe socket fittings; and solvent-cemented joints.

3. Aboveground domestic water piping shall be one of the following:
- A. Hard copper tube, ASTM B 88, Type L wrought-copper solder-joint fittings; and soldered joints.
 - B. Tube Size 2-1/2-inch and larger only; Hard copper tube, ASTM B 88, Type L, grooved joint; grooved joint couplings and fittings.
 - C. PEX tubing, fittings for PEX tubing; and crimped joints.
 - D. PEX pre-insulated tubing, fittings for PEX tubing; and crimped joints.

(C) Soil, Waste, Vent, and Storm Drainage:

1. Aboveground, soil, waste, vent and storm drainage piping shall be one (1) of the following:
- A. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - B. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 - C. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
2. Underground, soil, waste, vent and storm drainage piping shall be one of the following:
- A. Service class, cast-iron soil piping; gaskets; and calked joints.
 - B. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

(D) Natural Gas Piping:

1. Outdoor underground natural-gas piping shall be one (1) of the following:
- A. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
 - B. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
2. Outdoor aboveground natural-gas piping shall be one (1) of the following:
- A. Steel pipe with malleable-iron fittings and threaded joints.
 - B. Steel pipe with wrought-steel fittings and welded joints.
3. Aboveground natural-gas branch piping NPS 1 and smaller in the building shall be one (1) of the following:
- A. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
 - B. Steel pipe with malleable-iron fittings and threaded joints.

4. Aboveground natural-gas distribution piping in the building shall be one (1) of the following:
 - A. Steel pipe with malleable-iron fittings and threaded joints.
 - B. Steel pipe with wrought-steel fittings and welded joints.
5. Underground, below the building natural-gas piping shall be one (1) of the following:
 - A. Corrugated stainless-steel tubing without joints/fittings and installed inside containment conduit.
 - B. Steel pipe with wrought-steel fittings and welded joints and installed inside containment conduit. Coat pipe and fittings with protective coating for steel piping.
6. Containment conduit piping shall be one (1) of the following:
 - A. Schedule 40 PVC pipe and fittings.
 - B. Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

(E) Containment Conduit:

1. Containment conduit vent piping shall be one (1) of the following:
 - A. Schedule 40 PVC pipe and fittings.
 - B. Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

END OF SECTION 22 11 16 – PLUMBING PIPING

SECTION 22 11 19 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes the following plumbing specialties:

1. Vacuum breakers.
2. Backflow preventers.
3. Pressure-reducing and regulator valves.
4. Balancing valves.
5. Temperature-actuated water mixing valves.
6. Strainers.
7. Outlet boxes.
8. Hose bibbs.
9. Wall hydrants.
10. Ground hydrants.
11. Drain valves.
12. Water hammer arresters.
13. Cleanouts.
14. Floor drains.
15. Through-penetration firestop assemblies.
16. Miscellaneous drainage piping specialties.
17. Specialty valves.

1.03 PERFORMANCE REQUIREMENTS

- (A) Minimum Working Pressure for Plumbing Specialties: 125 PSIG, unless otherwise indicated.

1.04 SUBMITTALS

(A) Shop Drawing Submittals:

1. Product Data: For each type of product indicated.
2. Shop Drawings: Diagram power, signal, and control wiring.

(B) Closeout Submittals:

1. Operation and Maintenance Data: For plumbing specialties to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

(A) Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.

(B) Reduced-Pressure-Principle Backflow Preventers shall be listed as approved by the University of Southern California Foundation for Cross Connection Control and shall be approved by the local water utility provider.

(C) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

(D) NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.01 VACUUM BREAKERS

(A) Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Standard: ASSE 1001.
2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
3. Body: Bronze.
4. Inlet and Outlet Connections: Threaded.
5. Finish: Rough bronze.

(B) Hose-Connection Vacuum Breakers:

1. Standard: ASSE 1011.
2. Body: Bronze, nonremovable, with manual drain.

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3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
4. Finish: Rough bronze.

(C) Laboratory-Faucet Vacuum Breakers:

1. Standard: ASSE 1035.
2. Size: NPS 1/4 or NPS 3/8 matching faucet size.
3. Body: Bronze.
4. End Connections: Threaded.
5. Finish: Chrome plated.

2.02 BACKFLOW PREVENTERS

(A) Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Ames Co.
 - B. Conbraco Industries, Inc.
 - C. Watts Industries, Inc.; Water Products Div.
 - D. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 PSIG maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; epoxy coated ductile iron for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Accessories:
 - A. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
 - B. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

(B) Double-Check Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- A. Ames Co.
 - B. Conbraco Industries, Inc.
 - C. Watts Industries, Inc.; Water Products Div.
 - D. Zurn Plumbing Products Group; Wilkins Div.
- 2. Standard: ASSE 1015.
 - 3. Operation: Continuous-pressure applications, unless otherwise indicated.
 - 4. Pressure Loss: 5 PSIG maximum, through middle 1/3 of flow range.
 - 5. Body: Bronze for NPS 2 and smaller; epoxy coated ductile iron for NPS 2-1/2 and larger.
 - 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 - 7. Accessories:
 - A. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

2.03 PRESSURE-REDUCING VALVES

(A) Water Regulators:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Cash Acme.
 - B. Conbraco Industries, Inc.
 - C. Honeywell Water Controls.
 - D. Watts Industries, Inc.; Water Products Div.
 - E. Zurn Plumbing Products Group; Wilkins Div.
- 2. Standard: ASSE 1003.
- 3. Pressure Rating: Initial working pressure of 150 PSIG.
- 4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
- 5. Valves for Booster Heater Water Supply: Include integral bypass.
- 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

(B) Water Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. CLA-VAL Automatic Control Valves.
 - B. Watts Industries, Inc.
 - C. Zurn Plumbing Products Group; Wilkins Div.
2. Description: Pilot-operation, diaphragm-type, single-seated main water control valve.
3. Pressure Rating: Initial working pressure of 150 PSIG minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

(C) Gas Pressure Regulator:

1. General Requirements:
 - A. Single stage and suitable for natural gas.
 - B. Steel jacket and corrosion-resistant components.
 - C. Elevation compensator.
 - D. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.
2. Service Pressure Regulators: Comply with ANSI Z21.80.
 - A. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - B. Springs: Zinc-plated steel; interchangeable.
 - C. Diaphragm Plate: Zinc-plated steel.
 - D. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - E. Orifice: Aluminum; interchangeable.
 - F. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - G. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.

- H. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150% of design discharge pressure at shutoff.
 - I. Overpressure Protection Device: Factory mounted on pressure regulator.
 - J. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
3. Line Pressure Regulators: Comply with ANSI Z21.80.
- A. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - B. Springs: Zinc-plated steel; interchangeable.
 - C. Diaphragm Plate: Zinc-plated steel.
 - D. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - E. Orifice: Aluminum; interchangeable.
 - F. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - G. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - H. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150% of design discharge pressure at shutoff.
 - I. Overpressure Protection Device: Factory mounted on pressure regulator.
 - J. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
4. Appliance Pressure Regulators: Comply with ANSI Z21.18.
- A. Body and Diaphragm Case: Die-cast aluminum.
 - B. Springs: Zinc-plated steel; interchangeable.
 - C. Diaphragm Plate: Zinc-plated steel.
 - D. Seat Disc: Nitrile rubber.
 - E. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - F. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 - G. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

2.04 BALANCING VALVES

(A) Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Armstrong International, Inc.
 - B. ITT Industries; Bell & Gossett Div.
 - C. NIBCO INC.
 - D. TAC Americas.
 - E. Taco, Inc.
 - F. Watts Industries, Inc.; Water Products Div.
2. Type: Ball or Y-pattern globe valve with two readout ports and memory setting indicator.
3. Body: Bronze.
4. Size: Same as connected piping.

(B) Cast-Iron Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Armstrong International, Inc.
 - B. ITT Industries; Bell & Gossett Div.
 - C. NIBCO INC.
 - D. TAC Americas.
 - E. Watts Industries, Inc.; Water Products Div.
2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
3. Size: Same as connected piping.

(C) Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one(1) of the following:
 - A. Flow Design Inc.
 - B. Griswold Controls.
 - C. Nexus.

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2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Provide Y-strainer upstream of valve.
6. Provide pressure/temperature ports on inlet and outlet.
7. Size: Same as connected piping.
8. Performance: Maintain constant flow, plus or minus 5% over system pressure fluctuations.

2.05 TEMPERATURE-ACTUATED WATER MIXING VALVES

(A) Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Conbraco Industries, Inc.
 - B. Leonard Valve Company.
 - C. Powers; a Watts Industries Co.
 - D. Symmons Industries, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 PSIG.
4. Type: Thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Finish: Chrome plated.

(B) Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Lawler Manufacturing Company, Inc.
 - B. Leonard Valve Company.
 - C. Powers; a Watts Industries Co.

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- D. Symmons Industries, Inc.
- 2. Standard: ASSE 1017.
- 3. Pressure Rating: 125 PSIG.
- 4. Material: Bronze body with corrosion-resistant interior components.
- 5. Connections: Threaded union inlets and outlet.
- 6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
- 7. Valve Pressure Rating: 125 PSIG minimum, unless otherwise indicated.
- 8. Valve Finish: Rough bronze.
- 9. Piping Finish: Copper.

2.06 STRAINERS FOR DOMESTIC WATER PIPING

(A) Y-Pattern Strainers:

- 1. Pressure Rating: 125 PSIG minimum, unless otherwise indicated.
- 2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
- 3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
- 4. Screen: Stainless steel with round perforations, unless otherwise indicated.
- 5. Perforation Size:
 - A. Strainers NPS 2 and Smaller: 0.033-inch.
 - B. Strainers NPS 2-1/2 to NPS 4: 0.062-inch.
- 6. Drain: Factory-installed, hose-end drain valve.

2.07 OUTLET BOXES

(A) Clothes Washer Outlet Boxes:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Acorn Engineering Company.
 - B. Guy Gray Manufacturing Co., Inc.
 - C. IPS Corporation.
 - D. Oatey.

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- E. Sioux Chief.
 - F. Symmons Industries, Inc.
 - G. Watts Industries, Inc.; Water Products Div.
 - H. Zurn Plumbing Products Group.
- 2. Mounting: Recessed.
 - 3. Material and Finish: Enameled-steel, epoxy-painted-steel, or fire retardant ABS box and faceplate.
 - 4. Faucet: Combination, single lever valved fitting complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
 - 5. Supply Shutoff Fittings: NPS 1/2 globe or ball valves and NPS 1/2 copper, water tubing.
 - 6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.
- (B) Icemaker Outlet Boxes:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Acorn Engineering Company.
 - B. Guy Gray Manufacturing Company.
 - C. IPS Corporation.
 - D. Oatey.
 - E. Sioux Chief.
 - 2. Mounting: Recessed.
 - 3. Material and Finish: Enameled-steel, epoxy-painted-steel, or fire retardant ABS box and faceplate.
 - 4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
 - 5. Supply Shutoff Fitting: NPS 1/2 globe or ball valve and NPS 1/2 copper, water tubing.

2.08 HOSE BIBBS

- (A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
- 1. Josam Company.
 - 2. MIFAB, Inc.
 - 3. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.

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4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.
6. Woodford Manufacturing Company.
7. Zurn Plumbing Products Group.

(B) Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 PSIG.
7. Vacuum Breaker: Integral, non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Include operating key with each operating-key hose bibb.
9. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.09 WALL HYDRANTS

(A) Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Josam Company.
 - B. MIFAB, Inc.
 - C. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - D. Tyler Pipe; Wade Div.
 - E. Watts Drainage Products Inc.
 - F. Woodford Manufacturing Company.
 - G. Zurn Plumbing Products Group.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 PSIG.

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4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys(s): Two with each wall hydrant.

2.010 WATER HAMMER ARRESTERS

(A) Water Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. AMTROL, Inc.
 - B. Josam Company.
 - C. MIFAB, Inc.
 - D. PPP Inc.
 - E. Sioux Chief.
 - F. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - G. Tyler Pipe; Wade Div.
 - H. Watts Drainage Products Inc.
 - I. Zurn Plumbing Products Group.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows or copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.011 CLEANOUTS

(A) Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Josam Company; Josam Div.
 - B. Oatey.
 - C. Sioux Chief.
 - D. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - E. Tyler Pipe; Wade Div.
 - F. Watts Drainage Products Inc.
 - G. Zurn Plumbing Products Group.
2. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Required.
6. Outlet Connection: Spigot or threaded.
7. Closure: Polypropylene plug with tapered threads.
8. Adjustable Housing Material: Cast iron with threads.
9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Medium Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

(B) Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Josam Company; Josam Div.
 - B. MIFAB, Inc.
 - C. Sioux Chief.

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- D. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - E. Tyler Pipe; Wade Div.
 - F. Watts Drainage Products Inc.
 - G. Zurn Plumbing Products Group.
- 2. Standard: ASME A112.36.2M. Include wall access.
 - 3. Size: Same as connected drainage piping.
 - 4. Body: Hub-and-spigot, cast-iron soil pipe T-branch or hubless, cast-iron soil pipe test tee as required to match connected piping.
 - 5. Closure: Countersunk plug.
 - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 - 7. Wall Access: Round, deep, chrome-plated bronze cover plate with screw.

2.012 FLOOR DRAINS

(A) Cast-Iron Floor Drains:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Josam Company; Josam Div.
 - B. MIFAB, Inc.
 - C. Sioux Chief.
 - D. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - E. Tyler Pipe; Wade Div.
 - F. Watts Drainage Products Inc.
 - G. Zurn Plumbing Products Group.
- 2. Standard: ASME A112.6.3.

2.013 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

(A) Through-Penetration Firestop Assemblies:

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - A. ProSet Systems Inc.
 - B. Rectorseal Metacaulk.

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2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.014 MISCELLANEOUS DRAINAGE PIPING SPECIALTIES

(A) Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping.

(B) Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
 - A. NPS 2: 4-inch-minimum water seal.
 - B. NPS 2-1/2 and Larger: 5-inch-minimum water seal.

(C) Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

(D) Floor-Drain, Waterless Trap-Seal Protection Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Trap Guard.
 - B. SureSeal.
2. Warranty: 10 years.

(E) Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

(F) Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1-inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

(G) Expansion Joints:

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.015 SPECIALTY VALVES

(A) Emergency Gas Shutoff Control Systems:

1. General: Provide emergency gas shutoff control systems of size and type indicated. Comply with UL508-A, Standard for Industry Control Panels.
2. Install system with flush mount or wall mounted box as indicated on the Drawings. Box and access door shall be fabricated on 16 gauge stainless steel. Provide solenoid valve for each gas service to spaces served. Coordinate number of valves and services controlled for each system.
3. Emergency Gas Shut-off Valve: Electrically operated, 2-way normally closed brass shut-off valve designed for fuel gas service.
4. Emergency Gas Shut-off Switch: Maintained action push-button wall switch with red mushroom style push-button and wall plate with emergency stop label.
 - A. Operation emergency gas shut-off switch shall close electrically operated gas shut-off valve and interrupt the natural gas flow to the area.

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- B. Activation of the emergency gas shut-off switch shall send an alarm signal to the BMS.
 - C. Emergency gas shut-off switch location and operation shall comply with applicable accessibility requirements.
5. Manufacturer: Subject to compliance with requirements, provide emergency gas shutoff control systems of one (1) of the following:
- A. Isimet Controls

PART 3 - EXECUTION

3.01 INSTALLATION

- (A) Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
- 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- (B) Install water regulators with inlet and outlet shutoff valves [and bypass with memory-stop balancing valve]. Install pressure gages on inlet and outlet.
- (C) Install water control valves with inlet and outlet shutoff valves [and bypass with globe valve]. Install pressure gages on inlet and outlet.
- (D) Install balancing valves in locations where they can easily be adjusted.
- (E) Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
- 1. Install thermometers and water regulators if specified.
 - 2. Install cabinet-type units recessed in or surface mounted on wall as specified.
- (F) Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
- (G) Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs.
- (H) Install water hammer arresters in water piping as shown on drawings.
- (I) Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

- (J) Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet for piping NPS 2 and smaller and 100 feet for larger piping.
 4. Locate at base of each vertical soil and waste stack. Install access door if required.
- (K) For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- (L) For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- (M) Install floor drains at low points of surface areas to be drained.
1. Set grates of drains flush with finished floor, unless otherwise indicated.
 2. For kitchen floor drains, coordinate grate elevation with kitchen equipment supplier and local health department regulations.
 3. Position floor drains for easy access and maintenance.
 4. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - A. Radius, 30-Inches or Less: Equivalent to 1% slope, but not less than 1/4-inch total depression.
 - B. Radius, 30- to 60-Inches: Equivalent to 1% slope.
 - C. Radius, 60-Inches or Larger: Equivalent to 1% slope, but not greater than 1-inch total depression.
 5. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 6. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- (N) Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- (O) Install through-penetration firestop assemblies in plastic stacks at floor penetrations.
- (P) Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 2. Size: Same as floor drain inlet.

- (Q) Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- (R) Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- (S) Install interceptors according to authorities having jurisdiction and with clear space for servicing.
- (T) Install wood-blocking reinforcement for wall-mounting-type specialties.
- (U) Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- (V) Install automatic flow control valves in each hot-water circulation return branch.
- (W) Install Y-type strainer upstream of each automatic flow control valve.
- (X) Check Valves: Install swing check valve, between pump and shutoff valve.

3.02 CONNECTIONS

- (A) Install piping adjacent to equipment to allow service and maintenance.

3.03 LABELING AND IDENTIFYING

- (A) Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Primary, thermostatic, water mixing valves.

3.04 FIELD QUALITY CONTROL

- (A) Perform the following tests and prepare test reports:
 - 1. Test each reduced-pressure-principle backflow preventer and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.
- (B) Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.05 ADJUSTING

- (A) Set field-adjustable pressure set points of water pressure-reducing valves.
- (B) Set field-adjustable flow set points of balancing valves.
- (C) Set field-adjustable temperature set points of temperature-actuated water mixing valves.

3.06 PROTECTION

- (A) Protect drains during construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

- (B) Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 11 19 – PLUMBING SPECIALTIES

SECTION 22 11 23 - PLUMBING PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. In-line Centrifugal Pumps.
2. Submersible Sump Pumps.

1.03 SUBMITTALS

- (A) Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. Wiring Diagrams: For power, signal and control wiring.

- (B) Closeout Submittals: Operation and Maintenance data for plumbing pumps to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

- (A) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- (B) UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.05 DELIVERY, STORAGE, AND HANDLING

- (A) Retain shipping flange protective covers and protective coatings during storage.

- (B) Protect bearings and couplings against damage.

- (C) Comply with pump manufacturer's written rigging instructions for handling.

1.06 COORDINATION

- (A) Coordinate sizes and locations of concrete bases with actual equipment provided.

- (B) Coordinate sizes and locations of concrete sump pump basins with actual equipment provided.

PART 2 - PRODUCTS

2.01 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Armstrong Pumps Inc.
2. Bell & Gossett Domestic Pump; ITT Corporation.
3. Grundfos Pumps Corp.
4. TACO Incorporated.

(B) Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

(C) Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Casing: Stainless steel, with threaded or companion-flange connections.
3. Impeller: Plastic.
4. Motor: Single speed, unless otherwise indicated.

(D) Characteristics:

1. Minimum Working Pressure: 125 PSIG.
2. Maximum Continuous Operating Temperature: 220°F.

(E) Building Management System (BMS) Interface: Auxiliary contacts in pump controls for interface to BMS and capable of providing the following:

1. On-off status of pump.
2. Alarm status.

2.02 SUBMERSIBLE SUMP PUMPS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Bell & Gossett Domestic Pump; ITT Corporation.
2. Grundfos Pumps Corp.
3. Little Giant Pump Co.
4. Pentair Pump Group; Hydromatic Pumps.
5. Stancor, Inc.

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6. Sta-Rite Industries, Inc.
 7. Weil Rite Industries, Inc.
 8. Weinman Division; Crane Pumps & Systems.
 9. Zoeller Company.
- (B) Description: Factory-assembled and -tested sump-pump unit.
- (C) Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
- (D) Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
- (E) Impeller: Statically and dynamically balanced, ASTM B 584, cast bronze design for clear wastewater handling, and keyed and secured to shaft.
- (F) Pump and Motor Shaft: Stainless steel with factory-sealed, grease-lubricated ball bearings.
- (G) Seal: Mechanical.
- (H) Motor: Hermetically sealed, capacitor-start type; with built-in overload protection lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
- (I) Controls:
1. Enclosure: NEMA 250, Type 1.
 2. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 4. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and auxiliary contacts.
- (J) Building Management System (BMS) Interface: Auxiliary contacts in pump controls for interface to BMS and capable of providing the following:
1. On-off status of pump.
 2. Alarm status.
- 2.03 SUMP PUMP BASINS AND BASIN COVERS**
- (A) Basins: Factory-fabricated, watertight, cylindrical one piece seamless construction, basin sump with top flange and sidewall openings if required for pipe connections.
1. Materials: Fiberglass or Polyethylene.
 2. Reinforcement: Mounting plates for pumps, fittings, and accessories.

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3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

(B) Basin Covers:

1. Factory-fabricated, fiberglass, polyethylene or steel cover with openings as required for piping connections, power cables and access to pumps.
2. Provide open grate type cover for sump pump basin serving elevator pit.

2.04 CONTROLS

(A) Pressure Switches: Electric, adjustable for control of water-supply pump.

1. Type: Water-immersion pressure sensor, for installation in piping.
2. Enclosure: NEMA 250, Type 4X.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.

(B) Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Where indicated, provide aquastat on domestic hot water recirculation line to enable hot water recirculation pump. Aquastat control range shall be 95°F to 115°F. Aquastat shall be Taco Model 563-2 or approved equal.

(C) Automatic Flow Control Valves.

1. Provide automatic flow control devices, Class 150, cast-iron housing, stainless steel operating parts; threaded connections for 2-inch and smaller, flanged connections for 2-1/2-inch and larger. Factory set to automatically control flow rates within plus or minus 5% design, while compensating for system operating pressure differential.
2. Provide Y-strainer upstream of valve inlet. Provide pressure/temperature ports on inlet and outlet for flow measuring equipment. Provide a metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and rate flow in GPM.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A)** Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.02 PUMP INSTALLATION

- (A)** Comply with HI 1.4.

- (B)** Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.

- (C) Install horizontally mounted, in-line, centrifugal pumps with shaft(s) horizontal.
- (D) Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
- (E) Install continuous-thread hanger rods and spring hangers of size required to support pump weight.
- (F) Install pressure switches in water supply piping.
- (G) Install thermostats in hot-water return piping.

3.03 CONNECTIONS

- (A) Install piping adjacent to pumps to allow service and maintenance.
- (B) Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - A. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - B. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - C. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - 2. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping.
 - 3. Install pressure gage and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gage tapings where provided or install pressure-gage connectors in suction and discharge piping around pumps.

(C) Comply with Division 26 Sections for electrical connections and wiring methods.

(D) Connect control devices to pumps that they control.

3.04 FIELD QUALITY CONTROL

- (A) Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- (B) Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- (C) Pumps and controls will be considered defective if they do not pass test and inspections.
- (D) Prepare test and inspection reports.
- 3.05 STARTUP SERVICE
- (A) Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Check piping connections for tightness.
 3. Clean strainers on suction piping.
 4. Set control devices for automatic starting and stopping operation of pumps.
 5. Perform the following startup checks for each pump before starting:
 - A. Verify bearing lubrication.
 - B. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - C. Verify that pump is rotating in the correct direction.
 6. Prime pump by opening suction valves and closing drains and prepare pump for operation.
 7. Start motor.
 8. Open discharge valve slowly.
 9. Adjust control devices as required.
- 3.06 ADJUSTING
- (A) Adjust pumps to function smoothly and lubricate as recommended by manufacturer.
- (B) Adjust initial control set points.
- 3.07 DEMONSTRATION
- (A) Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 22 11 23 – PLUMBING PUMPS

SECTION 22 11 25 - DOMESTIC WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Multiplex, variable-speed booster pumps.

1.03 SUBMITTALS

- (A) Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. For booster pumps. Include plans, elevations, sections, details, and attachments to other work.
2. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Wiring Diagrams: For power, signal, and control wiring.

- (B) Closeout: Operation and Maintenance data for booster pumps to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

- (A) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- (B) ASME Compliance: Comply with ASME B31.9 for piping.

- (C) UL Compliance for Packaged Pumping Systems:

1. UL 508, "Industrial Control Equipment."
2. UL 508A, "Industrial Control Panels."
3. UL 778, "Motor-Operated Water Pumps."
4. UL 1995, "Heating and Cooling Equipment."

- (D) Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

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1.05 DELIVERY, STORAGE, AND HANDLING

(A) Retain protective coatings and flange's protective covers during storage.

1.06 COORDINATION

(A) Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.01 MULTIPLEX, VARIABLE-SPEED BOOSTER PUMPS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Armstrong Pumps Inc.
2. Bell & Gossett Domestic Pump; ITT Corporation.
3. Canariis Corporation.
4. Delta P Systems, Inc.
5. Grundfos Pumps Corporation U.S.A.
6. TIGERFLOW Systems, Inc.

(B) Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.

(C) Pumps:

1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
2. Casing: Radially split; stainless steel.
3. Impeller: Closed, ASTM B 584 cast bronze or stainless steel; statically and dynamically balanced and keyed to shaft.
4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
5. Seal: Mechanical.

(D) Piping: Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump.

(E) Valves:

1. Shutoff Valves NPS 2 and Smaller: Two-piece, full-port ball valve, in each pump's suction and discharge piping.
2. Shutoff Valves NPS 2-1/2 and Larger: Lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers.

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3. Check Valves NPS 2 and Smaller: Swing type in each pump's discharge piping.
 4. Check Valves NPS 2-1/2 and Larger: Silent type in each pump's discharge piping.
 5. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
- (F) Dielectric Fittings: With insulating material isolating joined dissimilar metals.
- (G) Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions.
1. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in controller. Install VFC for pump motors larger than 25 hp in separate panel; same type as motor control panel enclosure.
 2. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.
 3. Motor Overload Protection: Overload relay in each phase.
 4. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.
 - A. Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
 5. Pump Operation and Sequencing: Pressure-sensing method.
 - A. Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
 6. VFC: Voltage-source, pulse-width, modulating-frequency converter for each pump.
 7. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
 8. Instrumentation: Suction and discharge pressure gauges.
 9. Lights: Running light for each pump.
 10. Alarm Signal Device: Sounds alarm when backup pumps are operating.
 - A. Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with manual reset.
 11. Thermal-bleed cutoff.
 12. Low-suction-pressure cutout.
 13. High-suction-pressure cutout.
 14. Low-discharge-pressure cutout.
 15. High-discharge-pressure cutout.

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16. Building Automation System Interface: Provide auxiliary contacts for interface to building automation system. Include the following:
- A. On-off status of each pump.
 - B. Alarm status.
- (H) Base: Structural steel.
- 2.02 MOTORS
- (A) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
- 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.02 INSTALLATION

- (A) Equipment Mounting: Install booster pumps on concrete base using elastomeric pads.
- 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- (B) Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.03 CONNECTIONS

- (A) Comply with requirements for piping specified in Division 22 "Plumbing Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- (B) Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers.

1. Install shutoff valves on piping connections to booster-pump suction and discharge headers. Install ball or butterfly valves same size as suction and discharge headers.
2. Install union, flanged, or grooved-joint connections on suction and discharge headers at connection to domestic-water piping.
3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers.
4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers.
5. Install piping adjacent to booster pumps to allow service and maintenance.

3.04 IDENTIFICATION

- (A) Identify system components.

3.05 FIELD QUALITY CONTROL

- (A) Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

- (B) Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

- (C) Tests and Inspections:

1. Perform visual and mechanical inspection.
2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- (D) Pumps and controls shall be considered defective if they do not pass tests and inspections.

- (E) Prepare test and inspection reports.

3.06 STARTUP SERVICE

- (A) Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.07 ADJUSTING

- (A) Adjust booster pumps to function smoothly and lubricate as recommended by manufacturer.
- (B) Adjust pressure set points.
- (C) Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.08 DEMONSTRATION

- (A) Train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 22 11 25 – DOMESTIC WATER PACKAGED BOOSTER PUMPS

SECTION 22 31 00 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Commercial water softeners.
2. Chemicals.
3. Water-testing sets.

1.03 SUBMITTALS

- (A) Product Data: For each type of product indicated.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water softeners.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Wiring Diagrams: For power, signal, and control wiring.

- (B) Warranty: Special warranty specified in this Section.

- (C) Closeout: Operation and Maintenance data for water softeners to include in emergency, operation, and maintenance manuals.

1. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

- (A) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended application.

- (B) ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

- (C) ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.

- (D) UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

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1.05 COORDINATION

- (A) Coordinate sizes and locations of concrete bases with actual equipment provided.

1.06 WARRANTY

- (A) Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softeners that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - A. Structural failures of mineral and brine tanks.
 - B. Faulty operation of controls.
 - C. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - D. Attrition loss of resin exceeding 3% per year.
 - E. Mineral washed out of system during service run or backwashing period.
 - F. Effluent turbidity greater and color darker than incoming water.
 - G. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.
2. Commercial Water Softeners, Warranty Period: From date of Substantial Completion.
 - A. Mineral Tanks: 10 years.
 - B. Brine Tanks: 10 years.
 - C. Control Valve: Five (5) years.

1.07 MAINTENANCE SERVICE

- (A) Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of water softener Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper water softener operation at rated capacity. Provide parts and supplies the same as those used in the manufacture and installation of original equipment.
- (B) Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.08 EXTRA MATERIALS

- (A) Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Salt for Brine Tanks: Furnish in same form as and at least four times original load, but not less than 200 lb.
2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.

PART 2 - PRODUCTS

2.01 COMMERCIAL WATER SOFTENERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Culligan International Company.
2. Kinetico Incorporated.
3. WaterSoft; a division of Amtrol, Inc.
4. Wood Brothers, Industries.

(B) Description: Factory-assembled, pressure-type water softener.

1. Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects."
2. Mounting: Provide all tanks and accessories fully factory-piped and mounted on steel skid.
3. Wetted Components: Suitable for water temperatures from 40 to at least 150° F.
4. Mineral Tanks: FRP, pressure-vessel quality.
 - A. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."
 - B. Pressure Rating: 125 PSIG minimum.
 - C. Freeboard: 50% minimum for backwash expansion above normal resin bed level.
 - D. Support Legs or Skirt: Constructed of structural steel, welded to tank.
 - E. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
 - F. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, non-clogging plastic strainers, and arranged for even flow distribution through resin bed.
 - G. Liner: PE, ABS, or other material suitable for potable water.
5. Controls: Fully automatic; factory wired and factory mounted on unit.
 - A. Adjustable duration of various regeneration steps.
 - B. Push-button start and complete manual operation.

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- C. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
 - D. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration and return to service.
 - E. Pointer on pilot-control valve shall indicate cycle of operation.
 - F. Includes means of manual operation of pilot-control valve if power fails.
6. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
- A. Slow opening and closing, non-slam operation.
 - B. Diaphragm guiding on full perimeter from fully open to fully closed.
 - C. Isolated, dissimilar metals within valve.
 - D. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - E. Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
 - F. Sampling cocks for soft water.
 - G. Special tools shall not be required for service.
7. Flow Control: Automatic or manual, to control backwash and flush rates over wide variations in operating pressure; shall not require field adjustments.
- A. Time Clock Control (automatic regeneration): Each mineral tank shall be equipped with microprocessor time clock control that electrically activates cycle controllers to automatically regenerate at preset duration of operation in days. Control automatically resets to preset duration of operation in days for next service run. Electrical lockout prevents simultaneous regeneration of more than one tank.
8. Brine Tank: Combination measuring and wet-salt storing system.
- A. Tank and Cover Material: Fiberglass, 3/16-inch thick; or molded PE, 3/8-inch thick.
 - B. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawal and freshwater refill.
 - C. Size: Large enough for at least four regenerations at full salting.
9. Factory-Installed Accessories:
- A. Piping, valves, tubing, and drains.
 - B. Sampling cocks.

C. Main-operating-valve position indicators.

D. Water meters.

2.02 CHEMICALS

(A) Mineral: High-capacity, sulfonated-polystyrene, ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.

1. Exchange Capacity: 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.

(B) Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

2.03 WATER-TESTING SETS

(A) Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.04 SOURCE QUALITY CONTROL

(A) Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.

(B) Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 WATER SOFTENER INSTALLATION

(A) Equipment Mounting: Install water softeners on concrete base.

1. Maintain manufacturer's recommended clearances.

2. Arrange units so controls and devices that require servicing are accessible.

3. Anchor water softener and brine tanks to substrate.

(B) Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.

(C) Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

(D) Install water-testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.02 CONNECTIONS

(A) Where piping is installed adjacent to equipment, allow space for service and maintenance of equipment.

(B) Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank.

1. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

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- (C) Install pressure gauges on raw-water inlet and soft-water outlet piping of each mineral tank.
1. Exception: Water softeners with factory-installed pressure gauges at locations indicated.

- (D) Install valved bypass in water piping around water softeners.
1. Exception: Water softeners with factory-installed bypass piping at location indicated.

- (E) Install drains as indirect wastes to spill into open drains or over floor drains.

3.03 FIELD QUALITY CONTROL

- (A) Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- (B) Water softeners will be considered defective if they do not pass tests and inspections.
- (C) Prepare test and inspection reports.

3.04 STARTUP SERVICE

- (A) Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
- (B) Add water to brine tanks and fill with salt.
- (C) Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples) and prepare certified test reports for required water performance characteristics. Comply with ASTM D 1126, "Test Method for Hardness in Water."

3.05 DEMONSTRATION

- (A) Train Owner's maintenance personnel to adjust, operate, and maintain water softeners.

END OF SECTION 22 31 00 – DOMESTIC WATER SOFTENERS

SECTION 22 33 00 - DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Gas-fired, high-efficiency, storage, domestic-water heaters.
2. Domestic-water heater accessories.

- (B) Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections:

1. Water heater manufacturer shall provide control wiring schematic for water heater shutdown switches located at mechanical room exit doors as shown on the drawings. Shutdown control system shall comply with ASME CSD-1, latest edition, "Controls and Safety Devices for Automatically Fired Boilers". Division 22 Contractor shall provide switches and all required control wiring. All wiring shall be in conduit. A stainless steel guard shall be provided to prevent accidental operation of switches. Switches shall have engraved nameplates to identify switch as "Water Heater Emergency Shutdown".

1.03 SUBMITTALS

- (A) Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. Wiring Diagrams: For power, signal, and control wiring.

- (B) Closeout: Operation and Maintenance Data for domestic-water heaters to include in emergency, operation, and maintenance manuals.

- (C) Warranty: Sample of special warranty.

1.04 QUALITY ASSURANCE

- (A) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- (B) ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

- (C) ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

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2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.
- (D) NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."
- 1.05 COORDINATION
- (A) Coordinate sizes and locations of concrete bases with actual equipment provided.
- 1.06 WARRANTY
- (A) Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heaters that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - A. Structural failures including storage tank and supports.
 - B. Faulty operation of controls.
 - C. Deterioration of metals, metal finishes, and other materials beyond normal use.
 2. Warranty Periods: From date of Substantial Completion.
 - A. Storage and Compression Tank: Five (5) years.
 - B. Controls and Other Components: Three (3) years.
 - C. Heat Exchanger: 10 years.
- 1.07 SOURCE QUALITY CONTROL
- (A) Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- (B) Hydrostatically test domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

PART 2 - PRODUCTS

2.01 GAS-FIRED, HIGH-EFFICIENCY, STORAGE, DOMESTIC-WATER HEATERS

- (A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. AERCO International, Inc.
 2. Lochinvar Corporation.
 3. PVI Industries, LLC.
 4. RBI Water Heaters; a Mestek company.

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5. Rheem Manufacturing Company.
 6. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 7. State Industries.
 8. Weben-Jarco, Inc.
- (B) Standard: ANSI Z21.10.3/CSA 4.3.
- (C) Description: Manufacturer's proprietary design to provide at least 95% combustion efficiency at optimum operating conditions.
- (D) Storage-Tank Construction: ASME-code steel with 150 PSIG minimum working-pressure rating.
1. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - A. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - B. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 2. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 3. Lining: Glass complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
- (E) Factory-Installed Storage-Tank Appurtenances:
1. Anode Rod: Replaceable magnesium.
 2. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 3. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 4. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 5. Jacket: Steel with enameled finish.
 6. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
 7. Temperature Control: Adjustable thermostat.
 8. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 9. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

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2.02 DOMESTIC-WATER HEATER ACCESSORIES

(A) Domestic-Water Compression Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. AMTROL Inc.
 - B. Bell & Gossett.
 - C. John Wood Co.
 - D. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 - E. State Industries.
 - F. Taco, Inc.
 - G. Thrush.
2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction: ASME rated and stamped.
 - A. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - B. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - C. Air-Charging Valve: Factory installed.

(B) Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

(C) Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

(D) Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.

(E) Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include pressure rating as required to match gas supply.

(F) Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.

(G) Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

(H)

(H) Gas Venting for High Efficiency Water Heaters

1. Material: Sch. 40 PVC for combustion air piping and AL29-4C stainless steel positive pressure vent system of Sch. 40 PVC vent piping in accordance with manufacturer's installation instructions.
2. Terminate combustion air piping with screened gooseneck, terminate vent piping with approved stack cap. Maintain UL-listed minimum clearances from combustibles.
3. Accessories: Provide manufacturer's standard accessory items as required for complete installation.

PART 3 - EXECUTION

3.01 DOMESTIC-WATER HEATER INSTALLATION

(A) Install domestic-water heaters on concrete base.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.

(B) Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping.

(C) Install combination temperature-and-pressure relief valves in top portion of storage tanks. Install pressure relief valves in water piping for domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

(D) Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains.

(E) Install thermometers on outlet piping of domestic-water heaters.

(F) Install heat traps on inlet and outlet piping of domestic-water heater storage tanks.

(G) Install combustion air and vent piping per manufacturer's installation instructions.

(H) Fill domestic-water heaters with water.

(I) Charge domestic-water compression tanks with air.

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3.02 CONNECTIONS

- (A) Where installing piping adjacent to domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.03 FIELD QUALITY CONTROL

- (A) Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- (B) Domestic-water heaters will be considered defective if they do not pass tests and inspections.

- (C) Prepare test and inspection reports.

3.04 DEMONSTRATION

- (A) Train Owner's maintenance personnel to adjust, operate, and maintain domestic-water heaters.

END OF SECTION 22 33 00 – DOMESTIC WATER HEATERS

SECTION 22 40 00 - PLUMBING FIXTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes the following plumbing fixtures and related components:

1. Water Closets.
2. Urinals.
3. Lavatories.
4. Sinks.
5. Shower bases/enclosures.
6. Water coolers.
7. Service sinks and mop sink basins.
8. Laundry trays.
9. Flushometers.
10. Faucets.
11. Shower valves.
12. Disposers.
13. Toilet seats.
14. Lavatory protective shielding enclosures and piping covers.
15. Fixture supports.
16. General.

1.03 SUBMITTALS

- (A) Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.
- (B) Closeout: Operation and Maintenance data for plumbing fixtures to include in emergency, operation, and maintenance manuals.

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(C) Warranty: Special warranty specified in this section.

1.04 QUALITY ASSURANCE

(A) Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

(B) Regulatory Requirements: Comply with requirements in "Americans with Disabilities Act" for plumbing fixtures for people with disabilities.

(C) Regulatory Requirements: Comply with requirements in "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

(D) NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

(E) Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

(F) Comply with the applicable ASME, ANSI, ASTM, ASSE, NSF and UL standards and other requirements specified for plumbing fixtures, faucets and accessories.

1.05 WARRANTY

(A) Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of plumbing fixtures that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Flushometers: Three (3) years from date of substantial completion.

1.06 COORDINATION

(A) Coordinate all plumbing fixtures with architectural drawings. Refer to architectural drawings, elevations and sections for mounting heights. Notify Architect/Engineer if there are discrepancies.

(B) Coordinate all countertop sinks and lavatories with cabinetry prior to ordering to ensure that the fixtures fit and are installed per manufacturer's recommendations.

PART 2 - PRODUCTS

2.01 WATER CLOSETS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Standard Companies, Inc.
2. Crane Plumbing, LLC/Fiat Products.
3. Kohler Co.
4. Sloan.
5. TOTO USA, Inc.

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6. Zurn Plumbing Products Group.

2.02 URINALS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Standard Companies, Inc.
2. Crane Plumbing, LLC/Fiat Products.
3. Kohler Co.
4. Sloan.
5. TOTO USA, Inc.
6. Zurn Plumbing Products Group.

2.03 LAVATORIES AND SINKS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Standard Companies, Inc.
2. Briggs Plumbing Products, Inc.
3. Crane Plumbing, LLC/Fiat Products.
4. Elkay.
5. Gerber Plumbing Fixtures LLC.
6. Just.
7. Kohler Co.
8. Sloan.
9. TOTO USA, Inc.
10. Zurn Plumbing Products and Group.

2.04 SHOWER BASES/ENCLOSURES

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Acorn Engineering Company.
2. American Standard Companies, Inc.
3. Aqua Bath Company, Inc.
4. Aqua Glass Corporation.

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5. Best Bath Systems.
6. Bradley Corporation.
7. Comfort Design
8. Crane Plumbing, L.L.C./Fiat Products.
9. Kohler Co.
10. LASCO Bathware.
11. Sterling Plumbing Group, Inc.
12. Stern-Williams Co., Inc.

2.05 BATHTUBS AND WHIRLPOOLS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Standard Companies, Inc.
2. Aqua Bath Company, Inc.
3. Aqua Glass Corporation.
4. Best Bath Systems; a div. of Fiberglass Systems, Inc.
5. Crane Plumbing, L.L.C./Fiat Products.
6. Kohler Co.

2.06 WATER COOLERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Acorn.
2. Elkay Manufacturing Co.
3. Halsey Taylor.
4. Haws Corporation.
5. Oasis.

2.07 SERVICE SINKS AND MOP SINK BASINS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Acorn.
2. American Standard Companies, Inc.

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3. Crane Plumbing, L.L.C./Fiat Products.
4. Kohler Co.
5. Mustee, E.L. & Sons, Inc.
6. Stern-Williams Co., Inc.
7. Zurn Plumbing Products Group.

2.08 LAUNDRY TRAYS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Crane Plumbing, L.L.C./Fiat Products.
2. Gerber Plumbing Fixtures LLC.
3. Mustee, E. L. & Sons, Inc.
4. Swan Corporation (The).
5. Zurn Plumbing Products Group.

2.09 FLUSHOMETERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Hydrotek International, Inc.
2. Kohler.
3. Moen.
4. Sloan Valve Company.
5. TOTO USA, Inc.
6. Zurn Plumbing Products Group.

2.010 FAUCETS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Standard Companies, Inc.
2. Bradley Corporation.
3. Chicago Faucets.
4. Delta Faucet Company.
5. Elkay Manufacturing Co.

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6. Hydrotek International, Inc.
7. Kohler Co.
8. Moen, Inc.
9. Speakman Company.
10. Symmons.
11. T & S Brass and Bronze Works, Inc.
12. Zurn Plumbing Products Group.

2.011 SHOWER VALVES

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Acorn Engineering Company.
2. American Standard Companies, Inc.
3. Bradley Corporation.
4. Crane Plumbing, L.L.C./Fiat Products.
5. Kohler Co.
6. Moen.
7. Speakman.
8. Symmons.
9. Zurn Plumbing Products Group.

2.012 DISPOSERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. In-Sink-Erator; a div. of Emerson Electric Co.
2. KitchenAid.
3. Maytag Co.

(B) Description: Continuous-feed household, food-waste disposer. Include reset button; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless-steel grinder or shredder; NPS 1-1/2 outlet; quick-mounting, stainless-steel sink flange; antisplash guard; and combination cover/stopper.

2.013 TOILET SEATS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Standard Companies, Inc.
2. Bemis Manufacturing Company.
3. Centoco Manufacturing Corp.
4. Church Seats.
5. Comfort Seats.
6. Kohler Co.
7. Olsonite Corp.
8. Zurn Plumbing Products Group.

2.014 LAVATORY PROTECTIVE SHIELDING ENCLOSURES AND PIPING COVERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Engineered Brass Co.
2. McGuire Manufacturing Co., Inc.
3. Plumberex Specialty Products Inc.
4. TRUEBRO, Inc.
5. Zurn Plumbing Products Group.

(B) Shielding Enclosures:

1. Description: Manufactured rigid plastic premolded one-piece enclosure specifically designed for covering plumbing fixture supply pipes, valves, trap and drain piping, electronic faucet components, mixing valves, and instantaneous water heaters while allowing wheelchair accessibility below lavatories. Comply with Americans with Disabilities Act (ADA) requirements.
2. Construction: White, fungal and bacterial resistant PVC with tamper resistant fasteners.

(C) Piping Covers:

1. Description: Manufactured pipe covering assembly specifically designed for covering plumbing fixture supply pipes, valves, and trap and drain piping while allowing wheelchair accessibility below lavatories. Comply with Americans with Disabilities Act (ADA) requirements.
2. Construction: White, fungal and bacterial resistant molded vinyl with internal, reusable fasteners.

2.015 FIXTURE SUPPORTS

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group.

(B) Water-Closet Supports:

1. Description: Combination carrier designed for accessible or standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

(C) Urinal Supports:

1. Description: Urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

(D) Lavatory Supports:

1. Description: Lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

(E) Sink Supports:

1. Description: Sink carrier with hanger plate, bearing studs, and tie rod for sink-type fixture. Include steel uprights with feet.

2.016 GENERAL

(A) Supplies and Stops: All fixtures shall be provided with supplies and stops.

1. Stops shall be chrome-plated solid brass with brass stems and chloramines-chlorine resistant washers. Stops in public restrooms shall be keyed.
2. Supplies shall be chloramines-chlorine resistant braided stainless steel flexible connectors.

(B) Traps: All fixtures without integral traps shall be provided with traps.

1. P-traps shall be adjustable chrome-plated heavy cast brass 17 gauge tubular wall end, brass slip nuts, and brass flanges.
2. Sink end waste kits shall have cast brass tee and 17 gauge tubular waste arm and brass slip nuts.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- (B) Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- (C) Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- (A) Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- (B) Install plumbing fixtures of types indicated where shown and at indicated heights; in accordance with fixture manufacturer's written instructions, roughing-in drawings, and with recognized industry practices. Comply with requirements of the applicable Plumbing Code pertaining to installation of plumbing fixtures.
- (C) Fasten plumbing fixtures securely to indicated supports or building construction and ensure that fixtures are level and plumb. Secure plumbing supplies behind or within wall construction so as to be rigid and not subject to pull or push movement.
- (D) Supplies and Stops: Provide supplies with stops on all fixtures.
- (E) Traps: Provide traps and tubular waste piping for all fixtures without integral traps.
- (F) Lavatory Shields and Protective Guards: Install protective shields or premolded pipe and valve insulation assemblies beneath lavatories where indicated on the drawings.
- (G) Install flush control handle for accessible water closets and urinals with handle mounted on wide side of compartment.
- (H) Install escutcheons at piping wall/ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings.
- (I) Set bathtubs, shower receptors, and service basins in leveling bed of cement grout.
- (J) Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.03 CONNECTIONS

- (A) Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

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(B) Where plans indicate fixtures to be furnished by others, this Contractor shall provide all rough-in, furnish P-traps, stops and supplies and shall connect such fixtures to the plumbing system. Traps and tailpieces shall be of the same material as the pipe.

(C) Connect wiring and ground equipment according to Division 26 requirements.

3.04 FIELD QUALITY CONTROL

(A) Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

(B) Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

(C) Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

(D) Replace washers and seals of leaking and dripping faucets and stops.

(E) Install new batteries in sensor-operated mechanisms.

(F) Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Remove sediment and debris from faucet spouts and strainers.

(G) Provide protective covering for installed fixtures and fittings.

(H) Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 40 00 – PLUMBING FIXTURES

SECTION 23 00 00 - HVAC GENERAL PROVISIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This section includes general requirements for HVAC systems and HVAC motors.

1.03 CONTRACT DOCUMENT COORDINATION

- (A) Contract Documents are diagrammatic in showing certain physical relationships between architectural, structural, mechanical, plumbing and electrical work.

1. Verification and coordination of these relationships is the responsibility of the Contractor.
2. Contractor shall verify existing conditions before starting work.
3. Floor plan drawings do not necessarily indicate all required offsets, fittings, valves, etc.
4. Provide all necessary piping, fittings, valves, ducts, offsets, and other specialties required without additional cost to the Owner.

- (B) Should Contract Document requirements appear to make it impossible to provide a complete and operational system, or should discrepancies appear among Contract Documents, Contractor shall request clarification before proceeding with work.

1.04 QUALITY ASSURANCE

- (A) Comply with all State, and local codes and ordinances.
- (B) Obtain and pay for all required permits, fees and certificates of inspection of the work.
- (C) Install equipment and devices to provide required access for servicing and maintenance.
- (D) Mechanical Code Compliance: Comply with applicable portions of Local, City, and State Mechanical Code pertaining to mechanical materials construction and installation of products.

1.05 SUBMITTALS

- (A) General: See Division 01, Section Submittal Procedures.
1. Shop Drawing Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information.

PROJECT NO. H IH BLAC 19100

2. Shop Drawing Submittals may also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

(B) Submittal Requirements:

1. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
2. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name, specification section and similar information to distinguish it from other submittals.
3. Provide General Contractor's and Subcontractor's stamp, signed or initialed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Contract Documents. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".
4. Items from each specification section shall be prepared as separate submittals, not grouped or bound with other items. Submittals shall clearly indicate the applicable specification section.

(C) Alternate Equipment Submittal by Contractor:

1. Equipment of greater or larger dimensions, weight, capacity, or rated performance than that which is specified may be submitted provided all connecting mechanical and electrical services, including ductwork and piping connections, circuit breakers, electrical conduit and conductors, motors, equipment supports, building structure, and equipment spaces are modified as required by the proposed equipment. If performance ratings or efficiencies of the equipment are specified, the equipment must meet or exceed these design requirements as well as any specified commissioning requirements. **NO ADDITIONAL COST WILL BE APPROVED FOR ANY SUCH CHANGES RELATED TO THE ALTERNATE EQUIPMENT.**
2. Should proposed alternate equipment involve rearrangement of other designed equipment, a complete layout of the area involved shall be submitted by the Contractor along with the alternate equipment submittal, and shall be approved in writing by the Architect/Engineer prior to ordering, purchasing, delivery or installation of any such items of equipment.
3. **CONTRACTOR SHALL BE RESPONSIBLE FOR ALL ADDITIONAL EXPENSE AND COORDINATION WITH OTHER TRADES RESULTING FROM THE SUBSTITUTION OF EQUIPMENT OTHER THAN THAT SPECIFIED IN THE CONTRACT DOCUMENTS.**

(D) Submittal Review:

1. Review of submittal data is only for general conformance with the design concept of the Project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications.

2. Review of shop drawings does not release the Contractor from further satisfactory equipment operating responsibilities. Equipment shall be approved for final acceptance when installation is completed and all equipment and systems have been operated, tested, adjusted and balanced in compliance with the contract documents.
3. Re-submittals: When revised for resubmission, clearly indicate all changes since previous submission. Only those items required to be resubmitted shall be included.

(E) Operation and Maintenance (O&M) Manuals:

1. Prepare and submit three copies of operation and maintenance instructions for all Division 23 equipment furnished.
 - A. Provide individual 3-ring binders with a table of contents and tabbed sections for each specification section.
 - B. Identify equipment included in the manuals by the equipment mark used in the contract drawings.
 - C. Include emergency instructions, spare parts listing, copies of warranties, wiring diagrams, shop drawings, product data, signed letters of certification of inspection and similar information.
 - D. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner's representative(s) present, date and time of training.
 - E. Provide a list of manufacturer's representatives for each item of equipment including company name, address and phone number.
 - F. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.
2. All information contained in equipment manufacturer's operation and maintenance manual shall be specific to equipment provided. Contractor shall mark out or not include all unrelated information.
3. Electronic O&M Manuals: Provide electronic version of project O&M Manuals in pdf format in addition to hardcopy version of the manuals.

(F) Required Submittals List:

1. Shop Drawings shall be submitted for the items listed in each section of the specifications. Submittals in addition to those listed may be required by the Architect/Engineer.

1.06 RECORD DRAWINGS:

(A) See Division 01, Section Project Record Documents.

(B) Provide a set of mechanical drawings marked-up with actual as-built conditions for Division 23 work. Record drawings shall include all addenda and change orders.

1.07 CONTRACT DRAWING FILE REQUESTS

- (A) As an instrument of service to aid in Shop Drawing Submittals, Farris Engineering (FEI) will provide AutoCAD drawing files upon request. The files will be sent upon return receipt of the "Request for Drawings" agreement signed by an officer of the requesting firm. FEI does not assure that the drawings represent all changes, addenda items, change orders or modifications that may have occurred. The drawings are simply a tool for use in producing shop drawing submittals. The drawing files will be "cleaned-up" by having the FEI logo, Professional Engineer seal, and all extraneous notes and details removed. FEI must be compensated for this additional service by the requesting firm. A minimum fee of \$400.00 for up to eight (8) sheets and \$50.00 per sheet for each additional requested drawing will be invoiced to the requesting firm once the signed agreement is received.

1.08 MECHANICAL/ELECTRICAL COORDINATION

- (A) General: See Division 01, Multiple Contract Summary.
- (B) Mechanical Contractor shall coordinate with Electrical Contractor and verify that proper electrical power connections to mechanical equipment which requires electrical power is provided. Unless specifically shown otherwise Electrical Contractor shall provide power connections to the equipment and Mechanical Contractor shall provide wiring required for start-stop, temperature control and safety interlock functions.
- (C) If mechanical contractor has proposed alternate equipment to that specified in the contract documents, and such alternate equipment requires modified electrical power connections, mechanical contractor shall coordinate these requirements with electrical contractor prior to ordering, purchasing, delivery or installation of any electrical conduits, conductors, circuit breakers and other electrical devices serving the alternate equipment.
- (D) Types of work, normally recognized as electrical but provided as mechanical include but are not necessarily limited to the following:
1. Motors for mechanical equipment.
 2. Starters for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
 3. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, when specifically indicated to be furnished integrally with equipment.
 4. Electrical power connections for mechanical equipment that are not indicated on the electrical drawings.
- (E) Emergency Shutdown Switches: Mechanical Contractor shall coordinate with Electrical Contractor and shall verify that required shutdown switches for all equipment which requires emergency shutdown is provided. Types of equipment provided by mechanical, kitchen or foodservice equipment suppliers that may require emergency shutdown include but is not necessarily limited to the following:
1. Boilers.

1.09 ELECTRIC MOTORS

- (A) Basic Motor Requirements
1. Motors smaller than 1 HP: Single-phase.
 2. Motors 1 HP and Larger: Polyphase.

3. Frequency Rating: 60 Hz.
4. Voltage Rating: Determined by voltage of circuit to which motor is connected.
5. Service Factor: According to NEMA MG-1, unless otherwise indicated.
6. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
7. Enclosure: Open drip proof unless otherwise indicated.

(B) Polyphase Motors

1. Description: NEMA MG-1, medium induction motor.
 - A. Design Characteristics: NEMA MG-1, Design B, unless otherwise indicated.
 - B. Efficiency: NEMA Premium Energy-Efficient Design – all motors.
 - C. Stator: Copper windings, unless otherwise indicated. Multispeed motors shall have separate winding for each speed.
 - D. Rotor: Squirrel cage unless otherwise indicated.
 - E. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
 - F. Temperature Rise: Match insulation rating unless otherwise indicated.
 - G. Insulation: Class F unless otherwise indicated.
2. Motors Used with Variable-Frequency Controllers: Definite-purpose inverter-fed motors in accordance with NEMA MG-1, Part 31. Ratings, Characteristics, and features coordinated with and approved by controller manufacturer.
 - A. Critical vibration frequencies shall not be within operating range of controller output.
 - B. Temperature Rise: Match rating for Class B insulation.
 - C. Insulation: Class H.
 - D. Thermal Protection: Where indicated, conform to NEMA MG-1 requirements for thermally protected motors.
 - E. Motor Shaft Grounding: For motors controlled by variable frequency drives, provide factory installed shaft grounding that requires no maintenance for the service life of the motor.

1.010 TEMPORARY HEATING, COOLING AND VENTILATION DURING CONSTRUCTION

- (A) Existing mechanical systems may be used for temporary heating, cooling and ventilation during construction. New mechanical systems shall not be used for temporary heating, cooling and ventilation. All costs associated with providing temporary heating, cooling and ventilation during construction shall be the responsibility of the Contractor.
- (B) If contractor utilizes existing mechanical system during construction, the contractor shall be required to provide monthly filter changes during construction and one final filter change at the completion of construction.

1.011 FINAL COMPLETION

- (A) The Mechanical Contractor shall not call for a final completion check until all Mechanical Systems have been installed, adjusted, tested, and balanced and in full and complete satisfactory operation and the following certifications of inspection from equipment suppliers have been completed. Certifications of inspection are required on the following equipment:

1. Temperature Control Equipment.
2. Variable Frequency Controllers.
3. Hydronic Pumps.
4. Fans and Ventilators.
5. Boilers.
6. Furnaces and Condensing Units.
7. Chillers.
8. Cooling Towers.
9. Rooftop Units.
10. Air Handling Units.
11. Computer Room Air Conditioning (CRAC) Units.
12. Variable Refrigerant Flow (VRF) Equipment.
13. Water Source Heat Pumps.
14. Unit Heaters.
15. Humidifiers.

- (B) Certifications of Inspection shall consist of letters signed by Factory-Trained and -Authorized Service Personnel stating the following:

1. They have inspected all of their equipment on the project.
2. They approve the condition of the equipment and its installation.

- 3. They have fully checked its operation and certify that it is operating properly.
 - 4. They have noted any problems, conditions or objections that could lead to future operating problems.
- (C) Documentation of the signed letters of Certification of Inspection shall be furnished in the Operations and Maintenance Manuals, included with the associated equipment.

1.012 GUARANTEE

- (A) The one year guarantee period shall not start until the project is fully completed and the Contractor has received the Final Payment and Certificate of Completion.
- (B) All equipment and all work shall be fully guaranteed, parts and labor, for one full year from the date of the Certificate of Completion. Repairs made during this period must be fully guaranteed for an additional one year period from the date of repairs.
- (C) The Mechanical Contractor has the full responsibility to guarantee all equipment and work and shall assume full responsibility to repair any equipment at his cost that the manufacturer refuses to guarantee.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 ELECTRICAL WORK PROVIDED BY MECHANICAL

- (A) All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of the equipment manufacturer, this Section and Division 26.

3.02 PIPE HANGING AND SUPPORT

- (A) All piping systems shall be supported from building structural systems capable of supporting the applied load.
- (B) Piping shall not be supported from metal roof decking.

3.03 PAINTING AND FINISHING

- (A) Painting of exposed mechanical work is specified and performed under other divisions of these specifications, or as indicated on the drawings.
- (B) Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.
- (C) Paint inside of ductwork black, where it can be seen from occupied spaces through diffusers, grilles or louvers (under any lighting condition).

3.04 REBATES

- (A) Contractor shall assist the Owner with filing of applicable forms to obtain rebates. This shall include but not be limited to determination of qualifying equipment and materials and furnishing invoices for equipment and materials as required to support the rebate application.

END OF SECTION 23 00 00 – HVAC GENERAL PROVISIONS

SECTION 23 00 10 - MECHANICAL SUBMITTALS

PART 1 - GENERAL

1.01 GENERAL

- (A) Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information not in standard printed form for general application to a range of similar projects.
- (B) Submittals shall also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

1.02 SUBMITTAL REQUIREMENTS

- (A) Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
- (B) Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name and similar information to distinguish it from other submittals. Show Contractor's executed review and approval marking and providing space for Architect's/Engineer's "Action" marking. Package each submittal appropriately for transmittal and handling. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".
- (C) Provide Contractor's certification on form, ready for execution, stating that information submitted complies with requirements of contract documents.
- (D) The Contractor shall be responsible for and bear any expense of alterations to the building or its appurtenances resulting from the substitution of equipment to that specified in the Contract Documents.
- (E) Review of submittals does not release the Contractor from further satisfactory operating responsibilities. Material and equipment shall be approved for final acceptance when construction is completed and all units and systems have been operated, tested, adjusted and balanced to the satisfaction of the Architect/Engineer. Should proposed approved alternate equipment involve rearrangement of designed equipment, a complete layout of the area involved shall be submitted by the Contractor and shall be approved in writing before installation of any such items of equipment. Any additional expense involved shall be a Contractor-borne expense.
- (F) Electronic Submittals: All submittals for shop drawings, O & M Manuals and Record Drawings shall be in electronic PDF format. Identify and incorporate information in each electronic submittal file as follows:
1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
 2. Name file with submittal number or other unique identifier, including revision identifier.

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- A. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., IHS BLACKFEET-23 05 00). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., IHS BLACKFEET-23 05 00-A).
- 3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect and/or Construction Manager.
- 4. Transmittal Form for Electronic Submittals: Use software-generated form from electronic project management software acceptable to Architect, Engineer and Owner, containing the following information:
 - A. Project name.
 - B. Date.
 - C. Name and address of Architect.
 - D. Name of Construction Manager.
 - E. Name of Contractor.
 - F. Name of firm or entity that prepared submittal.
 - G. Names of subcontractor, manufacturer, and supplier.
 - H. Category and type of submittal.
 - I. Submittal purpose and description.
 - J. Specification Section number and title.
 - K. Specification paragraph number or drawing designation and generic name for each of multiple items.
 - L. Drawing number and detail references, as appropriate.
 - M. Location(s) where product is to be installed, as appropriate.
 - N. Related physical samples submitted directly.
 - O. Indication of full or partial submittal.
 - P. Transmittal number, numbered consecutively.
 - Q. Submittal and transmittal distribution record.
 - R. Other necessary identification.
 - S. Remarks.

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1.03 SUBMITTAL LIST

- (A) Submittals shall be submitted for, but not limited to, the items listed in each section of the specifications. Submittals, in addition to those listed, may be required by the Architect/Engineer. The following submittal register is a summary list of submittals required for the project.

SUBMITTAL REGISTER	
SECTION	ITEM
23 00 00	O&M Manuals
23 00 00	Record Drawings
23 00 00	Certification of Inspection
23 05 00	Valves
23 05 00	Piping Specialties
23 05 00	Meters and Gauges
23 05 00	Supports and Anchors
23 05 00	Mechanical Identification
23 05 00	Vibration Control
23 05 00	Access Panels
23 05 00	Joint Sealants
23 05 93	Test & Balance Report
23 07 00	HVAC Insulation Materials Schedule
23 09 00	Electric Control & Facilities Management Systems Installation Drawings
23 09 00	Electric Control & Facilities Management Systems Control Strategies
23 09 00	Electric Control & Facilities Management Systems Equipment
23 09 00	Operation & Maintenance Manuals
23 09 33	Variable Frequency Drives
23 20 00	Pumps
23 21 13	Hydronic Piping & Fittings
23 21 13	Hydronic Specialties
23 21 13	Hydronic System Testing and Cleaning
23 23 00	Refrigerant Piping & Fittings
23 23 00	Refrigerant Valves & Specialties
23 23 00	Brazing Certification
23 25 00	Hydronic System Cleaning & Treatment
23 25 00	Chemical Feeders
23 52 16	High Efficiency Boilers
23 52 16	Boiler Accessories
23 52 16	Boiler Stack and Combustion Air Duct
23 64 00	Water Chiller
23 64 00	Refrigerant Piping Schematic
23 72 00	Energy Recovery Ventilators
23 81 26	Ductless Split Systems
23 81 26	Ductless Split System Accessories
23 82 00	Fan Coils
23 82 00	Coils
23 82 39	Electric Cabinet Heaters
23 82 39	Electric Unit Heaters

END OF SECTION 23 00 10 – MECHANICAL SUBMITTALS

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**MECHANICAL SUBMITTALS
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SECTION 23 01 34 - INDOOR AIR QUALITY

PART 1 - GENERAL

1.01 SECTION INCLUDES

- (A) Construction procedures to promote adequate indoor air quality after construction.
- (B) Testing indoor air quality after completion of construction.
- (C) Testing air change effectiveness after completion of construction.

1.02 PROJECT GOALS

- (A) Duct and Airborne Particulates: Prevent deposition of dust and other particulates in HVAC ducts and equipment.
 - 1. Cleaning of ductwork is not contemplated under this Contract.
 - 2. Contractor shall bear the cost of cleaning required due to failure to protect ducts and equipment from construction dust.
- (B) Airborne Contaminants: Procedures and products have been specified to minimize indoor air pollutants.
 - 1. Furnish products meeting the specifications.
 - 2. Avoid construction practices that could result in contamination of installed products leading to indoor air pollution.
- (C) Ventilation: HVAC system has been designed to achieve the minimum requirements for ventilation specified in ASHRAE 62.2.

1.03 RELATED REQUIREMENTS

- (A) Quality Requirements: Testing and inspection services.
- (B) Volatile Organic Compound (VOC) Content Restrictions.
- (C) Testing, Adjusting and Balancing: Testing HVAC systems for proper air flow rates, adjustment of dampers and registers, and settings for equipment.

1.04 DEFINITIONS

- (A) Adsorptive Materials: Gypsum board, acoustical ceiling tile and panels, carpet and carpet tile, fabrics, fibrous insulation, and other similar products.
- (B) Contaminants: Gases, vapors, regulated pollutants, airborne mold and mildew, and the like, as specified.
- (C) Particulates: Dust, dirt, and other airborne solid matter.
- (D) Wet Work: Concrete, plaster, coatings, and other products that emit water vapor or volatile organic compounds during installation, drying, or curing.

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INDOOR AIR QUALITY
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1.05 SUBMITTALS

(A) See Administrative Requirements, for submittal procedures.

(B) Indoor Air Quality Management Plan: Describe in detail measures to be taken to promote adequate indoor air quality upon completion; use SMACNA IAQ Guidelines for Occupied Buildings Under Construction as a guide.

1. Submit not less than 60 days before enclosure of building.
2. Identify potential sources of odor and dust.
3. Identify construction activities likely to produce odor or dust.
4. Identify areas of project potentially affected, especially occupied areas.
5. Evaluate potential problems by severity and describe methods of control.
6. Describe construction ventilation to be provided, including type and duration of ventilation, use of permanent HVAC systems, types of filters and schedule for replacement of filters.
7. Describe cleaning and dust control procedures.
8. Describe coordination with commissioning procedures.

(C) Interior Finishes Installation Schedule: Identify each interior finish that either generates odors, moisture, or vapors or is susceptible to adsorption of odors and vapors, and indicate air handling zone, sequence of application, and curing times.

(D) Duct and Terminal Unit Inspection Report.

(E) Air Contaminant Test Plan: Identify:

1. Testing agency qualifications.
2. Locations and scheduling of air sampling.
3. Test procedures, in detail.
4. Test instruments and apparatus.
5. Sampling methods.

(F) Air Contaminant Test Reports: Show:

1. Location where each sample was taken, and time.
2. Test values for each air sample; average the values of each set of 3.
3. HVAC operating conditions.
4. Certification of test equipment calibration.
5. Other conditions or discrepancies that might have influenced results.

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(G) Ventilation Effectiveness Test Plan: Identify:

1. Testing agency qualifications.
2. Description of test spaces, including locations of air sampling.
3. Test procedures, in detail; state whether tracer gas decay or step-up will be used.
4. Test instruments and apparatus; identify tracer gas to be used.
5. Sampling methods.

(H) Ventilation Effectiveness Test Reports: Show:

1. Include preliminary tests of instruments and apparatus and of test spaces.
2. Calculation of ventilation effectiveness, E.
3. Location where each sample was taken, and time.
4. Test values for each air sample.
5. HVAC operating conditions.
6. Other information specified in ASHRAE 129.
7. Other conditions or discrepancies that might have influenced results.

1.06 QUALITY ASSURANCE

(A) Testing and Inspection Agency Qualifications: Independent testing agency having minimum of 5 years' experience in performing the types of testing specified.

PART 2 - PRODUCTS

2.01 MATERIALS

(A) Low VOC Materials: See other sections for specific requirements for materials with low VOC.

(B) Auxiliary Air Filters: MERV of 8, minimum, when tested in accordance with ASHRAE 52.2.

PART 3 - EXECUTION

3.01 CONSTRUCTION PROCEDURES

(A) Prevent the absorption of moisture and humidity by adsorptive materials by:

1. Sequencing the delivery of such materials so that they are not present in the building until wet work is completed and dry.
2. Delivery and storage of such materials in fully sealed moisture-impermeable packaging.
3. Provide sufficient ventilation for drying within reasonable time frame.

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- (B) Begin construction ventilation when building is substantially enclosed.
- (C) If extremely dusty or dirty work must be conducted inside the building, shut down HVAC systems for the duration; remove dust and dirt completely before restarting systems.
- (D) When working in a portion of an occupied building, prevent movement of air from construction area to occupied area.
- (E) HVAC equipment and ductwork may NOT be used for ventilation during construction:
 - 1. Provide temporary ventilation equivalent to 1.5 air changes per hour, minimum.
 - 2. Exhaust directly to outside.
 - 3. Seal HVAC air inlets and outlets immediately after duct installation.
- (F) Do not store construction materials or waste in mechanical or electrical rooms.
- (G) Prior to use of return air ductwork without intake filters clean up and remove dust and debris generated by construction activities.
 - 1. Inspect duct intakes, return air grilles, and terminal units for dust.
 - 2. Clean plenum spaces, including top sides of lay-in ceilings, outsides of ducts, tops and pipes and conduit.
 - 3. Clean tops of doors and frames.
 - 4. Clean mechanical and electrical rooms, including tops of pipes, ducts, and conduit, equipment, and supports.
 - 5. Clean return plenums of air handling units.
 - 6. Remove intake filters last, after cleaning is complete.
- (H) Do not perform dusty or dirty work after starting use of return air ducts without intake filters.
- (I) Use other relevant recommendations of SMACNA IAQ Guideline for Occupied Buildings Under Construction for avoiding unnecessary contamination due to construction procedures.

3.02 AIR CONTAMINANT TESTING

- (A) Perform air contaminant testing before occupancy.
- (B) Do not start air contaminant testing until:
 - 1. All construction is complete, including interior finishes.
 - 2. HVAC systems have been tested, adjusted, and balanced for proper operation.
 - 3. New HVAC filtration media have been installed.

(C) Indoor Air Samples: Collect from spaces representative of occupied areas:

1. Collect samples while operable windows and exterior doors are closed, HVAC system is running normally as if occupied, with design minimum outdoor air, but with the building unoccupied.
2. Collect samples from spaces in each contiguous floor area in each air handler zone, but not less than one sample per 25,000 square feet; take samples from areas having the least ventilation and those having the greatest presumed source strength.
3. Collect samples from height from 36 inches to 72 inches above floor.
4. Collect samples from same locations on 3 consecutive days during normal business hours; average the results of each set of 3 samples.
5. Exception: Areas with normal very high outside air ventilation rates, such as laboratories, do not need to be tested.
6. When retesting the same building areas, take samples from at least the same locations as in first test.

(D) Outdoor Air Samples: Collect samples at outside air intake of each air handler at the same time as indoor samples are taken.

(E) Analyze air samples and submit report.

(F) Air Contaminant Concentration Determination:

1. Carbon Monoxide: Not more than 9 parts per million and not more than 2 parts per million higher than outdoor air.
2. Carbon Dioxide: Measure in ppm, in relation to outdoor air; not more than 700 ppm higher than outdoor air.
3. Airborne Mold and Mildew: Measure in relation to outside air; not higher than outside air.
4. Formaldehyde: Not more than 50 parts per billion.
5. Total Volatile Organic Compounds (TVOC): No more than 500 micrograms per cubic meter.
6. 4-Phenylcyclohexane (4-PCH): Not more than 6.5 micrograms per cubic meter.
7. Particulates (PM10): Not more than 50 micrograms per cubic meter.
8. Regulated Pollutants: Measure in relation to outside air; not more than contained in outside air.

(G) If air samples show concentrations higher than those specified, ventilate with maximum outside air and retest at no cost to Owner, or conduct full building flush-out.

END OF SECTION 23 01 34

SECTION 23 05 00 - COMMON HVAC MATERIALS AND REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes the following common HVAC materials and requirements.

1. Valves:

- A. Gate
- B. Ball
- C. Plug
- D. Globe
- E. Butterfly
- F. Check

2. Valve Tags and Valve Schedules.

3. Piping Specialties:

- A. Pipe escutcheons
- B. Pipeline strainers
- C. Pipe sleeves
- D. Dielectric unions

4. Meters and Gauges:

- A. Glass thermometers
- B. Pressure gauges
- C. Test plugs

5. Supports and Anchors:

- A. Horizontal-piping hangers and supports
- B. Saddles and shields

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COMMON HVAC MATERIALS
AND REQUIREMENTS
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6. HVAC Identification.
7. Vibration Control:
 - A. Spring isolators
 - B. Isolation hangers
 - C. Flexible pipe connectors
 - D. Isolation pads
8. Access Panels.
9. Nonshrink Grout for equipment installations.
10. Joint sealers for sealing around mechanical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
11. Installation requirements common to piping and equipment specification Sections.
12. Concrete equipment base construction requirements.
13. HVAC demolition.
14. Cutting and patching.
15. Piping tests.

1.03 DEFINITIONS

- (A) Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.
- (B) Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below the roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
- (C) Exposed Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- (D) Exposed Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- (E) Concealed Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- (F) Concealed Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

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COMMON HVAC MATERIALS
AND REQUIREMENTS

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1.04 SUBMITTALS

(A) Shop Drawing Submittals:

1. General: Submit the following according to the Conditions of the Contract.
2. Product data for following piping specialties:
 - A. Valves.
 - B. Mechanical sleeve seals.
 - C. Thermometers.
 - D. Pressure gauges.
 - E. Identification materials and devices.
 - F. Vibration Isolators.
 - G. Access panels.

1.05 QUALITY ASSURANCE

- (A) All HVAC equipment, ductwork, piping and connections shall be installed per requirements of the applicable mechanical code.
- (B) Qualify welding processes and operators for structural steel according to AWS D1.1 "Structural Welding Code Steel."
- (C) Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions of ASME B31 Series "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.
- (D) MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions."
- (E) ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves."
- (F) FCI Compliance: Test and rate Y-type strainers in accordance with FCI 73-1 "Pressure Rating Standard for Y-type strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than Y-type".
- (G) UL and FM Compliance: Provide meters, gauges, and supports which are UL-listed and FM approved.
- (H) MSS Standard Compliance: Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

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- (I) ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
 - (J) Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements. No additional cost will be approved for any such changes.
- 1.06 DELIVERY, STORAGE, AND HANDLING**
- (A) Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
 - (B) Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.
 - (C) Protect flanges, fittings, and piping specialties from moisture and dirt.
 - (D) Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.
- 1.07 SEQUENCING AND SCHEDULING**
- (A) Coordinate HVAC equipment installation with other building components.
 - (B) Arrange for chases, slots, and openings in building structure during progress of construction to allow for HVAC installations.
 - (C) Coordinate the installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
 - (D) Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.
 - (E) Coordinate connection of electrical services.
 - (F) Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
 - (G) Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces.
 - (H) Perform demolition and new mechanical work in phases as indicated.
- 1.08 PROJECT CONDITIONS**
- (A) Conditions Affecting Selective Demolition:
 - 1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.

2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

(B) Conditions Affecting Excavations:

1. Maintain and protect existing building services which transit the area affected by excavations.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
4. Remove existing underground utilities indicated to be removed.
 - A. Uncharted or Incorrectly Charted Utilities: Contact Utility Owner immediately for instructions.
 - B. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Owner and Engineer prior to utility interruption.
5. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.01 PIPE AND PIPE FITTINGS

(A) Refer to individual piping system specification Sections for pipe and fitting materials and joining methods.

(B) Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

(A) Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, except where thickness or specific material is indicated.
 - A. Full-Face Type: For flat-face, Class 125 cast-iron and cast-bronze flanges.
 - B. Narrow-Face Type: For raised-face, Class 250 cast-iron and steel flanges.
2. ASME B16.20 for grooved, ring-joint, steel flanges.
3. AWWA C110, rubber, flat face, 1/8-inch thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.

(B) Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.

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(C) Solder Filler Metal: ASTM B 32.

1. Alloy Sn95 or Alloy Sn94: Tin (approximately 95%) and silver (approximately 5%), having 0.10% lead content.
2. Alloy Sn50: Tin (50%) and lead (50%) (for use on nonpotable water systems only).

(D) Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

(E) Solvent Cements: Manufacturer's standard solvents complying with the following:

1. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM F 493.
2. Poly(Vinyl Chloride) (PVC): ASTM D 2564.

(F) Plastic Pipe Seals: ASTM F 477, elastomeric gasket.

(G) Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.

(H) Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.

1. Sleeve: ASTM A126, Class B, gray iron.
2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron.
3. Gaskets: Rubber.
4. Bolts and Nuts: AWWA C111.
5. Finish: Enamel paint.

2.03 PIPING SPECIALTIES

(A) Pipe Escutcheons:

1. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

(B) Low Pressure Pipeline Strainers:

1. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 PSI working pressure, with Type 304 stainless steel screens, with 3/64-inch perforations at 233 per square inch.

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2. Threaded Ends, 2-inches and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.
 3. Threaded Ends, 2-1/2-inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
 4. Flanged Ends, 2-1/2-inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
 5. Butt Welded Ends, 2-1/2-inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.
 6. Grooved Ends, 2-1/2-inches and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.
- (C) Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.
1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.
 2. Insulating Material: Suitable for system fluid, pressure, and temperature.
 3. Dielectric Unions: Factory-fabricated, union assembly for 250 PSIG minimum working pressure at a 180°F temperature.
 4. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150 or 300 PSIG minimum pressure to suit system pressures.
 5. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - A. Provide separate companion flanges and steel bolts and nuts for 150 or 300 PSIG minimum working pressure to suit system pressures.
 6. Dielectric Couplings: Galvanized-steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300 PSIG minimum working pressure at 225°F temperature.
 7. Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300 PSIG working pressure at 225°F temperature.
- (D) Mechanical Sleeve Seals: Modular, watertight mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.
- (E) Sleeves: The following materials are for wall, floor, slab, and roof penetrations:
1. Steel Sheet-Metal: 24-gauge or heavier galvanized sheet metal, round tube closed with welded longitudinal joint.
 2. Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, galvanized, plain ends.

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3. Cast-Iron: Cast or fabricated wall pipe equivalent to ductile-iron pressure pipe, having plain ends and integral water stop, except where other features are specified.

2.04 VALVES

(A) General: Provide factory-fabricated valves recommended by Manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with Installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

(B) Gate Valves: Comply with the following requirements:

1. Gate Valves - 2-Inches and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze, threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Class 150 valves meeting the above shall be used where pressure requires.
2. Gate Valves - 2-Inches and Smaller: MSS SP-80; Class 150, body and union bonnet as ASTM B 62 cast bronze, threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Do not use solder end valves for hot water heating or steam piping applications.
3. Gate Valves - 2-1/2-Inches and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

(C) Ball Valves: Comply with the following requirements:

1. Ball valves - 1-inch and Smaller: Rated for 150 PSI SWP pressure, 600 PSI non-shock WOG pressure; 2-piece construction, bronze body conforming to ASTM B 584 or B61, full port, 316 stainless steel ball, reinforced "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide extended solder ends for condenser water and chilled water; full depth ANSI threaded ends for heating hot water and low pressure steam. Provide 2-inch extended handles of non-thermal conductive material. Valve pressure ratings shall be cast into the body of the valve.
2. Ball Valves - 1-1/4-Inches to 2-Inches: Rated for 150 PSI SWP pressure, 600 PSI non-shock WOG pressure; 2-piece construction, bronze body conforming to ASTM B 584 or B61, full port, 316 stainless steel ball, reinforced and replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide extended solder ends for condenser water and chilled water; full-depth ANSI threaded ends for heating hot water and low pressure steam. Provide 2-inch extended handles of non-thermal conductive material. Valve pressure ratings shall be cast into the body of the valve.

(D) Plug Valves: Comply with the following requirements:

1. Plug Valves - 2-Inches and Smaller: 150 PSI WOG, bronze body, straightaway pattern, square head, threaded ends.
2. Plug Valves - 2-1/2-Inches and Larger: MSS SP-78; 175 PSI WOG, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

(E) Globe Valves: Comply with the following requirements:

1. Globe Valves - 2-Inches and Smaller: MSS SP-80; Class 125, body and screwed bonnet of ASTM B 62 cast bronze, threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Class 150 valves meeting the above shall be used where pressure requires.
2. Globe Valves - 2-1/2-Inches and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; outside screw and yoke, bronze-mounted, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

(F) Butterfly Valves: Comply with the following requirements:

1. Butterfly Valves - 2-1/2-Inches and Larger: MSS SP-67; 200 non-shock PSI, cast iron body conforming to ASTM A 126, Class B. Valves shall have field replaceable EPDM sleeve, with aluminum bronze disc, 400 Series stainless steel stem, and EPDM O-ring stem seals. Sizes 2-1/2-inch through 6-inches shall have 10-position lever operators with locks, and sizes 8-inch through 24-inch shall have gear operators with position indicator. Provide wafer type valve. Drill and tap valves on dead-end service or requiring additional body strength. Valve shall be capable of bi-directional dead end service with downstream flange removed at full-rated pressure.

(G) Check Valves: Comply with the following requirements:

1. Swing Check Valves - 2-Inches and Smaller: MSS SP-80; Class 125, cast bronze body and cap conforming to ASTM B 62, horizontal swing, Y-pattern, with a bronze disc, and having threaded or solder ends. Valve shall be capable of being reground while the valve remains in the line. Class 150 valves meeting the above specifications may be used with threaded end connections where pressure requires or Class 125 valves are not available.
2. Swing Check Valves - 2-1/2-Inches and Larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.
3. Wafer Check Valves: Class 250, cast iron body; with replaceable bronze seat, and non-slam design lapped and balanced twin bronze flappers and stainless steel trim and torsion spring. Valve shall be designed to open and close at approximately one foot differential pressure.

2.05 VALVE TAGS

(A) Brass Valve Tags: Provide 19-gauge polished brass valve tags for all valves with stamp-engraved piping system abbreviation in 1/4-inch high letters and sequenced valve numbers 1/2-inch high, and with 5/32-inch hole for fastener.

1. Provide 1-1/2-inch diameter tags, except as otherwise indicated.
2. Fill tag engraving with black enamel.

(B) Valve Tag Fasteners: Manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

2.06 VALVE SCHEDULES

- (A) General: Provide a valve schedule for each piping system in electronic form and printed out on standard size bond paper for inclusion in Operation and Maintenance manual. Schedule shall include valve identification number, piping system, size and location of valve, normal operating position and additional remarks as required. Identify valve use for emergency shutoff or similar special use.

2.07 METERS AND GAUGES

(A) Thermometers:

1. General: Provide thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Case: Die cast aluminum finished in baked epoxy enamel or hard powder coat finish, glass or acrylic front, 9-inches long.
3. Adjustable Joint: Die cast aluminum, finished to match case, 180° adjustment in vertical plane, 360° adjustment in horizontal plane, with locking device.
4. Tube and Capillary: Blue organic-liquid filled, magnifying lens, ± 1 scale division accuracy, shock mounted.
5. Scale: Satin faced, non*reflective white aluminum, permanently etched black markings.
6. Stem: Copper-plated steel, brass or die-cast aluminum, for separable socket, length to suit installation.
7. Thermometer Wells: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2-inch extension for insulated piping. Provide cap fastened to well when used in a non-permanent thermometer location.
8. Thermometer wells shall be installed at each thermometer and at each point where a temperature sensing device is required by the control specifications.
9. Range: Conform to the following:
 - A. Heating Water: 30°F to 240°F with 2°F scale divisions.
 - B. Chilled Water: 0°F to 100°F with 1°F scale divisions.
 - C. Condenser Water: 0°F to 160°F with 2°F scale divisions.

(B) Pressure Gauges:

1. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Type: General use, $\pm 1\%$ accuracy, ANSI B 40.1 Grade 1A, phosphor bronze bourdon type, bottom connection.
3. Case: Stainless steel, glass or acrylic lens, 4-1/2-inch diameter.

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4. Connector: Brass, lower mount with 1/4-inch male NPT.
5. Scale: White coated aluminum, with permanently etched black markings.
6. Accessories:
 - A. Provide protective coil siphon when used for steam service.
 - B. Provide each gauge with a shut-off needle valve.
 - C. Provide pressure snubber where spikes may be present.
7. Range: Conform to the following:
 - A. Vacuum: 30-inch Hg - 15 PSI.
 - B. Water: 0-100 PSI.
 - C. Steam: 0-200 PSI.

(C) Test plugs:

1. Description: Test-station fitting made for insertion into piping tee fitting.
2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
3. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
4. Minimum Pressure and Temperature Rating: 500 PSIG at 200 deg F
5. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.08 SUPPORTS AND ANCHORS

(A) Horizontal-Piping Hangers and Supports:

1. General: Except as otherwise indicated, provide factory- fabricated horizontal-piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems.
2. Adjustable Steel Clevis Hangers: MSS Type 1.
3. Yoke Type Pipe Clamps: MSS Type 2.
4. Steel Double Bolt Pipe Clamps: MSS Type 3.
5. Steel Pipe Clamps: MSS Type 4.

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6. Pipe Hangers: MSS Type 5.
7. Trapeze type with horizontal angle iron.

(B) Saddles and Shields:

1. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
4. Thermal Hanger Shields: Constructed of 360 degree insert of high density, 100 PSI, water-proofed calcium silicate, encased in 360 degree sheet metal shield. Provide assembly of same thickness as adjoining insulation.

(C) Roof Equipment Supports:

1. General: Construct roof equipment supports using minimum 18-gauge galvanized steel with fully mitered and welded corners, 3-inch cant, internal bulkhead reinforcing, integral base plates, pressure treated wood nailer, and 18-gauge galvanized steel counterflashing.
2. Configuration: Construct to sizes as indicated, compensate for slope in roof so top of support is dead level.

2.09 MECHANICAL IDENTIFICATION

(A) Equipment Markers:

1. General: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive or fasteners to mount on equipment.
2. Terminology: Match drawing schedules as closely as possible unless directed otherwise by Owner.
3. Data Required:
 - A. Equipment Description, (i.e. Heat Pump).
 - B. Schedule Mark, (i.e. HP-1).
4. Marker Size: 2-1/2- by 4-inches for main control valves; 4-1/2- by 6-inches for equipment.

(B) Plastic Pipe Markers:

1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

2. Small Pipes: For external diameters less than 6-inches (including insulation if any), provide full-band pipe markers, extending 360° around pipe at each location, fastened by the following method:
 - A. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4-inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2-inches.
3. Large Pipes: For external diameters of 6-inch and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than three times letter height (and of required length), fastened by one of the following methods:
 - A. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2-inches wide, full circle at both ends of pipe marker, tape lapped 3-inches.
4. Lettering: Comply with piping system nomenclature as specified, scheduled or shown on drawings, and abbreviate only as necessary for each application length.
 - A. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

(C) Plastic Tape:

1. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 MILS thick, complying with ANSI A13.1.
2. Width: Provide 1-1/2-inch wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6-inches, 2-1/2-inch wide tape for larger pipes.

(D) Color Scheme: Comply with ANSI A13.1, or as scheduled below:

<u>ITEM</u>	<u>COLOR SCHEME</u>
Heating Water	Black text on Yellow
Chilled Water	White text on Green
Refrigerant Liquid and Suction	Black text on Yellow

2.010 VIBRATION CONTROL

- (A) Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.
 1. Include holes in bottom plate for bolting unit to substrate as indicated.
- (B) Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for three times rated loading of units. Fabricate units to accept misalignment of 15° off center in any direction before contacting hanger box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.
 1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.

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2. Provide neoprene element, with minimum deflection of 0.35-inches, securely retained in hanger box.
 3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
 4. Provide hangers, pre-compressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.
- (C) Flexible Pipe Connectors: Provide neoprene or EDPM construction consisting of multiple plies of nylon tire cord fabric and elastomer molded and cured in hydraulic rubber presses. Provide straight or elbow connector as indicated, rated at 125 PSI at 220°F.
- (D) Vibration Isolation Pads: Neoprene, modular, waffle-type 3/8-inch thick pad. Provide size as required for 15% deflection at maximum loading.
- 2.011 ACCESS PANELS**
- (A) All panels shall be MILCOR, Style "M" for masonry, Style A for acoustical tile, and Style K for plaster; except that Fire Rated UL 1-1/2 hour and "B" label access panels shall be furnished in fire-rated walls and ceilings as indicated on the Drawings.
- (B) Access doors shall be 12-inch x 12-inch minimum size for valves and dampers and shall be 24-inch x 36-inch for access to equipment and filters.
- 2.012 GROUT**
- (A) Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, non-staining, non-corrosive, non-gaseous, and recommended for interior and exterior applications.
 2. Design Mix: 5000 PSI, 28 day compressive strength.
 3. Packaging: Premixed and factory-packaged.
- 2.013 JOINT SEALERS**
- (A) General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
- (B) Colors: As selected by the Architect from manufacturer's standard colors.
- (C) Elastomeric Joint Sealers: Provide the following types:
1. One-part, non-acid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
 2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and non-porous joint substrates; formulated with fungicide; intended for sealing interior joints with non-porous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.

- (D) Acrylic-Emulsion Sealants: One-part, nonsag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5%.
- (E) Fire-Resistant Joint Sealers: Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors. Sealants and accessories shall have fire-resistant ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.01 PIPING SYSTEMS-COMMON REQUIREMENTS

- (A) General: Install piping as described below, except where system Sections specify otherwise.
- (B) General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, except where deviations to layout are approved on coordination drawings.
- (C) Install piping at indicated slope.
- (D) Install components having pressure rating equal to or greater than system operating pressure.
- (E) Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.
- (F) Install piping free of sags and bends.
- (G) Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.
- (H) Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.
- (I) Install piping to allow application of insulation plus 1-inch clearance around insulation.
- (J) Locate groups of pipes parallel to each other, spaced to permit valve servicing.
- (K) Install fittings for changes in direction and branch connections.
- (L) Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:
 - 1. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons, where required, for existing piping.
 - 2. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.
 - 3. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.
 - 4. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.

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5. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.
- (M) Sleeves are not required for core drilled holes.
- (N) Install sleeves for pipes passing through concrete and masonry walls, concrete floor and roof slabs, and where indicated.
1. Cut sleeves to length for mounting flush with both surfaces.
 - A. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2-inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring where specified.
 2. Build sleeves into new walls and slabs as work progresses.
 3. Install large enough sleeves to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - A. Steel Pipe Sleeves: For pipes smaller than 6-inches.
 - B. Steel Sheet-Metal Sleeves: For pipes 6-inches and larger that penetrate gypsum-board partitions.
 - C. Cast-Iron Sleeve Fittings: For floors having membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2-inches above finished floor level.
 4. Except for below-grade wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants.
- (O) Above Grade, Exterior Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.
1. Install steel pipe for sleeves smaller than 6-inch.
 2. Install cast-iron wall pipes for sleeves 6-inch and larger.
 3. Assemble and install mechanical seals according to manufacturer's printed instructions.
- (P) Below Grade, Exterior Wall, Pipe Penetrations: Install cast-iron wall pipes for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.
- (Q) Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material.
- (R) Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

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3. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."
 4. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:
 - A. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 - B. Apply appropriate tape or thread compound to external pipe threads (except where dry seal threading is specified).
 - C. Align threads at point of assembly.
 - D. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
 - E. Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 5. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to the "Quality Assurance" Article.
 6. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
 7. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:
 - A. Comply with ASTM F 402 for safe handling of solvent-cement and primers.
 - B. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM D 2846 and ASTM F 493.
 - C. Poly(Vinyl Chloride) (PVC) Pressure Application: ASTM D 2672.
 - D. Poly(Vinyl Chloride) (PVC) Non-Pressure Application: ASTM D 2855.
 8. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.
 - A. Plain-End Pipe and Fittings: Butt joining.
 - B. Plain-End Pipe and Socket-Type Fittings: Socket joining.
- (S) Piping Connections: Except as otherwise indicated, make piping connections as specified below.
1. Install unions in piping 2-inch and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch or smaller threaded pipe connection.

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2. Install flanges in piping 2-1/2-inches and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
3. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
4. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces.
5. Install isolation valves upstream of all dielectric unions and flanges.

3.02 EQUIPMENT INSTALLATION-COMMON REQUIREMENTS

- (A) Install equipment to provide the maximum possible headroom where mounting heights are not indicated.
- (B) Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.
- (C) Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, except where otherwise indicated.
- (D) Install HVAC equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
- (E) Install equipment giving right-of-way to piping systems installed at a required slope.

3.03 VALVE INSTALLATIONS

- (A) General Application: Use ball and butterfly valves for shut-off duty; globe, ball, and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.
- (B) Locate valves for easy access and provide separate support where necessary.
- (C) Install valves and unions for each item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
- (D) Install 3-valve bypass around each pressure reducing valve using throttling type valves.
- (E) Install valves in horizontal piping with stem at or above the center of the pipe, and to allow full stem movement.
- (F) Installation of Check Valves: Install for proper direction of flow as follows:
 1. Swing Check Valves: Install in horizontal position with hinge pin level.
 2. Wafer Check Valves: Install between two flanges in horizontal or vertical position.
 3. Lift Check Valve: Install in piping line with stem upright and plumb.

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(G) Valve Locations:

1. HVAC Hydronic Piping:

- A. Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves two or more hydronic terminals or equipment connections, and elsewhere as indicated.
- B. Shut-off Valves: Install on inlet and outlet of each mechanical equipment item, and on inlet of each hydronic terminal, and elsewhere as indicated.
- C. Throttling Valves: As required on plans.

2. Valve Tags:

- A. Provide valve tags for all valves and list on Valve Schedule.
- B. Install tags on valves in piping systems, except check valves, valves within factory-fabricated equipment units and HVAC terminal devices.

3.04 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

<u>VALVES 2-INCHES AND SMALLER</u>				
<u>SERVICE</u>	<u>GATE</u>	<u>GLOBE</u>	<u>BALL</u>	<u>CHECK</u>
Condenser Water	125	125	150	125
Chilled Water	125	150	150	125
Heating Water	150	150	150	150
Low Pressure Steam (0 to 15 PSIG)	150	150	150	150

<u>VALVES 2-1/2-INCHES AND LARGER</u>				
<u>SERVICE</u>	<u>GATE</u>	<u>GLOBE</u>	<u>BUTTERFLY</u>	<u>CHECK</u>
Condenser Water	125	125	200	125
Chilled Water	125	125	200	125
Heating Water	125	125	200	125
Low Pressure Steam (0 to 15 PSIG)	125	125	150	125

3.05 PIPING SPECIALTIES INSTALLATION

(A) Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shut-off valve in strainer blow-down connection, full size of connection, except for strainers 2-inch and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shut-off valve to plumbing drain, full size of blow-down connection.

- 1. Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:
 - A. Pumps.
 - B. Temperature control valves.
 - C. Pressure reducing valves.
 - D. Temperature or pressure regulating valves.

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E. Steam traps serving steam main drops.

(B) Dielectric Unions: Install at each piping joint between ferrous and nonferrous piping. Comply with manufacturer's installation instructions.

1. Install isolation valves on each side of all dielectric unions.

3.06 METERS AND GAUGES INSTALLATION

(A) Glass Thermometers:

1. General: Install glass thermometers in vertical upright position, and tilted so as to be easily read by observer standing on floor.

2. Locations: Install in the following locations, and elsewhere as indicated:

A. At inlet and outlet of each hydronic zone.

B. At inlet and outlet of each ground loop heat exchanger.

C. At inlet and outlet of each hydronic boiler and chiller.

D. At inlet and outlet of each hydronic coil in air handling units, and built-up central systems.

3. Thermometer Wells: Install in piping at each thermometer and temperature control sensing device in vertical upright position. Fill well with oil or graphite, secure cap.

(B) Pressure Gauges:

1. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.

2. Locations: Install in the following locations, and elsewhere as indicated:

A. Across suction and discharge of each pump.

B. At discharge of each pressure reducing valve.

C. Across inlet and outlet of each hydronics coil of air handling units and built-up central systems.

D. Across inlet and outlet of each heat exchanger, water chiller, evaporator, etc.

E. Across inlet and outlet of ground loop heat exchanger.

3.07 SUPPORTS AND ANCHORS INSTALLATION

(A) Hangers and Supports:

1. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping. **Piping shall not be supported from bottom cord of bar joist or from metal roof deck, unless approved by Structural Engineer.** Piping may be supported at panel points of bar joists.
2. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
3. Powder-actuated fasteners shall be approved only for installation where load will be applied perpendicular to the fasteners. **Powder-actuated fasteners shall not be used where load will be applied axially to the fasteners.**
4. Support fire-water piping independently of other piping.
5. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

(B) Saddles and Shields:

1. Insulated Piping: Comply with the following installation requirements:
 - A. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold or chilled water piping, install coated protective shields. For pipe 8-inch and over, install wood insulation saddles.
 - B. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.

3.08 MECHANICAL IDENTIFICATION INSTALLATION

(A) Install equipment markers with permanent adhesive or appropriate fasteners on or near each major item of mechanical equipment

1. Locate markers where accessible and visible.
2. Include markers for the following categories of equipment:
 - A. Main control and operating valves.
 - B. Boilers, pumps, compressors, chillers, condensers, cooling towers, heat exchangers, energy recovery units, fans, central station and zone-type units, heat pumps, tanks, pressure vessels, humidifiers, and similar equipment.

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- (B) Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
1. Near each valve and control device.
 2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
 4. At access doors, manholes and similar access points which permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced intermediately at maximum spacing of 50-feet along each piping run, except reduce spacing to 25-feet in congested areas of piping and equipment.
 7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.09 VIBRATION CONTROL INSTALLATION

- (A) General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.
- (B) Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.
- (C) Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
- (D) Locate isolation hangers as near overhead support structure as possible.
- (E) Flexible Pipe Connectors: Install on equipment side of shut-off valves, horizontally and parallel to equipment shafts wherever possible.

3.010 ACCESS PANEL INSTALLATION

- (A) HVAC Contractor shall locate and furnish for installation by General Contractor, all access panels as required for access to valves and dampers, and the proper servicing of equipment and piping installed under this Contract.

3.011 CONCRETE BASES

- (A) Construct concrete equipment bases of dimensions indicated, but not less than 4-inches larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 PSI, 28 day compressive strength concrete and reinforcement.

3.012 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- (A) Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- (B) Field Welding: Comply with AWS D1.1 "Structural Welding Code-Steel."

3.013 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- (A) Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.
- (B) Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- (C) Attach to substrates as required to support applied loads.

3.014 SELECTIVE DEMOLITION

- (A) General: Demolish, remove, demount, and disconnect abandoned HVAC ductwork, piping, materials and equipment indicated to be removed and not indicated to be salvaged or saved.
- (B) Materials and Equipment designated for Salvage: Remove, demount, and disconnect existing HVAC materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage by Owner.
- (C) Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.
- (D) HVAC Materials and Equipment: Demolish, remove, demount, and disconnect the following items:
 - 1. Inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, devices, and insulation.
 - A. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove materials above accessible ceilings. Drain and cap piping and ducts allowed to remain.

3.015 CUTTING AND PATCHING

- (A) Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for HVAC installations. Perform cutting by skilled mechanics of the trades involved.
- (B) Repair cut surfaces to match adjacent surfaces.

3.016 GROUTING

- (A) Install nonmetallic nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.
- (B) Clean surfaces that will come into contact with grout.

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- (C) Provide forms for placement of grout, as required.
- (D) Avoid air entrapment when placing grout.
- (E) Place grout to completely fill equipment bases.
- (F) Place grout on concrete bases to provide a smooth bearing surface for equipment.
- (G) Place grout around anchors.
- (H) Cure placed grout according to manufacturer's printed instructions.

3.017 PIPING TESTS

- (A) No piping work, fixtures, or equipment shall be concealed or covered until they have been observed by the Engineer's representative, who shall be notified by the Contractor when the work is ready for inspection. All work shall be completely installed, tested as required by this Section and by all applicable local and State Ordinances and Safety Orders, and shall be leak-tight before inspection is requested. All tests shall be repeated upon request to the satisfaction of those making the inspection.
- (B) Piping tests shall be made with the test medium and under test pressures listed in the following table. Use a calibrated Bristol Pressure Recorder, or equal, on all tests. Engineer's representative shall install and remove each chart. Recorder range shall be 0-300 pounds or required range for specific test.

<u>Type of Piping</u>	<u>PIPING TESTS Test Pressure</u>	<u>Test Medium</u>	
Fuel Gas	50 PSIG	Air	One Hour
Refrigeration Suction	1 st – 150 PSIG 2 nd – 25 in. vacuum	Nitrogen	One Hour Each Test
Refrigeration Liquid and Hot Gas	1 st – 300 PSIG 2 nd – 25 in. vacuum	Nitrogen	One Hour Each Test
Heating Water, Chilled Water and Condenser Water	50 PSIG or twice operating pressure, whichever is greater	Water	One Hour

- (C) Test pressure in lbs. per square inch, or inches of vacuum, gauge, are given as an initial pressure to be applied to lines being tested, together with test medium.
- (D) Final pressures at the end of test period shall be no more nor less than that caused by expansion or contraction of the test medium due to temperature changes.
- (E) Check of systems during application of test pressures should include visual check for water medium leakage, soap bubble or similar for air and nitrogen medium, and halide torch for refrigerant medium after charging.
- (F) During heating and cooling cycles, linear expansion shall be checked at all elbows, U-bends, expansion joints, etc., for proper clearance.

END OF SECTION 23 05 00 – COMMON HVAC MATERIALS AND REQUIREMENTS

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SECTION 23 05 93 - HVAC TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section includes testing, adjusting and balancing the following systems and equipment:

1. Air Systems:
 - A. Constant-volume air systems.
 - B. Return air systems.
 - C. Variable-air-volume systems.
 - D. Exhaust air systems.
2. Balancing Hydronic Piping Systems:
 - A. Variable-flow hydronic systems.
 - B. Primary-secondary hydronic systems.
3. Refrigerant system.
4. Equipment:
 - A. Heat exchangers.
 - B. Motors.
 - C. Chillers.
 - D. Units.
 - E. Boilers.
 - F. Heat-transfer coils.
 - G. Pumps.
 - H. Fans.
5. Testing, adjusting, and balancing existing systems and equipment.
6. Sound tests.

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7. Vibration tests.
8. Duct leakage tests.
9. Control system verification.
10. Space leakage tests.

1.03 DEFINITIONS

- (A) AABC: Associated Air Balance Council.
- (B) BAS: Building automation systems.
- (C) NEBB: National Environmental Balancing Bureau.
- (D) TAB: Testing, adjusting, and balancing.
- (E) TABB: Testing, Adjusting, and Balancing Bureau.
- (F) TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- (G) TDH: Total dynamic head.

1.04 SUBMITTALS

(A) Information Submittals:

1. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
2. Instrument calibration reports, to include the following:
 - A. Instrument type and make.
 - B. Serial number.
 - C. Application.
 - D. Dates of use.
 - E. Dates of calibration.
3. Contract Documents Examination Reports: With [30] [60] [90] <Insert Number> days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in part 3.
4. Strategies and Procedures Plan: With [30] [60] [90] <Insert Number> days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

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5. System Readiness Checklists: With [30] [60] [90] <Insert Number> days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
 6. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- (B) Closeout Submittals:
1. Certified TAB reports.
- 1.05 QUALITY ASSURANCE
- (A) TAB Specialists Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.
1. TAB Field Supervisor: Employee of the TAB specialist and certified by [AABC] [NEBB] [OR] [TABB].
 2. TAB Technician: employee of the TAB specialist and certified by [AABC] [NEBB] [OR] [TABB] AS A TAB TECHNICIAN.
- (B) TAB Conference: Meet with Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians.
1. Agenda Items:
 - A. Contract Documents examination.
 - B. The TAB plan.
 - C. Coordination and cooperation of trades and subcontractors.
 - D. Coordination of documentation and communication flow.
- (C) Certify TAB field data reports and perform the following:
1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- (D) Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- (E) ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- (F) ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."
- 1.06 PROJECT CONDITIONS
- (A) Do not proceed Closeout Submittal until work has been completed and systems and equipment are operable. Ensure that there is not latent residual work still to be completed.

- (B) Do not proceed with schedules for testing, adjusting, and balancing until systems and equipment are clean and free from debris, dirt and discarded building materials.
- (C) Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.07 COORDINATION

- (A) Coordinate with other trades for scheduled test dates and times.
- (B) Perform TAB work after leakage and pressure tests on distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS

2.01 PATCHING MATERIALS

- (A) Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs and similar purposes. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2.02 TEST INSTRUMENTS

- (A) Utilize test instruments and equipment for TAB work required, of type, precision, and capacity as recommended in NEBB's Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- (B) Examine systems for installed balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- (C) Examine the approved submittals for HVAC systems and equipment.
- (D) Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

- (E) Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- (F) Examine test reports specified in individual system and equipment Sections.
- (G) Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- (H) Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- (I) Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- (J) Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- (K) Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- (L) Examine system pumps to ensure absence of entrained air in the suction piping.
- (M) Examine operating safety interlocks and controls on HVAC equipment.
- (N) Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

- (A) Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

- (A) Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

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- (B) Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

- (C) Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- (A) Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- (B) For variable-air-volume systems, develop a plan to simulate diversity.
- (C) Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- (D) Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- (E) Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- (F) Verify that motor starters are equipped with properly sized thermal protection.
- (G) Check dampers for proper position to achieve desired airflow path.
- (H) Check for airflow blockages.
- (I) Check condensate drains for proper connections and functioning.
- (J) Check for proper sealing of air-handling-unit components.
- (K) Verify that air duct system is sealed as specified.

3.05 GENERAL PROCEDURES FOR BALANCING HYDRONIC SYSTEMS

- (A) Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5%.
- (B) Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
 2. Check liquid level in expansion tank.
 3. Check makeup water-station pressure gauge for adequate pressure for highest vent.

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4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.06 PROCEDURES FOR MOTORS

(A) Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

(B) Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.07 PROCEDURES FOR CHILLERS

(A) Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.

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5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.08 PROCEDURES FOR CONDENSING UNITS

- (A) Verify proper rotation of fans.
- (B) Measure entering- and leaving-air temperatures.
- (C) Record compressor data.

3.09 PROCEDURES FOR BOILERS

- (A) Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
- (B) Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.010 PROCEDURES FOR HEAT-TRANSFER COILS

- (A) Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

- (B) Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.

6. Fuse or circuit-breaker rating for overload protection.

(C) Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

(D) Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.011 TOLERANCES

(A) Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10% for fan capacity less than 5000 cfm. Plus or minus 5% for fan capacity of 5000 cfm and larger.
2. Air Outlets and Inlets: Plus or minus 10%.
3. Water Flow Rate: Plus or minus 10%.

3.012 FINAL REPORT

(A) General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

(B) Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.

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4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

(C) General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
 - A. Indicated versus final performance.
 - B. Notable characteristics of systems.
 - C. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.

3.013 ADDITIONAL TESTS

- (A) Within 90 days of completing TAB, perform additional TAB at the Engineer's request to correct unusual conditions.
- (B) Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93 – HVAC TESTING, ADJUSTING AND BALANCING

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SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed oven and warewash exhaust.
6. Indoor, exposed oven and warewash exhaust.
7. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
8. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

- (B) Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors.
2. Chilled-water and brine piping, indoors.
3. Heating hot-water piping, indoors.
4. Refrigerant suction and hot-gas piping, indoors and outdoors.

- (C) Section includes insulating the following HVAC equipment that is not factory insulated:

1. Heat exchangers.
2. Chilled-water pumps.
3. Heating, hot-water pumps.
4. Expansion/compression tanks.
5. Air separators.

(D) Related Sections:

1. Division 23 "Metal Ducts" for Duct liners.

1.03 SUBMITTALS

(A) Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation and accessory.

1. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

1.04 QUALITY ASSURANCE

(A) Furnish insulation and materials bearing the manufacturer's label. Only mechanics skilled at such work shall apply materials. Insulation and materials shall be by one of the manufacturers listed. Specialty material shall be of the manufacturer indicated or approved equal. Fire and smoke hazard classification ratings on insulation, jacket, and adhesive shall conform to NFPA 255, ASTM E 84, or UL-723 as follows:

1. Flame Spread Index not exceeding 25.
2. Smoke Developed Index not exceeding 50.

(B) Certifications: Submit certifications or other data as necessary to show compliance with these specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

1.05 DELIVERY, STORAGE, AND HANDLING

(A) Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.06 COORDINATION

(A) Coordinate size and location of supports, hangers, and insulation shields.

(B) Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

(C) Coordinate insulation and testing of heat tracing.

1.07 SCHEDULING

(A) Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

(A) Subject to compliance with requirements, provide products by one of the following:

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1. Armacell LLC.
2. Dow Chemical Company.
3. Johns-Manville Corp.
4. Keene Corp.
5. Knauf Fiber Glass.
6. Nomaco K-Flex.
7. Owens-Corning Fiberglass Corp.
8. Pittsburg Corning Corp.

2.02 MATERIALS

(A) Thermal Conductivity Average Maximum in Btu-in/hr-ft² at 75°F Mean Temperature:

1. Fiberglass Board = 0.26.
2. Fiberglass Blanket = 0.30.
3. Fiberglass Preformed Pipe Insulation = 0.26.
4. Cellular Glass = 0.30.
5. Flexible Elastomeric Cellular = 0.27.
6. Polyisocyanurate = 0.19.
7. Calcium Silicate = 0.60 @ 500°F.

(B) Vapor retarder film and tape shall have a maximum permeance of 0.030 perm.

(C) All pre-formed pipe insulation shall be provided with self-adhering and self-sealing overlapping flap.

(D) Pipe Insulation Protection:

1. Pipe insulation exposed in finished areas shall be protected with 0.030 inches thick PVC plastic jacketing covers, Ceel-Co 300 Series or approved equal.
2. Pipe insulation exposed in mechanical and electrical equipment rooms, indoor parking garages and other unfinished areas 8'-0" or less above finish floor shall be protected with 0.030 inches thick, ultraviolet resistant, PVC plastic jacketing covers, Ceel-Co 300 Series or approved equal.
3. Pipe insulation exposed to weather shall be protected with a pre-fabricated self-adhering and self-sealing sheet type waterproof membrane. Membrane shall be installed according to manufacturer's recommendations. The waterproof membrane shall be Flex-Clad 400 as manufactured by MFM Building Products Corporation of Coshocton, OH or approved equal.

(E) Duct Insulation Protection:

1. Ductwork Exposed to Weather: 2-inch thick, 4-PCF density spun fiberglass rigid insulation board with FSK facing. Adhere insulation board to the duct with asphalt mastic and metal clips. Cover insulation board with a pre-fabricated self-adhering and self-sealing sheet type waterproof membrane. Adhere the waterproof membrane to insulation according to manufacturer's recommendations. The waterproof membrane shall be Flex-Clad 400 as manufactured by MFM Building Products Corporation of Coshocton, OH or approved equal.

PART 3 - EXECUTION

3.01 PIPING INSULATION SCHEDULE

(A) Exposed Piping.

1. Refer to pipe insulation protection paragraphs above.

(B) Air Conditioning Coil Condensate Drain Piping – above ground.

1. Fiberglass: 1-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1/2-inch thick.
3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(C) HVAC Make-up water - 1-1/4-inch and smaller.

1. Fiberglass: 1-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1-inch thick.
3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(D) HVAC Make-up water - 1-1/2-inch and larger.

1. Fiberglass: 1-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
2. Elastomeric closed-cell plastic foam: 1-inch thick.
3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(E) Refrigerant Suction Piping – 1-1/2-inch and smaller.

1. Elastomeric closed-cell plastic foam: 1-inch thick.
2. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(F) Refrigerant Suction Piping – 2-inch and larger.

1. Elastomeric closed-cell plastic foam: 1-1/2-inch thick.
2. Polyisocyanurate closed-cell: 1-1/2-inch thick with vapor retarder film.

- (G) Hot Water Heating Piping to 200 °F – 1-inch and smaller.
1. Fiberglass: 1-1/2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
- (H) Hot Water Heating Piping to 200 °F – 1-1/2-inch and larger.
1. Fiberglass: 2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
- (I) Chilled Water Piping – 4-inch and smaller.
1. Fiberglass: 1-1/2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
 2. Cellular Glass: 1-inch thick with vapor barrier jacket.
 3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- (J) Chilled Water Piping – 5-inch and larger.
1. Fiberglass: 2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
 2. Cellular Glass: 2-inch thick with vapor barrier jacket.
 3. Polyisocyanurate closed-cell: 1-1/2-inch thick with vapor retarder film.
- 3.02 DUCT INSULATION SCHEDULE**
- (A) Ductwork Exposed to Weather or Abuse.
1. Refer to duct insulation protection paragraphs above.
- (B) Concealed Low Velocity Rectangular Supply Air Ductwork (< 2000 FPM)
1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 2. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- (C) Concealed Low Velocity Rectangular Return Air Ductwork (< 2000 FPM)
1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 2. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- (D) Concealed Low Velocity Round Supply and Return Air Ductwork (< 2000 FPM)
1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
- (E) Concealed High Velocity Supply Air Ductwork (> 2000 FPM)
1. Fiberglass Blanket: 2-inch thick 1.5-PCF density with heavy duty FSK vapor barrier.
- (F) Concealed Outside Air Ductwork (untempered).
1. Fiberglass Blanket: 3-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.

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2. Fiberglass Rigid Board: 1-1/2-inch thick 3-PCF density with heavy duty FSK vapor barrier.
- (G) Concealed Ventilation Air Ductwork (tempered outside air).
1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 2. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- (H) Concealed Low Velocity Ductwork in Unconditioned Space.
1. Fiberglass Blanket: 3-inch thick, 0.75-PCF density with heavy duty FSK vapor barrier.
 2. Duct Liner: 2-inch thick 1.5-PCF density.
- (I) Supply, Return, and Mixed Air Ductwork and Plenums in Equipment rooms.
1. Fiberglass Blanket: 2-inch thick 1.5-PCF density with heavy duty FSK vapor barrier.
 2. Fiberglass Rigid Board: 1-1/2-inch thick 3-PCF density with heavy duty FSK vapor barrier.
 3. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- (J) Air Transfer Ductwork.
1. Duct Liner: 1-inch thick 1.5-PCF density.
- (K) Concealed Exhaust Ductwork and Clothes Dryer Vent Ductwork from Roof or Exterior Wall to 15 feet inside of building.
1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
- 3.03 EQUIPMENT INSULATION SCHEDULE**
- (A) Chilled Water Pumps:
1. Fiberglass Rigid Board: 2-inch thick 6-PCF density with vapor barrier jacket.
 2. Cellular Glass: 3-inch thick with vapor barrier jacket.
 3. Elastomeric closed-cell plastic foam: 1-inch thick.
 4. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- (B) Chilled Water Headers:
1. Elastomeric closed-cell plastic foam: 1-inch thick.
 2. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- (C) Chilled Water Air Separator:
1. Fiberglass Rigid Board: 1-inch thick 6-PCF density with vapor barrier jacket.

2. Cellular Glass: 2-inch thick with vapor barrier jacket.

3. Elastomeric closed-cell plastic foam: 1-inch thick.

4. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(D) Heat Exchangers (Cooling Service):

1. Fiberglass Rigid Board: 1-inch thick 6-PCF density with vapor barrier jacket.

2. Cellular Glass: 2-inch thick with vapor barrier jacket.

3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.

(E) Heating Hot Water Air Separator:

1. Fiberglass Rigid Board: 2-inch thick 6-PCF density.

(F) Boiler Flue Stack and Boiler Combustion Air Duct:

1. Fiberglass Rigid Board: 2-inch thick 6-PCF density.

(G) Vent and Intake Piping for Condensing Furnaces and Boilers in Unconditioned Space.

1. Elastomeric closed-cell plastic foam: 1-1/2-inch thick.

3.04 EXAMINATION

(A) Examine substrates and condition for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.05 PREPARATION

(A) Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

(B) Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.06 GENERAL INSTALLATION REQUIREMENTS

(A) Install insulation products in accordance with manufacturer's written instructions, and in accordance with the MICA National Commercial and Industrial Insulation Standards to ensure that insulation serves its intended purpose.

(B) Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

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- (C) Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- (D) Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- (E) Install insulation with longitudinal seams at top and bottom of horizontal runs.
- (F) Install multiple layers of insulation with longitudinal and end seams staggered.
- (G) Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- (H) Keep insulation materials dry during application and finishing.
- (I) Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- (J) Install insulation with least number of joints practical.
- (K) Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- (L) Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- (M) Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- (N) Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- (O) For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.

5. Handholes.
 6. Cleanouts.
- (P) Provide neatly beveled edge at interruptions of insulation.
- 3.07 PENETRATIONS**
- (A) Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- (B) Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- (C) Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- (D) Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- (E) Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.

(F) Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2-inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

3.08 INSTALLATION OF PIPING INSULATION

- (A)** Install insulation on pipe systems subsequent to testing and acceptance of tests.
- (B)** Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. The appearance of the completed insulation shall be a significant factor in determining the acceptability of the work.
- (C)** Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- (D)** Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
- (E)** Where vapor retarders are specified, elbows and fittings shall be wrapped with vapor retarder tape 3-inches wide or shall have PVC jacketing.
- (F)** Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation applied to adjoining pipe run. Install factory-molded, pre-cut or job-fabricated units (at installer's option) except where specific form or type is indicated.
- (G)** Insulation of Piping Specialties on Cold Piping Services: Insulate union, flanges, strainers, flexible connections, hoses, and expansion joints on cold piping services with flexible elastomeric cellular insulation. Thickness of flexible elastomeric cellular insulation shall be equivalent to thickness of insulation on the piping service as specified in this Section or as shown on the drawings. Insulation shall be sealed to provide a vapor tight barrier. Cold piping services include chilled water systems, and geothermal heat pump water loop systems.
- (H)** Piping Insulation Omitted: Omit insulation on hot piping within radiation enclosures or unit cabinets.
- (I)** Insulated piping systems shall be supported on the exterior of the insulation surface. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation.
- (J)** Metal shields: Conform to table below for minimum length of shield:

<u>PIPE SIZE</u>	<u>INSULATION THICKNESS</u>	<u>LENGTH OF SHIELD</u>
Less than 1"	Up to 1"	3"
1"-2"	1"	4-1/2"
1"-2"	1-1/2"	5-1/2"

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2-1/2"-4"	1"	6-1/2"
2-1/2"-4"	1-1/2"	7-1/2"
2-1/2"-4"	2"	8-1/2"
2-1/2"-4"	2-1/2"	9-1/2"
5" and Larger	1"	13"
5" and Larger	1-1/2"	14"
5" and Larger	2"	15"
5" and Larger	2-1/2"	16"
5" and Larger	3" and Larger	18"

- (K) Pipe Hanger, Trapeze, and Roller Support Insulation Inserts: Butt pipe insulation against pipe hanger insulation inserts. Apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3-inch wide vapor barrier tape or band.

3.09 INSTALLATION OF EQUIPMENT INSULATION

- (A) Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.
- (B) Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
- (C) Do not apply insulation to hot equipment.
- (D) Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
- (E) Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
- (F) Cover insulated surfaces with glass cloth jacketing neatly fitted and firmly secured. Lap seams at least two inches. Apply over vapor barrier where applicable.
- (G) Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
- (H) For below ambient services, remove equipment nameplate and re-install on exterior insulation surface or provide duplicate nameplate for field installation on exterior insulation surface.
- (I) Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective finish, or jacketing, as recommended by manufacturer.

3.010 INSTALLATION OF DUCTWORK INSULATION

- (A) Install insulation materials with smooth and even surfaces.
- (B) Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- (C) Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.
- (D) Flexible Fiberglass Insulation: Apply insulation with edges tightly butted secure on 15-inch centers with approved adhesive and pins. Secure joints by overlapping facing or 4-inch wide strips of same material adhered with Benjamin Foster 85-20 adhesive.
- (E) Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.
- (F) Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.
- (G) Flexible Duct Connections: Install insulation materials over flexible duct connections wherever ductwork connect to vibration isolated equipment. Provide adequate flexibility to allow for thermal, axial, transverse, and torsional movement.

3.011 PROTECTION AND REPLACEMENT

- (A) Protection: Provide protection for insulation work during remainder of construction period, to avoid damage and deterioration.
- (B) Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

END OF SECTION 23 07 00 – HVAC INSULATION

SECTION 23 08 00 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.
- (B) OPR, BOD and Commissioning Plan documentation are included by reference for information only.
- (C) ASHRAE Guideline 0.

1.02 SUMMARY

- (A) Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.

1.03 DESCRIPTION

- (A) The owner has elected to use the Commissioning Process as part of their quality process to design, construct and operate this project. As with any quality process, Commissioning provides tools to enable everyone involved in the construction of a building to ensure that the final building meets the original intent of the Owner. A primary tool used is the completion of construction checklists by individual workers. The checklists are simple to fill out and easily track the current state of work by providing the key criteria in the specifications that the Owner has defined as important for the successful installation and long-term operation of systems and equipment.

1.04 INCLUDED SYSTEMS

- (A) The following systems, at a minimum, and their components are the focus of the Commissioning Process due to their complexity and the need to have coordination among the various subcontractors:

- 1. HVAC System (and all integral equipment controls)

- A. Heat Pumps
- B. Fan Coil Units
- C. Boilers
- D. Cooling Tower
- E. Chiller
- F. Chilled/Hot Water Pumps
- G. Controls Sequences
- H. Review Test and Balance Report

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- I. Building automation system (controlled devices, control loops and system integration)
2. Plumbing System
 - A. Domestic Water Heating, Pumps, and Accessories
3. Electrical System
 - A. Emergency Generator
 - B. Transfer Switches
4. Elevator

1.05 DEFINITIONS

- (A) BoD: Basis of Design. A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.
- (B) Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- (C) CxA: Commissioning Authority.
- (D) OPR: Owner's Project Requirements. A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.
- (E) TAB: Testing, Adjusting and Balancing
- (F) Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.06 COMMISSIONING TEAM

- (A) Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
- (B) Members Appointed by Owner:
1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process.
 2. Representatives of the facility user and operation and maintenance personnel.
 3. Architect and engineering design professionals.

1.07 OWNER'S RESPONSIBILITIES

- (A) Provide the OPR documentation to the CxA and Contractor for information and use.
- (B) Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.
- (C) Provide the BoD documentation, prepared by Architect/Engineer and approved by Owner, to the CxA and Contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

1.08 CONTRACTOR'S RESPONSIBILITIES

- (A) Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 - 1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 - 2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
 - 3. Attend commissioning team meetings held on an as needed basis.
 - 4. Integrate and coordinate commissioning process activities with construction schedule.
 - 5. Review and accept construction checklists provided by the CxA.
 - 6. Complete paper construction checklists as Work is completed and provide to the Commissioning Authority as requested.
 - 7. Review and accept commissioning process test procedures provided by the Commissioning Authority.
 - 8. Complete commissioning process test procedures.

1.09 CxA'S RESPONSIBILITIES

- (A) Organize and lead the commissioning team.
- (B) Provide commissioning plan.
- (C) Convene commissioning team meetings.
- (D) Provide Project-specific construction checklists and commissioning process test procedures.
- (E) Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.

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- (F) Prepare and maintain the Issues Log.
- (G) Verify proper owner training.
- (H) Verify proper testing and balancing.
- (I) Witness functional performance testing.

PART 2 - PRODUCTS

2.01 SCHEDULE

- (A) The CxA shall provide the Contractor with a schedule of commissioning activities. Commissioning activities will not be critical path activities.
- (B) The Contractor shall incorporate the commissioning activities into the overall project schedule.

2.02 CONSTRUCTION CHECKLIST OVERVIEW

- (A) The intent of the construction checklist is to provide a formalized means to easily track construction progress and to provide individual workers the key criteria for a successful installation.
- (B) Construction checklists for all pieces of equipment typically follow the same format, yet are tailored to the specific equipment being installed.
- (C) Construction checklists are developed for each individual piece of equipment to track and verify equipment from when they are delivered, installed, and started up. The contractor will be provided with all checklists developed for each piece of equipment or system with the following sections:
 - 1. Pre-Installation Checks: Includes several yes/no or short answer questions to document the condition of the equipment prior to installation and several blank columns to compare delivery items such as manufacturer, model, serial no., etc. to the corresponding submitted/approved items.
 - 2. Installation and Startup: Includes several yes/no or short answer questions to document that the equipment is installed, electrically wired, controlled and started up and balanced according to the specified requirements. A Negative Response section is included at the end of the checklist to document the reasons for any "no" responses or discrepancies in the various sections. A space is included to document the actions taken to correct the problems resulting in "no" responses.
- (D) The checklist shall be completed by the individual actually completing the work. Prior to any work, the checklist shall be reviewed by the individual contractor for pertinent information. Any negative responses on the checklist shall be explained and documented at the end of the checklist.
- (E) The checklists shall not be filled out by a supervisor or other individual who did not work on the equipment.
- (F) The completion of the checklist does not eliminate the contractor's responsibility for meeting other requirements in the specifications and drawings.
- (G) The CxA will periodically verify the accuracy and completeness of the checklists. If consistent errors are found, the responsible contractor shall re-validate 100% of the checklists for the problem equipment or system type.

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- (H) The Checklists are designed to detect and eliminate delivery, installation and startup problems, and problems with miscommunication. This process also serves as a convenient way to document the progress of the work.

2.03 CONTROL SYSTEM VERIFICATION

- (A) Particular emphasis will be placed on the automatic control system performance.
- (B) Included in this work will be sample-based verification of instrument calibration, access to components, labeling of devices, clear sequences and shop drawings.
- (C) The verification of the control system will be accomplished as an on-going task during construction to identify and resolve systemic issues early in the project.
- (D) The control system operation must be sufficiently operational prior to the TAB of the system. It is understood that a portion of the final control system startup occurs in conjunction with the TAB work. The intent of this requirement is for the TAB work to be productive and not be hampered by a control system that is not sufficiently functional.
- (E) The control system testing will utilize the controls system instrumentation for testing. Therefore, the first portion of the control system testing will be verification of the sensors, inputs and outputs.
- (F) Point-to-Point Verification: All wiring shall be checked out by the Control Contractor from end to end, point to point, from field to computer screen to ensure correct connection and a system free from wiring defects.
- (G) CxA verification of sensors will be made using the sampling method; an exhaustive retest of the control system inputs and outputs will not be conducted by the CxA. Prior to CxA verification, the Control Contractor shall be responsible for complete input/output checkout quality assurance.

1. Sensor and Actuator Calibration, General:

- A. This section is included to emphasize the importance of the Control Contractor calibrating the instrumentation and to make clear the requirement for same; and that "factory calibration" or "calibration by exception" is not acceptable.
- B. All field-installed temperature, relative humidity, CO, CO2 and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Alternate methods may be used, if approved by the Owner beforehand. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.
- C. All procedures used shall be fully documented and clearly reference the procedures followed and include written documentation of initial, intermediate and final results.

2.04 FUNCTIONAL PERFORMANCE TESTING

- (A) The systems in the building will be operated in their different modes of operation to ensure the facility operates properly as a whole. This testing provides both Owner and the General and subcontractors with documentation that the building was operating properly at turnover.
- (B) Each subcontractor will be responsible, as required, to put the system in various modes of operation and fixing minor problems found during the test.

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- (C) If major problems are discovered during the test, the responsible subcontractors and General Contractor will fix the problem and the test shall be redone. If more than two functional performance tests are required, the responsible subcontractor will be back-charged for the CxA's time and expenses.
- (D) The CxA will provide all commissioning team members, and others as required, the functional performance test plan prior to scheduled testing.
- (E) The CxA shall schedule and direct the testing once all construction checklists have been completed and accepted by the CxA.
- (F) Control system setup, calibration and operation shall be completed and verified prior to system functional performance testing. System functional performance testing shall not be completed until the Adjusting and Balancing report has been verified and accepted by the CxA.
- (G) Skilled technicians shall be provided by the appropriate Contractor familiar with the system and building to execute the functional performance testing of the control system and perform functional performance testing of equipment.

2.05 TRAINING VERIFICATION

- (A) The lead subcontractor for the respective system is responsible for the development of the training material for the system. Any coordination of training between different subcontractors is the responsibility of the lead subcontractor.
- (B) The training material shall be submitted to the CxA 60 days prior to the originally scheduled system training for review and acceptance.
- (C) All training shall be videotaped using professional-grade equipment.
- (D) All training sessions shall be scheduled and coordinated by the General Contractor through Owner.
- (E) Major component training shall be completed and accepted by Owner prior to substantial completion and occupancy.

2.06 COMMISSIONING PLAN

- (A) A detailed commissioning plan containing the Owner's Project Requirements, designer's Basis of Design, and a compilation of all test forms will be provided and reviewed with the subcontractors.
- (B) The commissioning plan is intended only as a guide for commissioning activities on the project. The specifications are the contract requirements and shall be considered the extent of the subcontractor's responsibilities.

END OF SECTION 23 08 00 – GENERAL COMMISSIONING REQUIREMENTS

SECTION 23 09 00 - ELECTRIC CONTROL SYSTEMS & FACILITIES MANAGEMENT SYSTEMS

PART 1 - GENERAL

1.01 WORK INCLUDED

- (A) Extent of electric control system work required by this section is indicated by drawings and schedules, and by requirements of this section.
1. Control sequences are specified in Division 23 section "Sequence of Operation".
- (B) Refer to Division 23 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems.
- (C) Installation of Facility Management System (FMS):
1. The FMS Contractor shall furnish and install a complete Facility Management System (FMS) for all mechanical systems and other facility systems as included in the project documents. The FMS will provide the functional features as defined in Part 1-General Requirements, Part 2-Products, and Part 3-Execution of these Specifications. The FMS Contractor shall provide a complete and operational system to perform all sequences of operations stated within section "Sequence of Operation".
2. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each authorized PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
3. The work under this Section shall include all materials and labor to perform all work required for the installation of the FMS as specified.
4. The drawings and Specifications are complementary to one another—meaning that what is called for on one is to be considered called for in both. Where conflicts exist between the Specifications and/or drawings, the more stringent requirement shall apply.
5. The FMS Contractor shall be responsible for field verification of site conditions and for gathering all necessary field data for all items to be provided under this contract prior to submitting his or her bid.
6. Where work specified under other Sections of this Specification connects to equipment or systems that are listed and described in this Section, the FMS Contractor shall provide proper connection(s) to such equipment, including trade coordination.
- (D) Provide all temperature control wiring not shown on the electrical drawings.
1. Temperature control wiring shall be defined as wiring from any device furnished as part of the temperature control system, to the connection point with equipment furnished under other sections, or as required in the sequence of operation.

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2. Provide power wiring to control panels, sensors, actuators, and accessories as necessary.
 3. The term wiring shall include wire conduit, miscellaneous material and labor required for mounting and wiring electrical control devices.
 4. Wiring shall comply with the requirements of Division 26.
- (E) Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:
1. All electrical power and control wiring required for the control system that is not specifically shown on the electrical drawings.
- (F) Refer to Division 23 Section General Provisions for equipment certification requirements.
- 1.02 DEFINITIONS
- (A) Algorithm: A software procedure for solving a recurrent mathematical or logical problem.
- (B) Analog: A continuously varying signal or value (temperature, current, velocity, etc.).
- (C) Binary: A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level.
- (D) Facility Management System (FMS): The entire system of hardware and software specifically designed to centrally manage building HVAC and related utilities. The FMS includes the DDC subsystem, open system ports, and open protocol bus or integrators and network routers for connection to information networks.
- (E) FMS Contractor: The Facility Management System Contractor responsible for the installation of the Facility Management System specified herein.
- (F) Control Process: The software required to perform a complete control loop from input signal to interlock logic, process calculation to final output signal control.
- (G) Control Wiring: Includes conduit, wire and wiring devices to install a complete Control System including motor control circuits, interlocks, thermostats and like devices. Includes all wiring from a DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute the sequence of operation. Includes necessary power wiring to all FMS devices, digital controllers including terminal units and actuators.
- (H) Deadband: A temperature range over which no heating or cooling energy is supplied, such as 72-78°F, i.e. as opposed to single point changeover or overlap, or a range from setpoint over which no control action is taken.
- (I) Direct Digital Control System: The portion of the FMS which provides closed loop control of all HVAC equipment.
- (J) Distributed Control: A system whereby all control processing is decentralized and independent of a central computer. The control system is built up of stand-alone controllers. A single controller failure shall not impact more than one system.

- (K) Integration: The ability of control system components from different manufacturers to connect together and provide coordinated control via real-time data exchange through a common communications data exchange protocol. Integration shall extend to the operator's workstation software, which shall support user interaction with all control system components. Methods of integration include industry standard protocols such as: BACnet, LonMark/LonTalk, ModBus, OLE for Process Control (OPC), or integrator interfaces between cooperating manufacturer's systems.
- (L) Network: A system of distributed control units that are linked together on a communication highway. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location. First tier networks shall provide "Peer-to-Peer" communications. Second tier networks shall provide either "Peer-to-Peer", Master-Slave or Supervised Token Passing communications.
- (M) Open Protocol Bus (OPB): A pre-programmed communications integrator that allows devices from one manufacturer to communicate and interact with those of another.
- (N) Open System Port (OSP): A user programmable communications port that provides the ability to develop custom communications processes to integrate other operating systems with the FMS System.
- (O) Operator-Machine Interface: A method by which an operator communicates with a FMS System. Operator-machine interfacing allows an operator to command, monitor, and program the system.
- (P) Peripheral: Input/Output equipment used to communicate with the computer and make copies of system outputs; peripherals include CRT, printer, tape deck, diskette, etc.
- (Q) Pick Point: A pick point is a graphical display element that allows the operator to 'click' the item and automatically display the associated screen or service. Any screen may have pick points to or be linked from any other screen. Pick points shall be configured on each display screen to provide a logical user navigation system using a ladder tree hierarchy.
- (R) PID Control Loop: A mathematical calculation used to evaluate a control input and determine the control output value required to maintain the input value at setpoint. The PID (Proportional, Integral, Derivative) control loop shall have operator adjustable maximum rate of change, P and D gains and loop response time delay. The loop shall be self-integrating so that no integral constant is required and the loop shall not be subject to 'Integral Windup'.
- (S) The term 'provide' means 'provide complete in place', that is, furnished and installed and ready for operation and use.

1.03 QUALITY ASSURANCE

- (A) General:
1. The Facility Management System (FMS) herein specified shall be fully integrated and installed as a complete package by the Facility Management System Contractor. The System shall include all wiring, piping, installation supervision, calibration, adjustments, and checkout necessary for a complete and fully operational system.
 2. The Facility Management System Contractor shall be a factory owned branch office or authorized factory representative that is regularly engaged in the engineering, programming, installation and service of Facility Management Systems of similar size and complexity.

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3. The FMS Contractor shall be responsible for all work fitting into place in a satisfactory and neat workmanlike manner acceptable to the Owner/Architect/Engineer.
4. The FMS Contractor will coordinate with other Trade Contractors regarding the location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, and so forth, in order to eliminate any delays in the progress of the job.

(B) Experience Record:

1. The FMS Contractor shall have a minimum of five years' experience with the complete, installation of Facility Management Systems of similar size and technical complexity. The FMS Contractor shall provide a list of five comparable projects that have Facility Management Systems with the features as specified for this project. These projects must be on-line and functional.
2. The FMS Contractor shall employ specialists in the field of Facility Management Systems including: Programming, Engineering, Field Supervision, and Installation. Specialists shall have a minimum of five years of experience with Facility Management Systems.

(C) Products:

1. The Facility Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Facility Management Systems, and shall be the manufacturer's latest standard of design. Controllers and DDC (Direct Digital Control) system components shall be current production products.

(D) Quality Assurance Program:

1. The FMS Contractor shall implement a Quality Assurance Program. At minimum, this program shall consist of the following requirements:
 - A. The FMS Contractor shall assign a single individual to serve as the Quality Assurance Manager, who is to be responsible for the management of the program.

(E) Governing Code & Standards Compliance:

1. The FMS Contractor shall comply with all current governing codes, ordinances, and regulations including UL, NFPA, the local Building Code, NEC, and so forth.
2. IEEE 802.15.4 - IEEE Standard for Information technology - Telecommunications and information exchange between systems--Local and metropolitan area networks-- Specific requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (LR-WPANs)

(F) FCC Regulation:

1. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.04 COORDINATION

(A) Divisions:

1. The FMS Contractor shall cooperate with other divisions performing work on this project as necessary to achieve a complete and neat installation. The Contractor shall also consult the drawings and specifications of all trades to determine the nature and extent of others' work.

(B) Contractors, Sub-contractors, Employees:

1. It will be the duty of this Contractor to work in cooperation with other contractors, and with other sub-contractors and employees, rendering assistance and arranging his or her work so that the entire project will be delivered in the best possible condition and in the shortest time.

1.05 SUBMITTALS

(A) Shop Drawings, Product Data, and Samples:

1. The FMS Contractor shall submit within 60 days after award, installation drawings and control strategies for review.
2. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address, and title; FMS Contractor name, address and phone number; FMS Contractor project manager, quality control manager, and project engineer names and phone numbers.
3. Each submittal shall include the following information:
 - A. FMS riser diagram showing all DDC controllers, operator workstations, network repeaters, and network wiring.
 - B. One-line schematics and system flow diagrams showing the location of all control devices.
 - C. Points list for each DDC controller, including: Tag, Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number.
 - D. Vendor's own written description for each sequence of operations, to include the following:
 - (1) Sequences shall reference input/output and software parameters by name and description.
 - (2) The sequences of operations provided in the submittal by the FMS Contractor shall represent the detailed analysis needed to create actual programming code from the design documents.
 - (3) Points shall be referenced by name, including all software points such as programmable setpoints, range limits, time delays, and so forth.

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- (4) The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system.
 - E. Cataloged cut sheets of all equipment used. This includes, but is not limited to, the following: DDC Panels, peripherals, sensors, actuators, dampers, control air system components, and so forth.
 - F. Range and scale information for all transmitters and sensors. This sheet shall clearly indicate one device and any applicable options. Where more than one (1) device to be used is on a single sheet, submit two sheets, individually marked.
 - G. Training course outlines for each four-hour session.
 - H. Hardware data sheets for all operator workstations, local access panels, and portable operator terminals.
 - I. Software manuals for all applications programs to be provided as a part of the operator workstations, portable operator terminals, programming devices, and so forth for evaluation for compliance with the performance requirements of this Specification.
 - J. Initial project team Quality Assurance compliance report.
4. FMS Contractor shall not begin fabrication or field installation until receiving authorization to proceed in the form of an approved submittal. FMS Contractor shall be solely responsible for the removal and replacement of any item not approved by submittal at no cost to the Owner.
- 1.06 O&M MANUALS
- (A) Submit three sets of each manual.
- 1. Include the following documentation in the Hardware Manual:
 - A. General description and cut sheets for all components.
 - B. Detailed wiring and installation illustrations and complete calibration procedures for each field and panel device.
 - C. Complete trouble-shooting procedures and guidelines.
 - D. Complete operating instructions for all systems.
 - E. Maintenance Instructions: Document all maintenance and repair/replacement procedures.
 - 2. Include the following documentation in the DDC Software Manual:
 - A. Sequence of Operations.
 - B. Program Listing of Software Source Code OR Flow Chart.
 - C. Diagrams of Programming Objects.

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- D. Printed listing of controller and operator workstation database files.
 - E. Software Point Name Abbreviation List.. Include Name, Description, Controller Where Located, Point Type and Point ID.
 - F. I/O Point List. Include Point Name, Controller Location, Point Number, Control Device, Range and Span.
 - G. Printouts of all; Reports, Group Listings and Alarm Messages.
 - H. Index of all DDC point names with documentation manual page number references.
3. Provide three copies of all manufacturers manuals covering the installed system. This shall include, as a minimum:
- A. System Engineering Manual.
 - B. System Installation Manual.
 - C. Programming Manual.
 - D. Engineering and Troubleshooting Bulletins.
 - E. Operator Workstation Software Manual.
 - F. All other pertinent manuals published by the control system manufacturer.
4. All manuals shall be provided in hard copy format or on a single Compact Disk (CD) as part of an on-line documentation system through the operator workstation.
5. Provide complete record drawings of the completed system.

1.07 **WARRANTY**

(A) Material:

1. The Control System shall be free from defects in material and workmanship under normal use and service. If within one (1) year from the date of completion any of the equipment herein described is defective in operation, workmanship or materials, it will be replaced, repaired or adjusted at the option of the FMS Contractor free of charge.

(B) Installation:

1. The Control System shall be free from defects in installation workmanship for a period of one (1) year from acceptance. The FMS Contractor shall respond within 24 hours, and correct any defects in workmanship within one week of request of warranty service by the Owner.
2. Control System failures and deficiencies during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner.

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1.08 OWNERSHIP OF PROPRIETARY MATERIAL

(A) Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

(A) Manufacturer: Subject to compliance with requirements, provide electric control systems of one (1) of the following:

1. Metasys Systems by Johnson Controls, Inc.

2.02 MATERIALS AND EQUIPMENT

(A) General: Provide electric control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, sensors, controllers, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer. Provide electric control systems with the following functional and construction features as indicated.

(B) Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

(C) Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.

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5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.

(D) Control Valves: Provide factory-fabricated electrical control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature rating of piping system. Except as otherwise indicated, provide valves which mate and match material of connecting piping. Equip control valves with control valve motors and with proper shutoff ratings for each individual application.

1. Water Service Valves: Equal percentage characteristics with range of 50 to 1, and maximum full flow pressure drop of 5 PSIG.
2. Type: Provide two- or three-way control valves for two-position or modulating service as shown.
 - A. Water Valves.
 - (1) Valves providing two-position service shall be quick opening. Two-way valves shall have replaceable disc or ball.
 - (2) Close-off (Differential) Pressure Rating. Valve actuator and trim shall provide the following minimum close-off pressure ratings.
 - B. Two-way: 150% of total system (pump) head.
 - C. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
 - D. Ports. Valves providing modulating service shall have equal percentage ports.
 - E. Sizing.
 - (1) Two-position service: line size.
 - (2) Two-way modulating service: select pressure drop not to exceed 5 psi.
 - (3) Three-way modulating service: select pressure drop not to exceed 5 psi.
 - F. Fail Position: Water valves shall fail normally open or closed as follows unless otherwise specified.

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- (1) Water zone valves: normally open.
 - (2) Heating coils: normally open.
 - (3) Chilled water control valves: normally closed.
 - (4) Other applications: as scheduled or as required by sequences of operation.
3. Valve Trim and Stems: Polished stainless steel.
4. Packing: Spring-loaded Teflon, self-adjusting.
5. Terminal Unit Control Valves: Provide control valves for control of terminal units including, but not necessarily limited to, convectors, finned tube radiation, VAV boxes, and fan-coil units that are of integral motor type. Provide modulating type valves
- (E) Dampers: Provide automatic control dampers as indicated, with damper frames not less than formed 13-gage galvanized steel. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16-gage galvanized steel, with maximum blade width of 8 inches. Equip dampers with motors, with proper rating for each application.
 1. Secure blades to 1/2-inch diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristic, plus size schedule for controlled dampers.
 2. Operating Temperature Range: From -20°F to 200°F.
 3. For standard applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with optional closed-cell neoprene edging.
 4. For low-leakage applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm/sq. ft. of damper area, at differential pressure of 4 inches w.g. when damper is being held by torque of 50 inch-pounds.
 5. Provide unit ventilator outside air dampers with adjustable minimum settings so that ventilation can be adjusted for each space or room.
- (F) Damper and Valve Actuators: Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified.
 1. Electronic actuation shall be provided.
 2. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp shall be of a "V" bolt design with associated "V" shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.

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3. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator.
 4. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
 5. All spring return actuators shall be field selectable in direction.
 6. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal. Include field adjustable zero and span.
 7. Power: Nominal 24 VAC. For 24 VAC/DC include Class 2 wiring. Meet NEMA 1 rating with torque equal to 150% of required duty.
 8. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
 9. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections. Include on-off toggle switch.
 10. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.
 11. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.
- (G) Room Temperature Sensors: Provide room thermostats with locking covers, and with concealed or readily-accessible adjustment devices and dead band, as indicated.
1. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
 2. Where indicated, provide heavy-duty "asylum type", clear plastic, or wire tamper-proof guards.
 3. Line-Voltage On-Off Thermostats: Provide thermostats of bi-metal actuated open contact, or bellows actuated enclosed snap-switch type, or equivalent solid-state type; UL-listed at electrical rating comparable with application. Provide bi-metal thermostats which employ heat anticipation. Equip thermostats which control electric heating loads directly, with Off position on dial wired to break ungrounded conductors.
 4. Combination Thermostat and Fan Switches: Comply with requirements for line-voltage thermostats. In addition, include as integral part of each thermostat, 2-, 3-, or 4-position push-button or lever operated manual switch for control of fan in each unit with type of control as indicated.

- A. Label switches "fan on-off", "fan high-low-off", "fan high-med-low-off". Provide factory-fabricated unit, capable of being mounted on 2-gang switch box or mud ring.
- 5. Low-Voltage On-Off Thermostats: Comply with general requirement indicated for line-voltage thermostats. Provide thermostats of bi-metal operated mercury-switch type, with either adjustable or fixed universal anticipation heater.
- 6. Low-Voltage Modulating Thermostats: Provide potentiometer type, operated by vapor-filled bellows.
- (H) Low-Temperature Protection Thermostats: Provide low-temperature protection thermostats of manual-reset type, with sensing elements 10 feet - 0 inches in length. Provide thermostat designed to operate in response to coldest 1 foot 0 inches length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25 sq. ft. of coil face area or fraction thereof.
- (I) Duct Mounted Smoke Detectors: Duct Mounted Smoke Detectors are provided as work of Division 26.
- (J) Clocks: Provide time clocks specified as part of temperature control sequences, of 7-day, 24-hour type, with weekend or skip-a-day features. Equip time clocks with 10-hour carryover to maintain clock movement in case of power failure.
- (K) Time clocks shall be a quartz clock with 365 day programming capability. At least three start and three stop times shall be available for each channel every day. In case of power failure, the clock shall continue to operate and the memory shall be protected for a minimum of 24 hours.
- (L) Step Controllers: Provide step controllers for control sequencing or for control of electric heat power loads, of 6- or 10-stage type, with heavy-duty switching rated to handle loads, UL-listed and operated by electric motors of quality specified for valve and damper actuation.
- (M) Electronic Sensors:
 - 1. Temperature sensors shall be of the thermistor (NTC) type with a high resistance change versus temperature change to insure good resolution and accuracy. Sensors shall be available for room, duct or well mounting. Room type sensors shall be available with built-in setpoint adjustment, occupancy override, and communication port. Sensors shall be available in various ranges to properly suit the application.
 - A. Immersion Sensor: Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in and it shall withstand pipe design flow velocities.
 - B. Duct Sensors: Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross-section
 - 2. Humidity sensors shall be of the solid state type utilizing hygroscopic plastic as the sensing element. The sensor shall vary the output voltage with a change in relative humidity. Sensors shall be available for room or duct mounting. Room type sensor shall be available with built in setpoint potentiometer.

3. Duct mounted averaging type temperature sensor shall utilize a resistance sensing element incorporated in a copper capillary of 20 feet. The sensor shall vary the output voltage with a change in temperature.
 4. Differential pressure sensor shall vary the output voltage with a change in differential pressure. The sensor shall connect to the remote controller by means of a three-wire unshielded cable.
 5. Outdoor air sensor shall be of the thermistor (NTC) type with a high resistance change versus temperature change. Sensor shall be available for outdoor or duct mounting. Sensor shall connect to remote controller by means of a two-wire unshielded cable.
- (N) Electronic Controllers: Temperature/humidity/pressure controllers shall be proportional type with integrated circuits. Each output shall have separate zero and proportional band adjustments. Indicating lamps shall be provided for each output which will vary in intensity to indicate amount of output. Controller shall be available with either 0-20 VDC proportional output, two position, or any combination. Controller shall have internal switches for each output to change the output signal to either direct or reverse. Controller shall be available with integral electronic circuit for absolute high or low limit control.
- (O) Fan Speed Controllers: Provide solid-state fan speed controllers, to maintain room temperature by varying fan speed of fan units, in response to room temperature changes. Provide proportioning control of motor speed, from maximum down to minimum of 55% (field adjustable). Equip controller to provide on-off action below demand for minimum fan speed, to prevent low-speed operation and ensure normal motor life. Design controller to apply full-voltage for brief period each time motor is started, to bring motor up to minimum speed rapidly. Equip controller with filter circuit to eliminate objectionable radio interference.
- (P) Electric Heat Current Controllers: Accomplish switching of load current with semiconductor devices located in load circuit of operation controller, and not by mechanical or mercury relays. Provide controllers which operate on zero-voltage switching principle, to minimize radio frequency interference; do not substitute devices incorporating phase control firing. Arrange power controller, for loads of 10 kw or larger, for 3-phase operation. Incorporate solid-state switch for loads of 48 amps per phase or larger, in each ungrounded line of load circuit.
1. Refer to heating equipment specifications for integral high temperature limit controllers.
- (Q) Electric Contactors: Provide contactors for operating or limit- control of electric heating loads which are UL-listed for 100,000 cycles of resistive loads. Equip with replaceable molded coils and replaceable silver cadmium oxide contacts. Coat core laminations with heat-resistant inorganic firm to reduce core losses. Provide line and load terminals on contactors with higher-than-35-amp rating, or provide one-piece formed-and-welded pressure type. Provide screw-type contactors for 35-amp-or-lower rating. Equip field-mounted contactors with suitable steel enclosures; and provide open-type mounting for those installed in factory- fabricated panels.
- (R) Water Flow Switches: Provide water flow switches of stainless steel or bronze paddle types. Where flow switches are used in chilled water application, provide vapor-proof type to prevent condensation of electrical switch. Provide pressure-flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated.
- (S) Humidity Sensors:
1. Duct and room sensors shall have a sensing range of 20%-80%. For humidification applications, duct sensor shall have a sensing range of 20% - 95% RH.
 2. Duct sensors shall have a sampling chamber.

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3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°C-75°C (40°F-170°F).
 4. Humidity sensors shall not drift more than 1% of full scale annually.
- (T) Flow Switches: Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
 2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- (U) CO₂ Sensors: Sensor to be Non-dispersive infrared type and have a recommended calibration interval of 5 years. An LCD screen indicating sensor reading shall be used when it is not directly connected to a DDC system for monitoring. Control output shall be selectable and include 0 – 10 V, 2 – 10 V, and/or 4 – 20 mA options. Sensor shall be wall mounted for general space monitoring and duct mounted for monitoring air through ductwork.
1. A 24 VDC SPST relay may be required to independently provide equipment control. See Division 23 Section Sequence of Operation for operation.
- (V) Relays:
1. Control Relays: Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
 2. Time Delay Relays: Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable $\pm 100\%$ from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.
- (W) Override Timers:
1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.
- (X) Current Transmitters:
1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be $\pm 1\%$ full-scale at 500 ohm maximum burden.
 2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
 3. Unit shall be split-core type for clamp-on installation on existing wiring.

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(Y) Current Transformers:

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for $\pm 1\%$ accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

(Z) Voltage Transmitters:

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
2. Adjustable full-scale unit ranges shall be 100-130 VAC, 200-250 VAC, 250-330 VAC, and 400-600 Vac. Unit accuracy shall be $\pm 1\%$ full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 VAC rating.

(AA) Voltage Transformers:

1. AC voltage transformers shall be UL/CSA recognized, 600 VAC rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide $\pm 0.5\%$ accuracy at 24 VAC and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

(BB) Power Monitors: Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.

1. Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of $\pm 2\%$ at 1.0 power factor or $\pm 2.5\%$ at 0.5 power factor.

(CC) Current Switches:

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

(DD) Pressure Transducers:

1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.

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3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.
 4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.) Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.
- (EE) Differential Pressure Switches: Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- (FF) Local Control Panels: Provide control panels with suitable brackets for either wall or floor mounting, for each supply fan and miscellaneous control systems. Locate panel adjacent to systems served.
1. Fabricate panels of 14-gage furniture-quality steel, or 6063-T5 extruded aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard ship-painted finish and color. Provide UL-listed cabinets for use with line voltage devices.
 2. Panel Mounted Equipment: Include temperature and humidity controllers, relays and automatic switches, except exclude low-temperature protection thermostats, firestats, and other devices excluded in sequence of operation. Fasten devices with adjustments accessible through front of panels.
 3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper "minimum-off" positioning switches, "summer-winter" switches, and "manual-automatic" switches; and including dial thermometers.
- (GG) Central (Master) Control Panels: Provide central control panels of fully-enclosed steel cubical type, with locking doors and/or locking removable backs. Match finish of panels and provide multi-color graphic displays, schematically showing system being controlled.
- (HH) Flow switches shall be of the paddle type equipped with SPOT contacts to establish proof of flow. Flow switches shall be of the vapor proof type similar to a McDonnell Miller FSS-V.
- (II) Line voltage to 24V AC transformer shall be supplied as required to provide adequate control voltage to the control system.
- (JJ) Indicators: Remote indicator shall interface with sensor/controller to indicate measured value at the sensor. Indicator shall be capable of indicating temperature, pressure or humidity.
- 2.03 GENERAL PRODUCT DESCRIPTION
- (A) The Facility Management System (FMS) shall be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, and trend data collection.
- (B) The FMS shall consist of the following:
1. Standalone DDC Panels
 2. Standalone Application Specific Controllers (ASCs).

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3. Operator's Workstations or Servers.

The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASCs, and operator devices.

- (C) The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2.04 NETWORKING/COMMUNICATIONS

- (A) The design of the FMS shall be networked as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via a local network, auto-dial telephone line modem connections, or a combination of the two networking schemes.

- (B) Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a unified control network. A gateway (translator) shall communicate with third-party equipment furnished or installed by others.

- (C) Install new wiring and network devices as required to provide a complete and workable control network. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

- (D) Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

- (E) Inter-network operator interface and value passing shall be transparent to inter-network architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each inter-network controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each inter-network controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the inter-network. Program and test all cross-controller links required to execute control strategies specified in Section 15900 Appendix A. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

- (F) System shall automatically synchronize controller time clocks daily from an operator-designated controller via the inter-network. If applicable, system shall automatically adjust for daylight saving and standard time.

- (G) System shall capable of being expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

- (H) Local Network:

1. DDC Panel Support. The DDC Panel shall directly oversee a local network such that communications may be executed directly to and between ASCs.

2. Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application data on the network.

- A. Access to system data shall not be restricted by the hardware configuration of the facility management system.

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3. Global Data Sharing: Global Data Sharing or Global point broadcasting shall allow point data to be shared between ASCs, when it would be inefficient or impractical to locate multiple sensors.
4. General Networking Design: Network design shall include the following provisions:
 - A. Data transfer rates for alarm reporting and quick point status from multiple ASCs. The minimum baud rate shall be 9600 baud.
 - B. Support of any combination of ASCs. A minimum of 100 ASCs shall be supported on a single local network. The bus shall be addressable for up to 256 ACSs.
 - C. Detection of single or multiple failures of ASCs or the network media.
 - D. Error detection, correction and retransmission to guarantee data integrity.
 - E. Commonly available, multiple-sourced, networking components shall be used.
 - F. Use of an industry standard protocol, such as Optomux and IEEE RS-485 communications interface.

2.05 DIGITAL PANELS

(A) General: Digital Panels shall be microprocessor-based, multi-tasking, multi-user, digital control processors.

(B) Memory:

1. Each Digital Panel shall have sufficient memory to support its own operating system and databases including:
 - A. Control processes.
 - B. Energy Management Applications.
 - C. Alarm Management.
 - D. Trend Data.
 - E. Maintenance Support Applications.
 - F. Operator I/O.
 - G. Dial-up Communications.
 - H. Manual Override Monitoring.

(C) Point types: Each DDC panel shall support the following types of point inputs and outputs.

1. Digital Inputs for status/alarm contacts.
2. Digital outputs for on/off equipment control.
3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements.

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4. Analog Outputs for valve and damper position control and capacity control of primary equipment.
 5. Pulse Inputs for pulsed contact monitoring.
- (D) Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of field controllers, sensors, actuators.
- (E) Serial Communication Ports: Digital Panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices, such as laptop computers, personal computers, and video display terminals.
- (F) Hardware Override Monitoring: Digital Panels shall monitor the status of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.
- (G) Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
- (H) Integrated Online Diagnostics: Each Digital Panels shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. Digital Panels shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each Digital Panel.
- (I) Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.
- (J) Environment: Controller hardware shall be suitable for anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F)..
 2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- (K) Serviceability:
1. Controllers shall have diagnostic LEDs for power, communication, and processor.
 2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
- (L) Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of the Digital Panel to prevent the loss of database or operating system software. Nonvolatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
1. Upon restoration of normal power, the Digital Panel shall automatically resume full operation without manual intervention.
 2. Should Digital Panel memory be lost for any reason, the user shall have the capability of reloading the Digital Panel via the local RS-232C port or local area network.

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2.06 SYSTEM SOFTWARE FEATURES

(A) General:

1. All necessary software to form a complete operating system, as described in this specification, shall be provided.
2. The software programs specified in this section shall be provided as an integral part of the Digital Panel and shall not be dependent upon any higher level computer for execution.
3. Operating System: Web server shall have an industry-standard professional-grade operating system.

(B) System Tools: System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. A set of all site survey and installation tools as well as software shall be provided to the contractor use for system installation and commissioning for the duration of the warranty period. A set of all site survey and installation tools as well as software shall be provided to the owner for permanent possession for ongoing system maintenance and trouble shooting.
2. Automatic System Database Configuration: Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
3. Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
4. System Configuration: Operators shall be able to configure the system.
5. Online Help: Context-sensitive online help for each tool shall assist operators in operating and editing the system.
6. Security: System shall require a username and password to view, edit, add, or delete data.
 - A. Operator Access: Each username and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.
 - B. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
 - C. Encrypted Security Data: Store system security data including operator passwords in an encrypted format such as 128 bit SSL encryption. System shall not display operator passwords.
7. System Diagnostics: System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

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8. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Division 23 Section Sequences of Operation.
9. Alarm Messages: Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
10. Alarm Reactions: Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
11. Alarm Maintenance: Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
12. Trend Configuration: Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk.
13. Object and Property Status and Control: Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
14. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
15. Standard Reports: Furnish the following standard system reports:
 - A. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
 - B. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
 - C. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:
 - (1) Alarm History.
 - (2) Trend Data: Operator shall be able to select trends to be logged.
 - (3) Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

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16. Custom Reports: Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.
17. Graphics Generation: Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.
18. Graphics Library: Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.
19. Custom Application Programming: Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
 - A. Language: Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
 - B. Programming Environment: Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
 - C. Independent Program Modules: Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
 - D. Debugging and Simulation: Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
 - E. Conditional Statements: Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - F. Mathematical Functions: Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

G. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

(1) Time Variables: Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

(2) System Variables: Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

(C) Control Software Description:

1. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
2. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
3. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

(D) Energy Management Applications: Building and energy management application software shall reside and operate in DDC Panels. Applications shall be editable through operator workstation, web browser interface, or engineering workstation. DDC Panels shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling.
2. Calendar Based Scheduling.
3. Holiday Scheduling.
4. Optimal Start.
5. Optimal Stop.
6. Demand Limiting.
7. Load Rolling.
8. Heating/Cooling Interlock.
9. Average/High/Low Signal Select and Reset.

- (E) All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment described in the "Execution" portion of this specification.
- (F) Programming Capability: Digital Panels shall be able to execute configured processes defined by the user to automatically perform calculations and control routines.
1. Process Inputs and Variables: It shall be possible to use any of the following in a configured process:
 - A. Any system-measured point data or status.
 - B. Any calculated data.
 - C. Any results from other processes.
 - D. Boolean logic operators (and, or).
 2. Process Triggers: Configured processes may be triggered based on any combination of the following:
 - A. Time of day.
 - B. Calendar Date.
 - C. Other processes.
 - D. Events (e.g., point alarms).
 3. Data Access: A single process shall be able to incorporate measured or calculated data from any and all other ASCs on the local network.
- (G) Pre-Tested Control Algorithms: DDC Panels shall have the ability to perform the following pre-tested control algorithms:
1. Two Position Control.
 2. Proportional Control.
 3. Proportional plus Integral Control.
 4. Proportional, Integral, plus Derivative Control.
 5. Automatic Control Loop Tuning.
- (H) Alarm Management: Alarm management shall be provided to monitor, buffer and direct alarm reports to operator devices and memory files. Each Digital Panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Digital Panel's ability to report alarms be affected by either operator activity at the local I/O device, or communications with other ASCs on the network.

1. Point Change Report Description: All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 2. Prioritizing: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Users shall have the ability to manually inhibit alarm reporting for each point.
 - A. The user shall also be able to define conditions under which point changes need to be acknowledged by an operator, and/or logged for analysis at a later date.
 3. Reporting Routing: Alarm reports and messages shall be directed to an operator device.
 4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to more fully describe the alarm condition or direct operator response.
 5. Remote Alarm Horn: Each Digital Panel shall be capable of triggering a binary output on an ASC when a critical or network alarm is received. The alarm horn feature shall be silenced when the critical alarm is acknowledged.
- (I) Historical Data and Trend Analysis: A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.
1. Continuous Point Histories: Standalone DDC Panels shall store Point History Files for all analog and binary inputs and outputs.
- (J) The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commends for each point.
1. Measured and calculated analog and binary data shall be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one-minute or one-hour intervals, shall be provided. Each Digital Panel shall have a dedicated buffer for trend data, and shall have up to 4 points trended at 48 data samples each. Data shall be stored at the Digital Panel.
- (K) Runtime Totalization: Digital Panels shall automatically accumulate and store runtime hours for binary input and output points specified in the "Execution" portion of this specification.
1. The Totalization routine shall have a sampling resolution of one minute.
 2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.
- (L) Pulse Totalization: Digital Panels shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected binary pulse input-type points.
1. The Totalization routine shall provide calculations and storage accumulations of up to 9,999,999 units (e.g. KWH, gallons, KBTU, ton, etc.).

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2. The Totalization routine shall have a sampling resolution of one minute.
 3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
 4. The information available from the Pulse Totalization shall include, but not be limited to, the following:
 - A. Peak demand, with date and time stamp.
 - B. 24-hour demand log.
 - C. Accumulated KWH for day.
 - D. Sunday through Saturday KWH usage.
 - E. Sunday through Saturday Demand KW.
 - F. Demand KW annual history for past 12 periods.
 - G. KWH annual history for past 12 periods.
- (M) Event Totalization: Digital Panels shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off.
1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
 2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
- 2.07** APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS
- (A) Each Digital Panel shall be able to extend its monitoring and control through the use of standalone Application Specific Controllers (ASCs).
- (B) Each ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- (C) Each ASC shall have sufficient memory to support its own operating system and databases including:
1. Control Processes.
 2. Energy Management Applications.
 3. Operator I/O (Portable Service Terminal).
- (D) The operator interface to any ASC point data or programs shall be through the Digital Panel or portable operator's terminal connected to any ASC on the network.

- (E) ASCs shall directly support the temporary use of a portable service terminal that can be connected to the ASC via zone temperature or directly at the controller. The capabilities of the portable service terminal shall include, but not be limited to, the following:

1. Display temperatures.
2. Display status.
3. Display setpoints.
4. Display control parameters.
5. Override binary output control.
6. Override analog setpoints.
7. Modification of gain and offset constants.

- (F) Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

- (G) Application Descriptions:

1. VAV Terminal Unit Controllers:

- A. VAV Terminal Unit Controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements described in the "Execution" portion of this specification, and for future expansion:

- (1) Single Duct Only (Cooling Only, or Cooling with Reheat).
 - (2) Fan Powered (Parallel/Side Pocket, Series/On-Off Logic, Series/Proportional Fan).
 - (3) Dual Duct (Constant Volume, Variable Volume).
 - (4) Supply/Exhaust.

- B. VAV Terminal Unit Controllers shall support the following types of point inputs and outputs:

- (1) Proportional Cooling Outputs.
 - (2) Box and Baseboard Heating Outputs:
(Proportional or 1 to 3 Stages).
 - (3) Fan Control Output:
(On/Off Logic, or Proportional Series Fan Logic).

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C. VAV Terminal Unit Controllers shall support the following library of control strategies to address the requirements of the sequences described in the "Execution" portion of this specification, and for future expansion:

- (1) Daily Schedules.
- (2) Comfort/Occupancy Mode.
- (3) Economy Mode:
 - Standby Mode.
 - Unoccupied.
 - Shutdown.
- (4) Lighting Logic Interlock to Economy Mode.
- (5) Temporary Override Mode:
 - Temporary Comfort Mode (Occupancy-Based Control).
 - Boost.

D. Occupancy-based Economy/Comfort Mode Control: Each VAV Terminal Unit Controller shall have a provision for occupancy sensing overrides. Based upon the contact status of either a manual wall switch or an occupancy sensing device, the VAV Terminal Unit Controller shall automatically select either an Economy or Comfort mode.

E. Occupancy-Based Zone Lighting Control: VAV Terminal Unit Controllers shall provide an auxiliary binary output to serve as the interface to an associated lighting relay. Based upon the status of either an occupancy sensing device or manual wall switch, the VAV Terminal Unit Controller shall provide a contact output to automatically turn on or off the lights. This accommodates occupant requirements while reducing electrical consumption. Economy/Comfort (described in the previous section) and Lighting overrides shall be served by the same occupancy override input.

F. Temporary Override Modes:

- (1) Temporary Occupancy Mode: The controller interface to the zone temperature sensor shall allow for an optional momentary switch to change the mode of the controller from economy to comfort and optionally interlock the room lights for a preset amount of time.
- (2) Boost Mode: The controller interface to the zone temperature sensor shall allow for an optional momentary switch to override the controller's output to full heating or cooling. This command shall be active for a preset amount of time, to anticipate a substantial change in the room's load.

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- G. Alarm Management: Each VAV Terminal Unit Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2. Unitary Controllers:

- A. Unitary Controllers shall support, but not be limited to, the following types of systems to address specific applications described in the "Execution" portion of this specification, and for future expansion:

- (1) Unit Vents (ASHRAE Cycle I, II, III, or W).
- (2) Heat Pumps (Air-to-Air, Water-to-Air).
- (3) Packaged Rooftops.
- (4) Fan Coils (Two-Pipe, Four-Pipe).

- B. Unitary Controllers shall support the following types of point inputs and outputs:

- (1) Economizer Switchover Inputs:
 - Drybulb.
 - Outdoor Air Enthalpy.
 - Differential Temperature.
 - Binary Input from a separate controller.
- (2) Economizer Outputs:
 - Integrated Analog with minimum position.
 - Binary output to enable self-contained economizer actuator.
- (3) Heating and Cooling Outputs:
 - 1 to 3 Stages.
 - Analog Output with two-pipe logic.
 - Reversing valve logic for Heat Pumps.
- (4) Fan Output:
 - On/Off Logic Control.

- C. Unitary Controllers shall support the following library of control strategies to address the requirements of the sequences described in the Execution portion of this specification, and for future expansion:

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(1) Daily/Weekly Schedules.

(2) Comfort/Occupancy Mode.

(3) Economy Mode:

Standby Mode/Economizer Available.

Unoccupied/Economizer Not Available.

Shutdown.

Lighting Logic Interlock to Economy Mode.

(4) Temporary Override Mode:

Temporary Comfort Mode (Occupancy-Based Control).

Boost (Occupant Warmer/Cooler Control).

D. Occupancy-based Standby/Comfort Mode Control: Each Unitary Controller shall have a provision for occupancy sensing overrides. Based upon the contact status of either a manual wall switch or an occupancy sensing device, the Unitary Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

E. Occupancy-Based Zone Lighting Control: Unitary Controllers shall provide an auxiliary binary output to serve as the interface to an associated lighting relay. Based upon the status of either an occupancy sensing device, or manual wall switch, the Unitary Controller shall provide a contact output to automatically adjust the lighting level to accommodate occupant requirements while reducing electrical consumption. Standby/Comfort (described in the previous section) and Lighting overrides shall be served by the same occupancy override input.

F. Continuous Zone Temperature Histories: Each Unitary Controller shall automatically and continuously, maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

G. Alarm Management: Each Unitary Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

3. AHU Controllers:

A. AHU Controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion:

(1) Air Handling Units > 15,000 CFM or < 50,000 CFM:

Mixed Air-Single Path.

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Mixed Air-Dual Path.

100% Single Path.

100% Dual Path.

Generic Point Multiplexing.

- B. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.
- C. AHU Controllers shall have a library of control routines and program logic to perform the sequence of operation as specified in the Execution portion of this specification.
- D. Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously, maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.
- E. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

4. Lab and Central Plant (LCP) Controllers:

- A. LCP controllers shall support, but not be limited to, the following configurations of systems to address current requirements described in the "Execution" portion of this specification, and for future expansion.
 - (1) Single boiler or chiller plants with pump logic cooling towers.
 - (2) Zone Pressurization of labs.
 - (3) Generic System interlocking through hardware.
- B. LCP controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.
- C. LCP controllers shall have a built-in status and adjust panel interface to allow for the local adjustment of all setpoints, temporary override of any input or output points and status of any points in alarm.

2.08 LIGHTING APPLICATIONS

- (A) The FMS system shall be able to extend its capacity through the use of Lighting Control Panels, including third party panels. Lighting Control Panels shall provide standalone remote control of building lighting circuits, including weekly and holiday time programming, local overrides, and local status indication. Communication protocols shall be coordinated, as needed, between the controls and electrical contractors.
- (B) Each Lighting control panel shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Lighting Control Panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

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- (C) Each Lighting Control panel shall have sufficient memory to support its own operating system and databases, including:

1. Weekly Scheduling.
2. Energy Management Applications.
3. Local Overrides.

2.09 OPERATOR INTERFACE

- (A) Web workstation or server shall reside on high-speed network with building controllers. Operators shall be able to utilize a commercially available browser such as Microsoft Internet Explorer with the appropriate plug-in software. No additional software shall have to be installed on the client PC for normal operation of the system. Each standard browser connected to server shall be able to access all system information.

- (B) Any unlimited number of users shall be able to access the DDC system via a web browser. A minimum of 5 users shall be able to utilize this device at the same time.

- (C) Communication: Workstation or web server and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol.

- (D) Hardware: Each workstation or web server shall consist of the following:

1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified above in this section. Hard disk shall have sufficient memory to store system software, 500 MB available for trended points, and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance. Web server or workstations shall be IBM-compatible PCs with a minimum of:

- A. Intel Pentium 2.66 GHz processor
- B. 1 GB RAM
- C. 40 GB hard disk providing data at 100 MB/sec
- D. 48x CD-ROM drive
- E. Serial, parallel, and network communication ports and cables required for proper system operation
- F. 19" flat LCD screen

- (E) Basic Interface Description:

1. Command Entry/Menu Selection Process: Operator interface software shall minimize operator training through the use of English language prompting and English language point identification.

2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
3. Graphical and Text-based Displays: The Operator interface shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.
4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit control, display, and database manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
 - A. Passwords shall be exactly the same for all operator devices.
 - B. A minimum of three levels of access shall be supported:
 - (1) Level 1 = Data Access and Display.
 - (2) Level 2 = Level 1 + Operator Overrides and Commands.
 - (3) Level 3 = Level 2 + Database Generation and Modification.
 - C. A minimum of four passwords shall be supported at each Digital Panel.
 - D. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device shall be limited to only those items defined for the access level of the password used to log-on.
 - E. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices logged on.
5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
 - A. Start-up or shutdown selected equipment.
 - B. View and Adjust Equipment Properties: Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration per their access level.
 - C. View and adjust operating schedules of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show override schedules and holidays on the schedule display.
 - D. Enable/Disable process execution.
 - E. Lock/Unlock alarm reporting for each point.
 - F. Enable/Disable and configure Totalization for each point.

- G. Enable/Disable and configure Trending: View a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
 - H. Change time/date.
 - I. Enter/Modify analog warning and alarm limits as well as view and respond to alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
 - J. Enable/Disable demand limiting.
 - K. Enable/Disable duty cycle.
 - L. Enable/Disable average/high/low signal select and reset.
 - M. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
6. Logs and Summaries: Reports shall be generated manually and directed to the displays. As a minimum, the system shall allow the user to easily obtain the following types of reports:
- A. A general listing of all points in the system shall include, but not be limited to, the following:
 - (1) Points currently in alarm.
 - (2) Off-line points.
 - (3) Points currently in override status.
 - (4) Holiday Programming.
 - B. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.
- (F) Dynamic Color Graphic Displays: Color graphic floor plans that clearly display the zones and areas served by air systems, system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, hot water boiler systems, and variable air volume zones shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition. Graphics layout and usability shall be approved by the owner and/or engineer prior to implementation.
1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.

2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention. Space temperature values shall also graphically display its extent away from setpoint, such as through real-time color hue changes.
 3. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.
 - A. The FMS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
 - B. The graphic development package shall allow the user to perform the following:
 - (1) Define symbols.
 - (2) Position and size symbols.
 - (3) Define background screens.
 - (4) Define connecting lines and curves.
 - (5) Locate, orient and size descriptive text.
 - (6) Define and display colors for all elements.
 - (7) Establish correlation between symbols or text and associated system points or other displays.
 - C. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the facility.
 - D. To accomplish this, the user shall be able to build graphic displays that include point data from multiple application specific controllers.
- (G) System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
 - A. Add/Delete/Modify Application Specific Controllers.
 - B. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants.
 - C. Add/Delete/Modify alarm reporting definition for each point.
 - D. Add/Delete/Modify time- and calendar-based programming.

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- E. Add/Delete/Modify energy management applications.
 - F. Add/Delete/Modify Totalization for every point.
 - G. Add/Delete/Modify Historical Data Trending for every point.
 - H. Add/Delete/Modify configured control processes.
 - I. Add/Delete/Modify dial-up telecommunication definition.
 - J. Add/Delete/Modify all operator passwords.
 - K. Add/Delete/Modify Alarm Messages.
2. Programming Description: Definition of operator device characteristics, ASCs, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.
- A. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single ASC but shall be able to include data from any and all to other ASCs to allow the development of network-wide control strategies.
3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data.
4. Database Save/Restore/Back-up: Back-up copies of all ASC and Digital Panel databases shall be stored in at least one personal computer or laptop.
- (H) Users shall also have the ability to manually execute downloads of an ASC or Digital panel database.
- (I) Personal Computer Operator Workstation Description: Personal Computer Operator Workstations shall be provided for command entry, information management, network alarm management, and database management functions. All real-time control functions shall be resident in the Standalone DDC Panels to facilitate greater fault tolerance and reliability.
- 1. Workstations shall be general purpose, commercially available, personal computers with sufficient memory and processor capacity to perform all functions described in this specification.
 - 2. Sufficient Winchester Technology bulk storage shall be provided to accommodate all fully configured point databases, all graphics databases, all user-defined reports, and all historical data archival as described in this specification.
 - 3. The display provided for system operation shall have a minimum display resolution of no less than 800 x 600 pixels. Separate controls shall be provided for color, contrast and brightness. The screen shall be non-reflective.

2.010 ASSOCIATE EQUIPMENT

- (A) Reporting Accuracy: System shall report values with minimum end-to-end accuracy listed in Table 1.
- (B) Control Stability and Accuracy: Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

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Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.3°F
Ducted Air	±0.3°F
Outside Air	±1 °F
Dew Point	±3°F
Water Temperature	±1°F
Delta-T	±0.25°F
Relative Humidity	See below
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	See below
Air Pressure (space)	See below
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO ₂)	±50 ppm, Drift <= 5% in 5 yrs.

Note 1: Accuracy applies to 10% - 100% of scale

Note 2: For both absolute and differential pressure

Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±0.2 in. w.g. ±0.01 in. w.g.	0-6 in. w.g. -0.1 to 0.1 in. w.g.
Airflow	±10% of full scale	
Space Temperature	±2.0°F	
Duct Temperature	±3°F	
Humidity	±5% RH	
CO ₂ Sensor	± 100	0 – 2,000 ppm
Fluid Pressure	±1.5 psi ±1.0 in. w.g.	1-150 psi 0-50 in. w.g. diff.

(C) Temperature Sensors:

1. Housing and mounting shall be suitable for the application and room finish.
2. Accuracy: See Table 1 above.
3. Sensing element:
Thermistor.

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Balco.

Platinum RTD (100 ohms) (1000 ohms).

Solid State.

4. Range:

35°F to 140°F Room.

-50°F to 220°F Duct.

20°F to 300°F Immersion.

-60°F to 140°F Outside Air.

5. Room Sensor:

Wall mount with setpoint and/or override flush mount.

6. Stability: See Table 2 above

7. Immersion Wells:

(Brass) (304 SS).

Length to fit sensor and application.

(D) Humidity Sensor:

1. Housing and mounting shall be suitable for application and room finish.

2. Accuracy:

$\pm 3\%$ @ 0 - 90% and $\pm 4\%$ @ 90% to 100%.

$\pm 2\%$ @ 20% - 95%.

$\pm 1\%$ @ 10% - 80%.

3. Range:

0-100%.

(E) Dew Point, Enthalpy or Wet Bulb Sensor:

1. Housing and mounting shall be suitable for application and room finish.

2. Duct/Outside Air Range:

Dew Point and Dry Bulb -40°F to 185°F

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	Wet Bulb	20°F to 120°F
3.	Room Range:	
	Dew Point	-4°F to 122°F
	Enthalpy	0 to 100 BTU/#
	Wet Bulb	20 to 120°F
	Dry Bulb for Dew Point	32° to 122°F
	Dry Bulb for Enthalpy, Wet Bulb	-20°F to 120°F

(F) Current Operated Switches:

1. Switch rating: 1 to 135 VAC/DC, 0.3 Amps.
2. Switch type: Normally open, solid state.
3. OFF-state leakage: Zero.
4. Polarity: Not polarity sensitive, switch AC or DC.
5. Trip points: 1 Amp; 1.5 Amp.
6. Monitored AC current: 1 to 250 A*; 1.5 to 250 A*.
7. Monitored frequency: 6 Hz minimum**.
8. Operating temperature: -58°F to 149°F (-50°C to 65°C).
9. Case: ABS (meets UL flammability rating 94 V-0).
10. Insulation Class: 600 V.
11. Weight: 0.25 lb. (0.11 kg).
12. Approvals: UL listed, CSA certified.

(G) Differential Pressure Transmitter (Air) (Analog):

1. Accuracy: See Table 1 above
2. Range:

Space	0 to 0.3-inch H ₂ O
Duct	0 to 5-inch H ₂ O
	0 - 10-inch H ₂ O

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3. Output 4 - 20 ma.
4. Maximum momentary overpressure: 8X range.
5. Environment:
32°F to 125°F.
20% to 90% RH.

(H) Air Sensing Switch (Digital):

1. Range:
0.05-inch to 12.0-inch H₂O.
0.05-inch to 2.0-inch H₂O.
2. Differential:
0.02-inch @ 0.05-inch Setpoint.
0.8-inch @ 12.0-inch Setpoint.
3. SPDT.
4. Approval: UL, FM, CSA.
5. Manual Reset.

(I) Pressure Transmitter (H₂O/steam):

1. Output: 4-20 ma.
2. Range: As required.
3. Overpressure: 3x range.
4. Operating temperature: -30°F to 248°F.
5. 316 S.S. wetted parts.
6. Accuracy: ±0.4%.

(J) Differential Pressure Transmitter (Water):

1. Output: 4-20 ma.
2. Range: As required.
3. Operating temperature: 32°F to 122°F.

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- 4. 316 S.S. wetted parts.
- 5. Accuracy: $\pm 0.5\%$.
- (K) Differential Pressure Switch:
 - 1. SPDT.
 - 2. Range: As required.
 - 8 - 60 PSIG with 1.5 PSI differential.
 - 2 - 30 PSIG with 2.5 PSI differential.

2.011 PROJECT RECORDS

- (A) Complete project records describing the individual component operation, system operation, and specific application, shall be provided at job completion. Project records shall provide complete and detailed step-by-step operating instructions.
- (B) As-built installation drawings shall be provided, indicating the mechanical and electrical equipment connected to the environmental control system.
- (C) During job acceptance, the contractor shall provide complete training of building personnel, utilizing the project records outlined.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine areas and conditions under which electric control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
- (B) Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.
- (C) Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.
- (D) Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate Division 23 Section Electric Control Systems and Facilities Management Systems work with work of others. Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.02 PROTECTION

- (A) Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

- (B) Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.03 COORDINATION

(A) Site:

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

- (B) Submittals. See Division 23 Section Mechanical General Provisions Article 1.3 (Submittal List):

(C) Test and Balance:

1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
2. Train Test and Balance Contractor to use control system interface tools.
3. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

(D) Life Safety:

1. Duct smoke detectors required for air handler shutdown are provided under Division 26. Interlock smoke detectors to air handlers for shutdown as specified in Division 23 Section Sequence of Operation.
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in Division 23 Section Sequence of Operation.
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 21. Fire and smoke damper control is provided under Division 26.

- (E) Coordination with Other Controls: Integrate with and coordinate controls and control devices furnished or installed by others as follows.

1. Communication media and equipment shall be provided as specified in Article 2.5 (Networking /Communication).
2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described in Division 23 Section Sequences of Operation regardless of where within the contract documents those products are described.

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3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.04 INSTALLATION OF ELECTRIC CONTROL SYSTEMS

- (A) General: Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications. Mount controllers at convenient locations and heights.
- (B) Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connecting electric control devices from the control device to its point of connection with other devices. Wiring shown in the electrical plans shall be part of Division 26.
1. The control equipment and connecting wiring should be installed in neat and workmanlike manner. All wiring and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in finished spaces. Conduit may be run exposed in mechanical rooms or in an area where other piping is exposed.
 2. Wiring shall be run in adequately supported rigid raceway, EMT pipe or duct. Wiring in equipment rooms shall be in one of the metal containers mentioned above, run to within one foot of the final connection. The final connection shall be made with exposed wiring. These wires shall be protected by a suitable protective grommet and the end of the metal container shall be securely fastened.
 3. Class 2 wiring may be used above drop ceilings and in other concealed but accessible locations provided that it is run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner. Jacketed harnesses may be used where a number of wires are run together.
 4. Wiring that is in return air plenums shall be teflon protected or some other type of UL approved plenum cable.
- (C) Wiring System: Install complete wiring system for electric control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. Provide multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
- (D) Number-code or color-code conductors for future identification and servicing of control system.
- (E) Reset Limit Controls: Install manual-reset limit controls to be independent of power controllers; automatic duct heater resets may, at Contractor's option, be installed in interlock circuit of power controllers.
- (F) Unit-Mounted Equipment: Where control devices are indicated to be unit-mounted, ship electric relays, electric switches, valves, dampers, and damper motors to unit manufacturer for mounting and wiring at factory.

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3.05 HVAC CONTROL SYSTEM

(A) Wiring:

1. All conduit, wiring, accessories and wiring connections required for the installation of the Facility Management System, as herein specified, shall be provided by the FMS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
2. All system input wiring shall be twisted shielded pair, minimum 18-gage wire. All system analog output wiring shall be twisted shielded pair/3-wire as required, minimum 18-gage wire. Preconfigured cables between Terminal Unit Controllers and Thermostats are acceptable, minimum 24-gage.
3. All internal panel device wiring for binary outputs and pilot relay shall be minimum 16-gage wire.
4. All Class 2 (24 VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - A. Class 2 wiring not installed in conduit shall be plenum rated supported every 5 feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.
5. Low voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.
6. All wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size 3/4-inch.

(B) Identification Standards:

1. Panel Identification. All local control panels shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.
2. Wire Identification. All low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

(C) Digital Controller Systems:

1. Each system will be provided with its own dedicated direct digital controller or application specific controller. Mechanical systems such as AHUs, VAV's or Packaged system shall not be controlled from more than 1 application specific controller.
2. Systems that use second tier controllers as point expansion for system controllers shall only be allowed when the I/O points are directly controlled by the CPU of the local application specific controller.

(D) Input Devices:

1. All Input devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, duct smoke detectors, air flow stations, etc.
 - A. Low Differential Air Pressure Applications (Under 5 inches w.c.) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing contractor and Owner permanent easy-to-use connection. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible. Except on VAV box applications.
 - B. Medium Differential Air Pressure Applications (5 inches to 21 inches w.c.) Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.
 - C. Medium to High Differential Water Pressure Applications (Over 21 inches w.c.): Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.
 - D. Building Differential Air Pressure Applications (-1 inches to +1 inches w.c.): Mount pressure transmitter in the local control panel. Transmitter's exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind. The interior tip shall be inconspicuous and located within a central corridor shown on the drawings.
 - E. Air Flow Measuring Stations: Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be 2-inch to 3-inch to facilitate matching connecting ductwork. Stations shall be installed in strict accordance with the manufacturer's published requirements, and with ASME Guidelines affecting non-standard approach conditions.
 - F. Water Flow Monitoring Stations: Water Flow Monitoring Stations shall be installed in strict accordance with the manufacturer's published requirements, and with ASME Guidelines affecting non-standard approach conditions.
 - G. Outside Air Humidity Sensors: Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealite fittings and stainless steel bushings.
 - H. Outside Air Sensors: Outside air sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air temperatures accurately. Sensors exposed to solar radiation must be installed with solar shields. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.

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- I. Duct Temperature Sensors: Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. For ductwork greater in any dimension than 48 inches and/or air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor with multiple sensing points. The sensor shall be mounted to suitable supports using factory approved element holders. For large plenum applications such as mixed air temperature measurements, utilize a string of sensors mounted across the plenum to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12 foot long segment.
- J. Space Temperature Sensors: Shall be mounted at 54 inches above the finished floor for standard locations and at 48" for ADA accessible locations. Temperature sensors installed in public areas shall be provided with lockable covers to prevent tampering.
- K. Low Temperature Limit Switches: Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream. Mounting location shall meet ADA requirements where required.
- L. Differential Pressure Status Switches: Provide complete installation kit including; static pressure taps, tubing, fittings and air filters. Provide appropriate scale range and differential adjustment for intended service.

(E) Output Devices:

- 1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, etc.
- 2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
- 3. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
- 4. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Facility Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.06 PROGRAMMING

- (A) Point Naming: Name points as shown on the equipment points list provided with each sequence of operation in Division 23 Section Sequences of Operation. If character limitations make it advisable to shorten the name Owner standards, if available, shall govern. When a single workstation or server serves more than one building, a consistent naming scheme shall be used for each building. Final room numbers shall match those provided by the Owner.

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(B) Software Programming: Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.

1. Application Programming: Provide application programming that adheres to sequences of operation specified in Division 23 Section Sequences of Operation. Program documentation or comment statements shall reflect language used in sequences of operation.

2. System Programming: Provide system programming necessary for system operation.

(C) Operator Interface:

1. Standard Graphics: Provide graphics as specified in this section above entitled System Graphics. Show on each equipment graphic input and output points and relevant calculated points such as indicated on the applicable Points List in Division 23 Section Sequences of Operation. Point information on graphics shall dynamically update.

2. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation).

3.07 TRAINING

(A) The controls contractor shall provide the following training services:

1. One day of on-site orientation by a field engineer who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the control system software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

2. Factory training for two owner representatives in a factory training lab. This training shall be performed by a factory-certified professional trainer and, at a minimum, shall consist of:

A. Two days training covering basic system operation.

B. One day training covering system reporting and alarm management.

C. One day training of scheduling and point trending

(B) The owner representatives shall be issued Continuing Education Credits (C.E.U.s) for the factory training.

(C) General: Provide training course schedule, syllabus, and training materials 45 days prior to the start of training. Furnish a qualified instructor to conduct training courses for designated personnel in the maintenance and operation of the HVAC and DDC system. Orient training to the specific system being installed under this contract. Use operation and maintenance manual as the primary instructional aid. Operational and maintenance manuals shall be provided for each trainee with four additional sets, two sets delivered for archiving at the project site, one set for the mechanical contractor, and one set for the design engineer. Training manuals shall include an agenda, defined objectives and a detailed description of the subject matter for each lesson. Furnish audio-visual equipment and all other training materials and supplies. A training day is defined as 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunch time, Monday through Friday, during the daytime shift in effect at the training facility. For guidance, assume the attendees will have a high school education and are familiar with HVAC systems. The minimum amount of training for this project shall be 24 hours.

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- (D) Operator Training: Operator training shall include the detailed review of the control installation drawings, points list, and equipment list. The instructor shall then walk through the building identifying the location of the control devices installed. For each type of system, the instructor shall demonstrate how the system accomplishes the sequence of operation.

3.08 COMMISSIONING

- (A) Commissioning the Facility Management System is a mandatory documented performance requirement of the selected FMS Contractor for all control systems detailed in this Specification and sequence of operations. Commissioning shall include verification of proper installation practices by the FMS Contractor and subcontractors under the FMS Contractor, point verification and calibration, system/sequence of operation verification with respect to specified operation, and network/workstation verification. Documentation shall be presented upon completion of each commissioning step and final completion to ensure proper operation of the Facility Management System.

- (B) Testing Procedure:

1. Upon completion of the installation, the FMS Contractor shall start-up the system and perform all necessary testing and run diagnostic tests to ensure proper operation. The FMS Contractor shall be responsible for generating all software and entering all database information necessary to perform the sequences of control herein specified.
2. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.
 - A. Calibrate and prepare for service each instrument, control, and accessory equipment furnished herein.
 - B. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
 - C. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
 - D. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
 - E. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
 - F. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
 - G. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.

H. Alarms and Interlocks:

- (1) Check each alarm with an appropriate signal at a value that will trip the alarm.
- (2) Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
- (3) Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

(C) Testing Documentation, Demonstration, and Acceptance :

1. Prior to acceptance testing, FMS Contractor shall create, on an individual system basis, trend logs of input and output points, or have an automatic Point History feature for documentation purposes.

(D) Demonstration: Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.17 (Control System Checkout and Testing). Provide Engineer with log documenting completion of startup tests.

1. Demonstration shall follow process submitted and approved under Section "Submittals". Complete approved checklists and forms for each system as part of system demonstration.
2. Demonstrate actual field operation of each sequence of operation as specified in Division 23 Section Sequences of Operation. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
3. Demonstrate compliance with Section entitled "System Performance".
4. Demonstrate compliance with sequences of operation through each operational mode.
5. Demonstrate complete operation of operator interface.
6. Demonstrate each of the following:
 - A. DDC loop response: Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
 - B. Demand limiting: Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting setpoint, and status of setpoints and other affected equipment parameters.
 - C. Building fire alarm system interface.

D. Trend logs for each system: Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation in Division 23 Section Electric Control Systems and Facilities Management Systems Appendix A. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs as specified above in "Trend Configuration".

7. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

(E) Acceptance:

1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required herein, see Section "Submittals".

(F) VAV box performance verification and documentation:

1. As part of the commissioning of the terminal unit control and air distribution system, the Contractor shall initiate an automated test where the dampers in one half of a group of boxes are stepped towards full open while the other half are stepped towards full closed. At each step, after a settling time, box airflows and damper positions will be sampled. Following the cycle, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation, or Maximum flow not achieved. The report shall be submitted as documentation of the installation.
2. The controls contractor shall issue a report based on a sampling of the VMA calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance. The sampling shall take place after completion of Test and Balance, when design cooling and heating media have been available and occupied conditions approximated for five consecutive days.

(G) Noncompliant Items:

1. The Contractor shall remove and replace, at its expense, all items that are not in compliance with the Specification requirements.

3.09 SYSTEMS INTEGRATION/FMS SPECIFIC REQUIREMENTS

(A) FMS Remote Access:

1. The Facility Management System provided shall include the capability for multiple users to access the FMS simultaneously from remote locations via the Internet. Internet access shall be accomplished by use of standard Internet browser software applications such as Netscape Navigator ® or Microsoft Internet Explorer ® and shall not require the use of proprietary access software. Interface shall be to the entire FMS and provide capability to monitor all I/O and adjust parameters.

3.010 ALARM MANAGEMENT

(A) Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, to minimize network traffic, and to prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

(B) Point Change Report Description:

1. All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

(C) Prioritization:

1. The installer shall set up all system analog points with high and low alarm limits. All digital system points shall be associated with a status feedback point and all exceptions shall be reported as alarms. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized and filtered to minimize nuisance reporting and to speed operator response to critical alarms.
2. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

(D) Critical and Non-Critical Alarm Routing:

1. Critical alarms shall be defined as chiller, boiler, generator, critical space temperature or humidity, and kilowatt demand approaching threshold. Critical alarms shall be displayed at the workstation, printed at the alarm printer, and alpha paged to the on-duty maintenance person over the owners alphanumeric paging system. Alpha pages shall provide sufficient information to identify the equipment and the point in alarm and the time and date of occurrence.
2. All other alarms shall be considered non-critical and shall be displayed and acknowledged before being sent to the alarm log.

(E) Report Routing:

1. Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

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(F) Alarm Messages:

1. In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store an alarm message to more fully describe the alarm condition or direct operator response.
2. Each standalone DDC panel shall be capable of storing a library Alarm Messages. Each message may be assignable to any number of points in the panel.

(G) Auto-Dial Alarm Management:

1. In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request is made, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

3.011 DYNAMIC ANIMATED COLOR GRAPHIC DISPLAYS

(A) Color graphic floor plan displays, and system schematics for each piece of mechanical equipment (including air handling units, variable air volume boxes, fan coils, unit ventilators, cabinet heaters, exhaust fans, fin tube radiation, chilled water systems, hot water boiler systems, and so forth) shall be provided, as specified in the point list portion of this Specification, in order to optimize system performance analysis, speed alarm recognition, and simplify user interaction. The FMS Contractor shall fully configure the color graphics and plot all associated control/monitoring points on the screen. Copies of all color graphics screens shall be provided as color printouts to the engineer for approval.

(B) System Selection/Penetration:

1. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or test-based commands. Floor plans shall display room numbers and each zone shall be color-coded. The operator shall be able to point and click on a room or zone of rooms (in the case of an air handler that serves more than one zone). The room or zone will display an animated flow diagram of the mechanical equipment that serves that zone, with all control and monitoring points associated with that piece of equipment, including setpoints. Setpoints shall be overridden or modified from this screen.

(C) Dynamic Animated Data Displays:

1. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention. Damper and valve positions, air and water flow shall be animated and shall represent actual, current conditions.

(D) System Performance Analysis Screens:

1. System performance analysis screens shall be provided for the major mechanical systems (such as air handlers, chillers, boilers, and so forth.). For each of these systems, the screen shall be split into quadrants, simultaneously displaying the following data:
 - A. Quadrant 1. – Dynamic animated flow diagrams.

- B. Quadrant 2. – All analog values associated with the mechanical system shall be graphed on an X-Y axis graph. Five-minute samples for the last twenty-four hour period shall be plotted. Scaling shall be automatic.
- C. Quadrant 3. – Text sequence of operations from engineering as-built submittals.
- D. Quadrant 4. – Space temperature summaries from each zone being served by mechanical system.

(E) Windowing:

- 1. The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

(F) Alarm Annunciation:

- 1. Any point in a state of alarm shall change the color of its symbol to red until it is no longer in alarm.

3.012 ADJUSTING AND CLEANING

- (A) Start-Up: Start-up, test, and adjust electric control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- (B) Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- (C) Final Adjustment: After completion of installation, adjust thermostats, control valves, motors and similar equipment provided as work of this section.
 - 1. Final adjustment shall be performed by specially trained personnel in direct employ of primary temperature control contractor.

3.013 CLOSEOUT PROCEDURES

- (A) Owner's Instructions: Provide services of manufacturer's technical representative for one 8-hour day to instruct Owner's personnel in operation and maintenance of electric control systems.
 - 1. Schedule instruction with Owner; provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 230900 – ELECTRICAL CONTROL SYSTEMS & FACILITIES MANAGEMENT SYSTEMS

SECTION 23 09 33 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section includes separately enclosed, preassembled, combination VFC's, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

- (B) Related Requirements:

1. Division 26 "Motor Control Centers" for VFC's installed in motor control centers.

1.03 DEFINITIONS

- (A) CE: Conforme Européenne (European Compliance).
- (B) CPT: Control power transformers.
- (C) DDC: Direct digital controller.
- (D) EMI: Electromagnetic interference.
- (E) LED: Light-emitting diode.
- (F) NC: Normally closed.
- (G) NO: Normally open.
- (H) OCPD: Overcurrent protective device.
- (I) PID: Control action, proportional plus integral plus derivative.
- (J) RFI: Radio-frequency interference.
- (K) VFC: Variable-frequency motor controller.

1.04 SUBMITTALS

- (A) Product Data: Submit manufacturer's specifications for variable frequency drives showing dimensions, weights, capacities, ratings, performance characteristics, gages and finishes of materials and installation instructions.
- (B) Coordination Data: Submit nameplate information for each motor to be operated by the variable frequency drive.

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- (C) Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, construction details, required clearances and field connection details.
- (D) Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to variable frequency drives. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- (E) Maintenance Data: Submit maintenance instructions, trouble-shooting maintenance guide, motor and drive replacement and spare parts lists. Include this data, product data and shop drawings in maintenance manuals; in accordance with requirements of Division 23.

1.05 QUALITY ASSURANCE

- (A) Manufacturer's Qualifications: Firms who regularly engaged in manufacture of variable frequency drives, of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than five years.
- (B) Installer's Qualifications: Firm with at least three years of successful installation experience on projects with variable frequency drives similar to that required for project.
- (C) Codes and Standards:
 - 1. Electrical Standards: Provide electrical components of variable frequency drives which comply with NEC 430.120 for Adjustable Speed Drive Systems and IEC 16800 Parts 1 and 2.
 - 2. NEMA Compliance: Comply with NEMA ICS 7.0 AC Adjustable Speed Drives pertaining to components and devices.
 - 3. Underwriters Laboratories: Provide variable frequency drives with UL508C listing.
 - 4. Institute of Electrical and Electronic Engineers: Comply with IEEE 519 guide for harmonic analysis for jobsite total harmonic voltage and harmonic current distortion.

1.06 DELIVERY, STORAGE AND HANDLING

- (A) Handle variable frequency drives carefully to prevent damage, breaking, denting and scoring. Do not install damaged electric equipment or components; replace with new.
- (B) Store variable frequency drives in clean, dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.
- (C) Comply with manufacturer's rigging and installation instructions for unloading variable frequency drives and installing them to final location.

1.07 WARRANTY

- (A) The variable frequency drive product warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free technical support line shall be available.

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PART 2 - PRODUCTS

2.01 MANUFACTURERS

(A) Manufacturer: Subject to compliance with requirements, provide variable frequency drives of one of the following:

1. ABB Group
2. Allen Bradley
3. Eaton
4. Emerson
5. Rockwell Automation
6. Siemens
7. Square D; Schneider Electric
8. Yaskawa

2.02 VARIABLE FREQUENCY DRIVES

(A) General: Variable frequency drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. The drive manufacturer shall supply the drive and all necessary options as herein specified.

(B) Assembly: VFD and options shall be UL listed as a complete assembly. The variable frequency drive shall be UL-listed for 100,000 AIC without the need for input fuses.

(C) Enclosure: UL-listed Type 1 enclosure exceeding NEMA enclosure design criteria completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate at line voltage from +30% to -35% nominal voltage. Enclosure shall be UL listed as a plenum rated VFD.

(D) Operating Conditions: VFD shall be capable of continuous operation at 0° to 50° C ambient temperature as indicated on the submittal. All circuit boards shall have conformal coating.

(E) Interface: Digital display and keypad. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

1. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate a bumpless transfer of speed reference when switching between Hand and Auto modes. There shall be fault reset and Help buttons on the keypad. The Help button shall include on-line assistance for programming and troubleshooting.
2. The Keypad shall include a backlit LCD display. The display shall be in English for programming and fault diagnostics. The keypad shall include the following assistants:

A. Start-up assistant

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- B. Parameter assistants
 - C. Maintenance assistant
 - D. Troubleshooting assistant
 - E. Drive optimizer assistants
3. All applicable operating values shall be capable of being displayed in engineering units. A minimum of three operating values shall be capable of being displayed in English:
- A. Output Frequency
 - B. Motor Speed (RPM, percent, or units)
 - C. Motor Current
 - D. Motor Torque
 - E. Motor Power
 - F. DC Bus Voltage
 - G. Output Voltage
4. Time clock provided in the VFD keypad with a battery backup with 10 years minimum life span. The clock shall be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock for a programmable time frame. Provide four separate, independent timer functions that have both weekday and weekend settings.
- (F) Applications: The VFD shall utilize pre-programmed applications designed to facilitate start-up. Provide one command to reprogram all parameter interfaces for a particular application and two user macros to allow the end-user to create and save custom settings.
- (G) Fans: Provide cooling fans designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fan shall operate only when required.
- (H) Coasting: The VFD shall be capable of starting into a coasting load either forward or reverse operation up to full speed and accelerate or decelerate to set point without tripping or component damage.
- (I) Automatic Restart: The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
- (J) Overload Rating: VFD overload rating shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL for 4-pole motors.
- (K) Impedance Reactors: Provide internal 5% equivalent impedance reactors. The 5% equivalent impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFDs with only one DC reactor shall add an AC line reactor.

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- (L) Input Current Rating: The VFD shall be no more than 3% greater than the output current rating.
- (M) Surge Suppression: Provide a coordinated AC transient surge protection system with 5% equivalent impedance reactors.
- (N) Programming: Loss-of-load signal through a keypad warning, including a programmable time delay for motor acceleration from zero speed without signaling a false loss-of-load condition, with user defined programmable underload and overload curve functions.
- (O) PID Algorithms: Multiple two zone PID algorithms that allow the VFD to maintain PID control from two separate feedback signals (4-20 mA, 0-10 V, and / or serial communications). The two zone control PID algorithm will control motor speed based on a minimum, maximum, or average of the two feedback signals.
- (P) Loss of Reference: If input reference is lost, the VFD shall give the user the option of stopping and displaying a fault, running at a programmable preset speed, maintaining the VFD speed based on the last reference received, or issuing a warning. Provide sleep and wake up programmable functions to start and stop from a process feedback signal.
- (Q) Adjustments: Provide all of the following adjustments:
1. Three fully adjustable programmable critical frequency lockout ranges.
 2. Two PID set point controllers. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus.
 3. Independent second PID loop utilizing the second analog input to modulate one of the analog outputs.
 4. Two programmable analog inputs.
 5. Two programmable analog outputs.
 6. Six programmable digital inputs.
 7. Three programmable digital relay outputs with delay times.
 8. Two separate safety interlock inputs shall be provided.
 9. Programmable time delay for VFD start and keypad indication from 0 – 120 seconds.
 10. Seven programmable preset speeds.
 11. Two independently adjustable acceleration and deceleration ramps.
 12. Motor flux optimization circuit with selectable software for optimization of motor noise, energy consumption, and motor speed control.
 13. Automatic carrier frequency control circuit.
 14. Password protection against parameter changes.

- (R) Serial Communications: Provide EIA-485 port and standard certified protocols including Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. Optional protocols for LonWorks, Profibus, Ethernet, BACnet IP, and DeviceNet shall be available.
- (S) EMI/RFI filters: Onboard filters to permit the assembly to be CE Marked and meet product standard EN 61800-3 for the First Environment restricted level with up to 100 feet of motor cable.
- (T) Total Harmonic Distortion: The VFD manufacturer shall provide calculations specific to the installation, indicating total harmonic voltage distortion less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE Standard 519. All VFDs shall include a minimum of 5% equivalent impedance reactors.

2.03 OPTIONAL FEATURES

- (A) Provide optional features as indicated, furnished and mounted by the VFD manufacturer. All optional features shall be UL-listed by the VFD manufacturer as a complete assembly.
 - 1. Bypass Controller: Factory-wired and tested bypass system consisting of an output contactor and bypass contactor.
 - 2. Disconnect: Door interlocked, pad-lockable circuit breaker for all input power from the drive and all internally mounted options.
 - 3. Disconnect: Door interlocked, pad-lockable disconnect switch for all input power from the drive and all internally mounted options.
 - 4. Fieldbus Adapters: LonWorks, DeviceNet, Ethernet IP, ModBus TCP, BACnet IP, and Profibus shall be available with the addition of an optional card.

2.04 BYPASS CONTROLLER

- (A) General: Complete factory wired and tested bypass system consisting of an output contactor, bypass contactor, and quick response VFD input fuses. Bypass contactors shall be standard 120 VAC coils. Bypass shall operate at line voltage from +30% to -35% nominal voltage. Motor overload protection and shall be provided in both normal and bypass modes.
- (B) Disconnect: Door interlocked, pad-lockable circuit breaker or disconnect for all input power from the drive and all internally mounted options. The enclosure door and VFD enclosure shall be mechanically interlocked such that the disconnecting device must be in the "Off" position before the enclosure may be accessed.
- (C) Drive Isolation Fuse: Fast acting fuses shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection.
- (D) UL Listing: The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 amps and shall be indicated on the UL data label.
- (E) Single Phase Protection: Detect single phase input power condition while running in bypass, disengage the motor and signal single phase input power.
- (F) Stand Alone Operation: The bypass system shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system. Serial communications shall remain functional with the VFD removed.

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VARIABLE FREQUENCY DRIVES

- (G) Serial Communications: The bypass shall be capable of being monitored and controlled via serial communications. On-board communications protocols shall include ModBus; Johnson Controls N2; Siemens Building Technologies FLN; and BACnet.
- (H) Transfer Bypass: Keypad adjustment to select manual or automatic transfer bypass. The user shall be able to select via keypad programming which drive faults will result in an automatic or manual transfer to the bypass mode. The user may select whether the system shall automatically transfer from drive to bypass mode on the following drive fault conditions:
1. Over current
 2. Over voltage
 3. Under voltage
 4. Loss of analog input
- (I) Operators: The Keypad shall include a backlit LCD display. The display shall be in English for programming and fault diagnostics. The keypad shall include the following operators:
1. Bypass Hand-Off-Auto
 2. Drive mode selector
 3. Bypass mode selector
 4. Bypass fault reset
 5. Bypass LCD display
- (J) Indicating Lights and Display: Keypad display indications shall be provided. A test mode or push to test feature shall be included.
1. Power-on
 2. Run enable
 3. Drive mode selected
 4. Bypass mode selected
 5. Drive running
 6. Bypass running
 7. Drive fault
 8. Bypass fault
 9. Bypass Hand-Off-Auto mode
 10. Automatic transfer to bypass

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- 11. Safety open
- 12. Damper opening
- 13. Damper end-switch made
- (K) Bypass Controller: Provide a minimum of six programmable digital inputs, and five programmable relay outputs. Bypass I/O shall be available to the building management system even with the VFD removed.
- (L) Customer Interlock Terminal Strip: A separate terminal strip for independent connection of up to four inputs. External safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes.
- (M) Smoke Control Override Mode: A dedicated digital input to transfer motor from VFD mode to bypass mode from a dry contact closure at the fire alarm control system meeting the intent of UL864/UUKL.
- (N) Fireman's Override Mode: A programmable override input to permit the user to configure the unit to acknowledge digital inputs, to react to fire protection requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine areas and conditions under which variable frequency drives are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 INSTALLATION OF VARIABLE FREQUENCY DRIVES

- (A) General: Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable electrical specifications. Mount controllers at convenient locations and heights.
- (B) Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- (C) Support units with mounting brackets anchored to building substrate.
- (D) Coordinate with other trades to assure correct size for wall mounted units.
- (E) Protect units with protective covers during balance of construction.

3.03 ELECTRICAL WIRING

- (A) Power wiring shall be completed by the electrical contractor, complying with NEC code 430.122 wiring requirements based on the VFD input current. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.04 STARTUP

- (A) Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of variable frequency drives, including electrical connections. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer. Report results in writing.

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1. Test and adjust controls and safeties.
2. Operate motors and verify proper rotation and connections.
3. Operate controls and verify proper response to control inputs.
4. Submit a list of all adjustable and non-adjustable operating parameters and actual settings and adjustment ranges.
5. Replace damaged and malfunctioning controls and equipment.

3.05 TRAINING

- (A) General: The VFD manufacturer shall provide a comprehensive, HVAC Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFD unpacking, proper mechanical and electrical installation, and programming.
- (B) The CBT product shall allow the user to provide just-in-time training to new personnel or refresher training for maintenance and repair personnel on the user's site. The CBT product shall be repeatable, precise and shall include record keeping capability. The CBT product shall record answers to simulations and tests by student ID. The CBT product must be professionally produced and have interactive sections, student tests, and include video clips of proper wiring and installation
- (C) Schedule training with Owner, through Engineer, with at least seven days' advance notice.

3.06 CLEANING

- (A) Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 230933 – VARIABLE FREQUENCY DRIVES

SECTION 23 09 93 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 WORK INCLUDED

- (A) SEQUENCE OF OPERATION IS HEREBY DEFINED AS THE MANNER AND METHOD BY WHICH CONTROLS FUNCTION. REQUIREMENTS FOR EACH TYPE OF CONTROL SYSTEM OPERATION ARE SPECIFIED IN THIS SECTION.

1.02 SUBMITTALS

- (A) SHOP DRAWINGS: SUBMIT SHOP DRAWINGS FOR EACH SYSTEM AUTOMATICALLY CONTROLLED, CONTAINING THE FOLLOWING INFORMATION:

1. SCHEMATIC FLOW DIAGRAM OF SYSTEM SHOWING FANS, PUMPS, COILS, DAMPERS, VALVES AND CONTROL DEVICES.
2. LABEL EACH CONTROL DEVICE WITH SETTING OR ADJUSTABLE RANGE OF CONTROL.
3. INDICATE EACH CONTROL PANEL REQUIRED, WITH INTERNAL AND EXTERNAL PIPING AND WIRING CLEARLY INDICATED. PROVIDE DETAIL OF PANEL FACE, INCLUDING CONTROLS, INSTRUMENTS, AND LABELING. INCLUDE VERBAL DESCRIPTION OF SEQUENCE OF OPERATION.

- (B) MAINTENANCE DATA: INCLUDE COPY OF SHOP DRAWINGS IN EACH MAINTENANCE MANUAL.

PART 2 - PRODUCTS (NOT APPLICABLE TO THIS SECTION).

PART 3 - EXECUTION

3.01 TERMINAL UNITS' CONTROL SEQUENCES

- (A) CABINET HEATER CONTROL: PROVIDE SINGLE-TEMPERATURE ROOM THERMOSTAT TO CYCLE FAN MOTOR AND ELECTRIC ELEMENT TO MAINTAIN CONSTANT SPACE TEMPERATURE. PROVIDE INTEGRAL RESIDUAL HEAT SENSOR TO CONTINUE FAN OPERATION UNTIL ELEMENT TEMPERATURE FALLS BELOW PRE-SET POINT.

- (B) HEATING-AND-COOLING FAN COIL UNIT CONTROL: PROVIDE FACTORY-MOUNTED SELF-CONTAINED AUTOMATIC TEMPERATURE CONTROLS.

1. FOR HEATING-AND-COOLING FAN COIL UNITS WITH DUAL-COILS AND FOUR (4) PIPING CONNECTIONS, PROVIDE ROOM THERMOSTAT TO MAINTAIN SPACE TEMPERATURE BY MODULATING HEATING VALVE OPEN ON CALL FOR HEATING AND SEPARATE COOLING VALVE OPEN ON CALL FOR COOLING.

- A. WHEN SPACE TEMPERATURE IS AT THERMOSTAT SETTING, CLOSE BOTH VALVES TO COILS. WHEN FAN IS DE-ENERGIZED, CLOSE CHILLED WATER VALVE TO COOLING COIL.

- (C) DIRTY FILTER SWITCH: PROVIDE PRESSURE SWITCH TO INDICATE DIRTY FILTER AT EACH UNIT.

3.02 VENTILATION CONTROL SEQUENCES

- (A) ENERGY RECOVERY VENTILATOR (ERV) CONTROL: THE ERV OPERATION SHALL BE INTERLOCKED WITH THE ASSOCIATED FAN COIL UNIT OPERATION.

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(B) AIR DAMPER CONTROL: WHEN THE SYSTEM FAN IS ENERGIZED THE NORMALLY CLOSED INTAKE AND EXHAUST DAMPERS SHALL OPERATE TO FULLY OPEN POSITION.

(C) DIRTY FILTER SWITCH: PROVIDE PRESSURE SWITCH TO INDICATE DIRTY FILTER AT EACH UNIT.

3.03 CHILLER PLANT CONTROL SEQUENCES

(A) WHEN SWITCHING FROM THE WINTER TO THE SUMMER MODE, THE CHILLER SHALL NOT BE ENABLED IF THE 2-PIPE SYSTEM WATER TEMPERATURE IS TOO HOT FOR THE SAFE OPERATION OF THE CHILLER. CHECK WITH THE CHILLER MANUFACTURER FOR MAXIMUM WATER ENTERING TEMPERATURE AS SAFETY CONTROL POINT PREVENTING FROM STARTING THE CHILLER.

(B) TURN ON THE CHILLER AND BUILDING CHILLED WATER LOOP PUMP WHEN OUTDOOR TEMPERATURE IS GREATER THAN 60 DEGREES F (ADJUSTABLE).

(C) THE FAN COIL UNIT CHILLED WATER 3-WAY VALVES AS SHOWN ON THE DRAWINGS SHALL MAINTAIN THE CHILLED WATER MINIMUM FLOW THROUGH THE CHILLER. REFER TO CHILLER MANUFACTURER'S DOCUMENTATION FOR MINIMUM FLOW.

(D) THE BUILDING CHILLED WATER LOOP PUMPS SHALL BE CONFIGURED AS LEAD-STANDBY OPERATION.

(E) RESET CHILLED WATER SUPPLY TEMPERATURE FROM 44 DEGREES F (ADJUSTABLE) AT 95 DEGREES F OUTDOOR TEMPERATURE (ADJUSTABLE) TO 54 DEGREES F (ADJUSTABLE) AT 60 DEGREES F OUTDOOR TEMPERATURE (ADJUSTABLE).

(F) PROVIDE ALARMS ON THE CHILLED WATER SUPPLY TEMPERATURE WHEN THE CHILLER SYSTEM MODE IS ENABLED AND THE CHILLED WATER TEMPERATURE RISES 20 DEGREES F ABOVE THE CHILLED WATER SETPOINT (ADJUSTABLE).

(G) INTERFACE WITH THE CHILLER VIA BACNET COMMUNICATION PROTOCOL TO CONTROL THE FOLLOWING:

1. CHILLED WATER SETPOINT
2. COMPRESSOR MIN TIME OFF
3. CHILLER DEMAND LIMIT.

(H) INTERFACE WITH THE CHILLER VIA BACNET COMMUNICATION PROTOCOL TO PROVIDE ALARM MONITORING ON ALL DIAGNOSTIC CONDITIONS PROVIDED BY THE CHILLER MANUFACTURER.

(I) PROVIDE FOR AUTOMATIC START AND AUTOMATIC SUMMER/WINTER CHANGEOVER.

3.04 WATER LOOP CONTROL SEQUENCES

(A) SAFETY CONTROL:

1. IF ADEQUATE SYSTEM WATER FLOW IS NOT ESTABLISHED BY THE LEAD PUMP OR SYSTEM WATER FLOW STOPS, AS INDICATED BY A FLOW SWITCH, THE STANDBY PUMP SHALL AUTOMATICALLY BE STARTED AND THE CONTROLLER SHALL SIGNAL THAT THE LEAD PUMP FAILED TO ESTABLISH/MAINTAIN ADEQUATE WATER FLOW. IF STARTING THE STANDBY PUMP FAILS TO RESTORE ADEQUATE SYSTEM WATER FLOW WITHIN ONE (1) MINUTE (ADJUSTABLE), THE FACILITY DDC SYSTEM SHALL SIGNAL A LOW WATER FLOW ALARM CONDITION.

2. SYSTEM SAFETY ALARM CONDITIONS SHALL RESULT IN AN AUDIBLE ALARM AT THE CONTROLLER STATION, SHALL BE GRAPHICALLY DISPLAYED AT THE CONTROLLER MONITOR AND SHALL INITIATE AN AUTOMATIC DIAL OUT NOTIFICATION TO MULTIPLE PHONE NUMBERS (AS DETERMINED BY OWNER).

(B) OPERATING CONTROL:

1. VARIABLE PUMPING SEQUENCES: A PRESSURE DIFFERENTIAL SENSOR LOCATED ACROSS THE INLET AND OUTLET OF THE MOST DISTANT FAN COIL UNIT IN THE BUILDING SHALL MODULATE VARIABLE FREQUENCY DRIVES AND CORRESPONDING PUMPS TO MAINTAIN DIFFERENTIAL PRESSURE SETPOINT (ADJUSTABLE) AS DETERMINED BY CONTROL CONTRACTOR FOR OPTIMUM VARIABLE PUMPING OPERATION.
2. THERMOMETERS AND TEMPERATURE SENSORS SHALL INDICATE THE SYSTEM WATER TEMPERATURE BEING SUPPLIED AND RETURNED TO/FROM THE HEAT PUMPS, THE COOLING TOWER AND THE BOILERS.

3.05 BOILER PLANT CONTROL SEQUENCES

- (A) TURN ON BOILER, BOILER PUMP, AND BUILDING HOT WATER LOOP PUMP WHEN OUTDOOR TEMPERATURE FALLS BELOW 60 DEGREES F (ADJUSTABLE).
- (B) THE BUILDING HOT WATER LOOP PUMPS SHALL BE CONFIGURED AS LEAD-STANDBY OPERATION.
- (C) RESET HOT WATER SUPPLY TEMPERATURE FROM 180 DEGREES F (ADJUSTABLE) AT 0 DEGREES F OUTDOOR TEMPERATURE (ADJUSTABLE) TO 120 DEGREES F (ADJUSTABLE) AT 60 DEGREES F OUTDOOR TEMPERATURE (ADJUSTABLE).
- (D) PROVIDE ALARMS ON THE HOT WATER SUPPLY TEMPERATURE WHEN THE BOILER SYSTEM MODE IS ENABLED AND THE HOT WATER TEMPERATURE FALLS 20 DEGREES F BELOW SETPOINT (ADJUSTABLE).
- (E) ALL OPERATING CONTROLS SHALL BE PACKAGED WITH BOILERS AND INTEGRATED WITH BUILDING MANAGEMENT SYSTEM. REFER TO BOILER SPECIFICATIONS AND DRAWING SCHEDULES FOR CONTROLS TO BE PROVIDED WITH BOILERS AND COORDINATE AS REQUIRED.
- (F) PROVIDE REMOTE START/STOP FOR BOILER OPERATION. PROVIDE AUDIBLE AND VISUAL ALARM INDICATION THROUGH DDC CONTROL SYSTEM IF BOILERS DO NOT PROPERLY FIRE.
1. TEMPERATURE CONTROL CONTRACTOR SHALL PROVIDE AND INSTALL ALL CONTROL DEVICES NOT FACTORY PROVIDED AND SHALL PROVIDE AND INSTALL CONTROL WIRING TO REMOTE DEVICES AS REQUIRED.
- (G) INTERFACE WITH THE BOILERS VIA BACNET COMMUNICATION PROTOCOL TO PROVIDE ALARM MONITORING ON ALL DIAGNOSTIC CONDITIONS PROVIDED BY THE BOILER MANUFACTURER.

3.06 MISCELLANEOUS CONTROL SEQUENCES

- (A) DOMESTIC HOT WATER CIRCULATION PUMP CONTROL: PUMP TO BE CONTROLLED BY AQUASTAT SET AT 105°F (ADJUSTABLE).
- (B) DOMESTIC WATER BOOSTER PUMP CONTROL:
1. ALL OPERATING CONTROLS SHALL BE PACKAGED WITH BOOSTER PUMP SYSTEM AND INTEGRATED WITH BUILDING MANAGEMENT SYSTEM. REFER TO BOOSTER PUMP SPECIFICATIONS AND DRAWING SCHEDULES FOR CONTROLS TO BE PROVIDED WITH BOOSTER PUMP AND COORDINATE AS REQUIRED.

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2. ENABLE BOOSTER PUMP SYSTEM TO MODULATE TO MAINTAIN SYSTEM PRESSURE AND FLOWRATE.
3. TEMPERATURE CONTROL CONTRACTOR SHALL PROVIDE AND INSTALL ALL CONTROL DEVICES NOT FACTORY PROVIDED AND SHALL PROVIDE AND INSTALL CONTROL WIRING TO REMOTE DEVICES AS REQUIRED.
4. PROVIDE AUDIBLE AND VISUAL ALARM INDICATION THROUGH DDC CONTROL SYSTEM IF BOOSTER PUMPS DO NOT OPERATE PROPERLY.

END OF SECTION 23 09 93 – SEQUENCE OF OPERATION

SECTION 23 20 00 - HYDRONIC PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes the following:

1. Close-coupled, in-line centrifugal pumps.
2. Separately coupled, horizontal, in-line centrifugal pumps.
3. Separately coupled, vertical, in-line centrifugal pumps.
4. Separately coupled, base-mounted, end-suction centrifugal pumps.
5. Pump Specialty Fittings.

1.03 DEFINITIONS

- (A) Buna-N: Nitrile rubber.
- (B) EPT: Ethylene propylene terpolymer.

1.04 SUBMITTALS

- (A) Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

1. Pump Curve: Provide calibrated catalog pump curve for each pump in addition to computer generated pump selection curve.

- (B) Closeout Submittals:

1. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- (A) Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- (B) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- (C) UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.06 DELIVERY, STORAGE, AND HANDLING

- (A) Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- (B) Store pumps in dry location.
- (C) Retain protective covers for flanges and protective coatings during storage.
- (D) Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- (E) Comply with pump manufacturer's written rigging instructions.

1.07 COORDINATION

- (A) Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.08 EXTRA MATERIALS

- (A) Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

- (A) Pump selection shall be for operation near center-right of performance curve and near "best operating efficiency point."
- (B) Pump selection shall allow impeller replacement with either a larger or smaller impeller within the same pump casing.

2.02 MANUFACTURERS

- (A) Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.03 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- (A) Manufacturers:
 - 1. Armstrong Pumps Inc.
 - 2. Aurora Pump; Division of Pentair Pump Group.
 - 3. Bell & Gossett; Div. of ITT Industries.
 - 4. Grundfos Pumps Corporation.
 - 5. PACO Pumps.
 - 6. Patterson Pump Co.

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7. Taco, Inc.
- (B) Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125 PSIG minimum working pressure and a continuous water temperature of 225°F.
- (C) Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, and threaded companion-flange connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Permanently lubricated ball bearings.
- (D) Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing.
1. Motor shall be non-overloading over full range of pump performance curve.
 2. Motor shall be rated for inverter duty if designated for use with variable frequency controller.
- 2.04 SEPARATELY COUPLED, HORIZONTAL, IN-LINE CENTRIFUGAL PUMPS
- (A) Manufacturers:
1. Armstrong Pumps Inc.
 2. Bell & Gossett; Div. of ITT Industries.
 3. PACO Pumps.
 4. Patterson Pump Co.
 5. Taco, Inc.
- (B) Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 125 PSIG minimum working pressure and a continuous water temperature of 250°F.

(C) Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, and threaded companion-flange connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

(D) Shaft Coupling: Molded rubber insert with interlocking spider or interlocking frame with interconnecting springs capable of absorbing vibration.

(E) Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing.

1. Motor shall be non-overloading over full range of pump performance curve.
2. Motor shall be rated for inverter duty if designed for use with variable frequency controller.

2.05 SEPARATELY COUPLED, VERTICAL, IN-LINE CENTRIFUGAL PUMPS

(A) Manufacturers:

1. Armstrong Pumps Inc.
2. Bell & Gossett; Div. of ITT Industries.
3. PACO Pumps.
4. Patterson Pump Co.
5. Taco, Inc.

(B) Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 125 PSIG minimum working pressure and a continuous water temperature of 225°F.

(C) Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, and threaded companion-flange connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.

4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Permanently lubricated ball bearings.
- (D) Shaft Coupling: Axially split spacer coupling.
- (E) Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; rigidly mounted to pump casing with lifting eye and supporting lugs in motor enclosure.
1. Motor shall be non-overloading over full range of pump performance curve.
 2. Motor shall be rated for inverter duty if designed for use with variable frequency controller.
- 2.06** SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS
- (A) Manufacturers:
1. Armstrong Pumps Inc.
 2. Bell & Gossett; Div. of ITT Industries.
 3. PACO Pumps.
 4. Patterson Pump Co
 5. Taco, Inc.
- (B) Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 125 PSIG minimum working pressure and a continuous water temperature of 225°F.
- (C) Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket.
 5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

6. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.
- (D) Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration and designed for VFD pump service.
- (E) Shaft Grounding Kit: Provide shaft grounding kit for pumps with variable frequency drives.
- (F) Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; removable; attached to mounting frame.
- (G) Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- (H) Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment.
1. Motor shall be non-overloading over full range of pump performance curve.
2. Motor shall be rated for inverter duty if designed for use with variable frequency drive.

2.07 PUMP SPECIALTY FITTINGS

- (A) Suction Diffuser: Angle pattern, 175 PSIG pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.
- (B) Triple-Duty Valve: Angle or straight pattern, 175 PSIG pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gauge ports with integral check valve, and orifice for flow measurement.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- (B) Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- (C) Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- (D) Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONCRETE BASES

- (A) Install concrete bases of dimensions indicated for pumps and controllers.
1. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.03 PUMP INSTALLATION

- (A) Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- (B) Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- (C) Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Fabricate brackets or supports as required.
- (D) Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
 - 1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of $\frac{3}{4}$ - to 1-1/2-inches between pump base and foundation for grouting.
 - 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- (E) Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.04 ALIGNMENT

- (A) Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
- (B) Comply with pump and coupling manufacturers' written instructions.
- (C) Adjust pump and motor shafts for angular and offset alignment.
- (D) After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.05 CONNECTIONS

- (A) Install piping adjacent to machine to allow service and maintenance.
- (B) Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- (C) Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- (D) Install triple-duty valve on discharge side of pumps.
- (E) Install suction diffuser and shutoff valve on suction side of pumps.
- (F) Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- (G) Install pressure gauges on pump suction and discharge, at integral pressure-gauge tapping, or install single gauge with multiple input selector valve.

(H) Install check valve and gate or ball valve on each condensate pump unit discharge.

(I) Install electrical connections for power, controls, and devices in compliance with Division 26.

3.06 STARTUP SERVICE

(A) Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.

3. Clean strainers on suction piping.

4. Perform the following startup checks for each pump before starting:

A. Verify bearing lubrication.

B. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

C. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains and prepare pump for operation.

6. Start motor.

7. Open discharge valve slowly.

3.07 DEMONSTRATION

(A) Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 23 20 00 – HYDRONIC PUMPS

SECTION 23 21 13 - HYDRONIC PIPING AND SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Makeup-water piping.
4. Condensate-drain piping.
5. Air-vent piping.
6. Safety-valve-inlet and -outlet piping.
7. Hydronic system valves.
8. Air control devices.
9. Hydronic system specialties.

1.03 SUBMITTALS

- (A) Product Data: For each type of the following:

1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air control devices.
3. Hydronic specialties.

- (B) Closeout Submittals:

1. Operation and Maintenance Data: For air control devices, hydronic specialties, special-duty valves, and chemical feeders to include in emergency, operation, and maintenance manuals.

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1.04 QUALITY ASSURANCE

- (A) Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- (B) Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- (C) ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- (A) Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- (B) Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- (C) Wrought-Copper Fittings: ASME B16.22.
- (D) Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
- (E) Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230° F for use with housing, and steel bolts and nuts.
- (F) Wrought-Copper Unions: ASME B16.22.

2.02 STEEL PIPE AND FITTINGS

- (A) Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- (B) Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
- (C) Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- (D) Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- (E) Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- (F) Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

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- (G) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
1. Material Group: 1.1.
 2. End Connections: Butt welding.
 3. Facings: Raised face.
- (H) Grooved Mechanical-Joint Fittings and Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Anvil International, Inc.
 - B. Central Sprinkler Company; a division of Tyco Fire & Building Products.
 - C. National Fittings, Inc.
 - D. S. P. Fittings; a division of Star Pipe Products.
 - E. Victaulic Company of America.
 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- (I) Steel Pressure-Seal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Victaulic Company of America.
 2. Housing: Steel.
 3. O-Rings and Pipe Stop: EPDM.
 4. Tools: Manufacturer's special tool.
 5. Minimum 300 PSIG working-pressure rating at 230°F.
- (J) Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.03 PLASTIC PIPE AND FITTINGS

- (A) PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.
- (B) PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.04 FIBERGLASS PIPE AND FITTINGS

- (A) RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.
- (B) RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
- (C) Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum 1/8-inch thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.

2.05 JOINING MATERIALS

- (A) Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - A. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - B. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- (B) Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- (C) Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- (D) Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- (E) Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAu-1, silver alloy for joining copper with bronze or steel.
- (F) Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- (G) Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - A. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - B. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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2.06 TRANSITION FITTINGS

- (A) Plastic-to-Metal Transition Fittings: PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.
- (B) Plastic-to-Metal Transition Unions: MSS SP-107, PVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.07 DIELECTRIC FITTINGS

- (A) Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- (B) Insulating Material: Suitable for system fluid, pressure, and temperature.
- (C) Dielectric Unions: Factory-fabricated union assembly, for 250 PSIG minimum working pressure at 180°F.
- (D) Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150 or 300 PSIG minimum working pressure as required to suit system pressures.
- (E) Dielectric-Flange Kits:
 - 1. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150 or 300 PSIG minimum working pressure where required to suit system pressures.
- (F) Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300 PSIG minimum working pressure at 225°F.
- (G) Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300 PSIG minimum working pressure at 225°F.

2.08 VALVES

- (A) Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Armstrong Pumps, Inc.
 - B. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - C. Flow Design Inc.
 - D. Griswold Controls.
 - E. Taco.
 - 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.

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3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 PSIG.
10. Maximum Operating Temperature: 250°F.

(B) Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Armstrong Pumps, Inc.
 - B. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - C. Flow Design Inc.
 - D. Griswold Controls.
 - E. Taco.
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 PSIG.
11. Maximum Operating Temperature: 250°F.

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(C) Diaphragm-Operated Safety Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Amtrol, Inc.
 - B. Armstrong Pumps, Inc.
 - C. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - D. Conbraco Industries, Inc.
 - E. Spence Engineering Company, Inc.
 - F. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

(D) Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - A. Flow Design Inc.
 - B. Griswold Controls.
 - C. Hydronic Components, Inc. (HCI)
 - D. Nexus.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.

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4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5% over system pressure fluctuations.
8. Minimum CWP Rating: 300 PSIG.
9. Maximum Operating Temperature: 250°F.

2.09 HOSE KITS

(A) Manufacturers: Subject to compliance with requirements, provide products of one (1) of the following:

1. Flow Design, Inc.
2. Griswold Controls.
3. Hydronic Components, Inc. (HCI)
4. Nexus.
5. Pro-Hydronic Specialties.

(B) General: Hose kits shall be designed for minimum 400 PSIG working pressure, and operating temperatures from 25 to 211°F. Hose Kits shall be approved by State Fire Codes for use in rated return air plenum. Tag hose kits to equipment designations.

(C) Hose: Minimum diameter, equal to pipe connection size to water-source heat-pump.

(D) Isolation Valves: Two-piece bronze-body full port ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return.

(E) Strainer: Y-type with blowdown valve in supply connection.

(F) Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gauge.

1. Automatic balancing valve, factory set to operate within 10% of design flow rate over a 40:1 differential pressure range of 2 to 80 PSIG.

(G) Control Valve: Provide 2-position, quick-opening (15 seconds maximum to full open), slow-closing valve to allow water flow through unit.

(H) Maximum pressure drop through hose kit assembly, valves, automatic flow control valve and heat pump unit shall be 25-feet of water head loss.

2.010 AIR CONTROL DEVICES

(A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. John Wood Co.
5. Patterson Pump.
6. Spirotherm, Inc.
7. Taco.
8. Thrush
9. Wessels Co.

(B) Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 PSIG.
7. Maximum Operating Temperature: 225°F.

(C) Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 PSIG.

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7. Maximum Operating Temperature: 240°F.

(D) Bladder-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125 PSIG working pressure and 375°F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

(E) Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125 PSIG minimum working pressure and 375°F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

(F) In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 PSIG.
3. Maximum Operating Temperature: Up to 300°F.

(G) Air Purgers:

1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 PSIG.
3. Maximum Operating Temperature: 250°F.

(H) Air & Dirt Separators:

1. Tank: Welded steel; ASME constructed and rated for 150 PSIG working pressure with entering velocities not to exceed 4 feet per second at specified GPM.

2. Internal Parts: Unit shall include an internal bundle to suppress turbulence and provide high efficiency. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Unit shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connections an equal distance for dirt separation. Air Eliminators shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.
3. Separator shall include a removable head to facilitate removal of bundle assembly for inspection or cleaning, blow down valve at bottom of unit, gauge tap on both inlet and outlet connections, and sight glasses on upper and lower sections of unit.

2.011 HYDRONIC PIPING SPECIALTIES

(A) Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Mesh startup strainer and perforated stainless-steel basket with 50% free area.
4. CWP Rating: 125 PSIG.

(B) Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Mesh startup strainer and perforated stainless-steel basket with 50% free area.
4. CWP Rating: 125 PSIG.

(C) Stainless-Steel Bellows, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 PSIG.
5. Maximum Operating Temperature: 250°F.

(D) Pump Suction Diffusers: Cast-iron body, with threaded connections for 2-inch or smaller, flanged connections for 2-1/2-inch and larger; 175 PSIG working pressure, 250°F maximum operating temperature; and complete with the following features:

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1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
2. Cylinder strainer with 3/16-inch diameter openings with total free area equal to or greater than five times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
3. Disposable fine mesh strainer to fit over cylinder strainer.
4. Permanent magnet, located in flow stream, removable for cleaning.
5. Adjustable foot support, designed to carry weight of suction piping.
6. Blowdown tapping in bottom; gage tapping inside.

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3.01 PIPING APPLICATIONS

- (A) General: Pipe material selected shall be in compliance with all applicable codes.
- (B) Hot-water heating piping, aboveground, NPS 2 and smaller, shall be one (1) of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- (C) Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be one (1) of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- (D) Hot-water heating piping installed belowground and within slabs shall be the following:
1. Type K, annealed-temper copper tubing, without joints.
- (E) Chilled-water piping, aboveground, NPS 2 and smaller, shall be one (1) of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- (F) Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be one (1) of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- (G) Makeup-water piping installed aboveground: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- (H) Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, without joints.
- (I) Condensate-Drain Piping shall be one (1) of the following:
1. Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 2. Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. PVC piping shall not be installed in return air plenums.
- (J) Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- (K) Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- (L) Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
- 3.02 VALVE APPLICATIONS**
- (A) Install shutoff-duty valves at each branch connection to supply and return mains, and at supply and return connections to each piece of equipment.
- (B) Install balancing valves or automatic flow control valves in the return pipe of each heating or cooling terminal.
- (C) Install Y-type strainers upstream of each automatic flow control valve.
- (D) Install check valves at each pump discharge and elsewhere as required to control flow direction.
- (E) Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- (F) Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.03 PIPING INSTALLATIONS

- (A) Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- (B) Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- (C) Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- (D) Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- (E) Install condensate drain piping from rooftop units to within 12 inches of nearest roof drain or gutter.
- (F) Install piping to permit valve servicing.
- (G) Install piping at indicated slopes.
- (H) Install piping free of sags and bends.
- (I) Install fittings for changes in direction and branch connections.
- (J) Install piping to allow application of insulation.
- (K) Select system components with pressure rating equal to or greater than system operating pressure.
- (L) Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- (M) Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- (N) Install piping at a uniform grade of 0.2% upward in direction of flow.
- (O) Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- (P) Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- (Q) Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- (R) Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- (S) Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- (T) Install sleeves for piping penetrations of walls, ceilings, and floors.

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(U) Install sleeve seals for piping penetrations of concrete walls and slabs.

(V) Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.04 HANGERS AND SUPPORTS

(A) Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

(B) Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4-inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4-inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8-inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8-inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8-inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2-inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2-inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8-inch.
10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4-inch.
11. NPS 12: Maximum span, 23 feet; minimum rod size, 7/8-inch.
12. NPS 14: Maximum span, 25 feet; minimum rod size, 1-inch.
13. NPS 16: Maximum span, 27 feet; minimum rod size, 1-inch.
14. NPS 18: Maximum span, 28 feet; minimum rod size, 1-1/4-inches.

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15. NPS 20: Maximum span, 30 feet; minimum rod size, 1-1/4-inches.
- (C) Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4-inch.
 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4-inch.
 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
 6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8-inch.
- (D) Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- (E) Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- (F) Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.
- 3.05 PIPE JOINT CONSTRUCTION**
- (A) Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- (B) Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- (C) Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- (D) Brazed Joints: Construct joints according to AWS' "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- (E) Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- (F) Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

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- (G) Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- (H) Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- (I) Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- (J) Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- (K) Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
- (L) Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.
- 3.06 HYDRONIC SPECIALTIES INSTALLATION**
- (A) Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- (B) Install automatic air vents at high points of system piping in mechanical equipment rooms only.
- (C) Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2% upward slope toward tank.
- (D) Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- (E) Install air separator in pump suction. Install blowdown piping with full-port ball valve; extend full size to nearest floor drain.
- (F) Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install blowdown piping nipple with full-port ball valve.
- (G) Install expansion tanks as shown on drawings. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.07 TERMINAL EQUIPMENT CONNECTIONS

- (A) Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- (B) Install control valves in accessible locations close to connected equipment.
- (C) Install ports for pressure gauges and thermometers at coil inlet and outlet connections.

3.08 FIELD QUALITY CONTROL

- (A) Prepare hydronic piping according to ASME B31.9 and as follows:

- 1. Leave joints, including welds, uninsulated and exposed for examination during test.
- 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
- 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
- 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
- 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

- (B) Perform the following tests on hydronic piping:

- 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
- 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
- 3. Isolate expansion tanks and determine that hydronic system is full of water.
- 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90% of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
- 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
- 6. Prepare written report of testing.

- (C) Perform the following before operating the system:

- 1. Open manual valves fully.

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2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13 – HYDRONIC PIPING AND SPECIALTIES

SECTION 23 23 00 - REFRIGERANT PIPING AND SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

- (A) Extent of refrigerant piping work is indicated on drawings and schedules and by requirements of this section.
- (B) Types of refrigerant piping and specialties specified in this section include the following:
1. Piping and Fittings.
 2. Refrigeration Valves.
 3. Refrigeration Specialties.

1.03 SUBMITTALS

- (A) Product Data: Submit manufacturer's technical product data and installation instructions for refrigerant piping materials and products.
- (B) Brazing Certification: Certify brazing procedures, brazers and operators in accordance with ASME Standards (ANSI B31.5).
- (C) Shop Drawings: Submit scaled layout drawings of refrigerant pipe and fittings including, but not necessarily limited to, pipe and tube sizes, locations, elevations and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between piping and proximate equipment.
- (D) Record Drawings: At project closeout, submit record drawings of installed refrigerant piping and piping products.
- (E) Maintenance Data: Submit maintenance data and parts lists for refrigerant piping materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual.

1.04 QUALITY ASSURANCE

- (A) Manufacturer Qualifications: Firms regularly engaged in manufacture of refrigerant piping products, of types, materials and sizes required whose products have been in satisfactory use in similar service for not less than five (5) years.
- (B) Installer's Qualifications: Firm with at least three (3) years of successful installation experience on projects with refrigerant piping work similar to that required for project.
- (C) Codes and Standards:
1. ANSI Compliance: Fabricate and install refrigerant piping in accordance with ANSI B31.5 "Refrigeration Piping" and extend application lower pressure limits to pressures below 15 PSIG.

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2. UMC Compliance: Fabricate and install refrigerant piping in accordance with IAPMO "Uniform Mechanical Code".
3. ASHRAE Compliance: Fabricate and install refrigerant piping in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

PART 2 - PRODUCTS

2.01 MATERIALS AND PRODUCTS

- (A) General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ANSI B31.5 "Refrigeration Piping" where applicable; base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials, which match pipe materials used in refrigerant piping systems. Where more than one (1) type of materials or products is indicated, selection is Installer's option.

2.02 PIPING AND TUBING MATERIALS

- (A) General: Refer to Part 3, Article "PIPE APPLICATION" for identification of systems where the below specified pipe and fitting materials are used.
- (B) Copper Tubing: ASTM B 280, Type ACR, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing. Tubing shall be factory cleaned, ready for installation and have ends capped to protect cleanliness of pipe interiors prior to shipping.
- (C) Copper Tubing: ASTM B 88, Type L, hard-drawn straight lengths and soft-annealed coils, seamless copper tubing.

2.03 FITTINGS

- (A) Wrought-copper Fittings: ANSI B16.22, streamlined pattern.

2.04 JOINING MATERIALS

- (A) Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver).

2.05 SPECIAL REFRIGERATION VALVES

- (A) General: Special valves required for refrigerant piping include the following types:

1. Ball and Check Valves:
 - A. Ball Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300°F temperature rating, 500 PSI working pressure.
 - B. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully-guided brass piston and stainless steel spring, 250°F temperature rating, 500 PSI working pressure.

C. Manufacturer: Subject to compliance with requirements, provide globe and check valves of one (1) of the following:

- (1) Henry Valve Co.
- (2) Parker Hannifin Corp., Refrigeration & Air-Cond. Div.
- (3) Sporlan Valve Co.

2. Solenoid Valves:

A. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24-volt, 60 Hz., UL Listed, 1/2-inch conduit adapter, 250°F temperature rating, 400 PSI working pressure.

B. Manual Operator: Provide manual operator to open valve.

C. Manufacturer: Subject to compliance with requirements, provide solenoid valves of one (1) of the following:

- (1) Alco Controls Div., Emerson Electric Co.
- (2) Automatic Switch Co.
- (3) Sporlan Valve Co.

2.06 REFRIGERANT SPECIALTIES

(A) Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL Listed, 350 PSI working pressure.

(B) Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL Listed, 200°F temperature rating, 500 PSI working pressure.

(C) Refrigerant Filter-Driers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron cover plate with steel cap screws, replaceable filter-drier core, 500 PSI working pressure.

(D) Evaporator Pressure Regulators: Provide corrosion-resistant, spring loaded, stainless steel springs, pressure operated, evaporator pressure regulator, in size and working pressure indicated, with copper connections.

(E) Refrigerant Discharge Line Mufflers: Provide discharge line mufflers as recommended by equipment manufacturer for use in service indicated, UL-listed.

(F) Manufacturer: Subject to compliance with requirements, provide refrigeration accessories of one (1) of the following:

- 1. Alco Controls Div., Emerson Electric Co.
- 2. Henry Valve Co.
- 3. Parker-Hannifin Corp., Refrigeration & Air-Conditioning Div.
- 4. Sporlan Valve Co.

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PART 3 - EXECUTION

3.01 EXAMINATION

- (A) General: Examine areas and conditions under which refrigerant piping systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 PIPING INSTALLATIONS

- (A) Use Type L or Type ACR drawn copper tubing with wrought copper fittings and brazed joints above ground, within building. Use Type K, annealed temper copper tubing for 2-inch and smaller without joints, below ground and within slabs. Mechanical fittings (crimp or flair) are not permitted.
- (B) Install annealed temper tubing in pipe duct. Vent pipe duct to the outside.
- (C) If other than Type ACR tubing is used, clean and protect inside of tubing as follows:
1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.
 2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 3. Draw a clean, lintless cloth saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.03 INSTALLATION OF SPECIAL REFRIGERANT VALVES

- (A) General: Install refrigerant piping in accordance with ASHRAE Standard 15 - "The Safety Code for Mechanical Refrigeration."
- (B) Install piping in as short and direct arrangement as possible to minimize pressure drop.
- (C) Install piping for minimum number of joints using as few elbows and other fittings as possible.
- (D) Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.
- (E) Provide adequate clearance between pipe and adjacent walls and hanger or between pipes for insulation and installation. Use sleeves through floors, walls or ceilings, sized to permit installation of full thickness insulation.
- (F) Insulate suction lines. Liquid lines are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.
1. Do not install insulation until system testing has been completed and all leaks have been eliminated.
- (G) Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

- (H) Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.
- (I) Slope refrigerant piping as follows:
1. Install horizontal hot gas discharge piping with 1/2-inch per 10-feet downward slope away from the compressor.
 2. Install horizontal suction lines with 1/2-inch per 10-feet downward slope to the compressor, with no long traps or dead ends, which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
 3. Install traps and double risers where required to entrain oil in vertical runs and in accordance with unit manufacturer's custom piping diagram.
 4. Liquid lines may be installed level.
- (J) Use fittings for all changes in direction and all branch connections.
- (K) Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.
- (L) Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
- (M) Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.
- (N) Install piping tight to slabs, beams, joints, columns, walls and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
- (O) Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- (P) Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6-inch shall be steel; pipe sleeves 6-inch and larger shall be sheet metal.
- (Q) Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.
- (R) Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.
- (S) Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

3.04 INSTALLATION OF REFRIGERATION ACCESSORIES

- (A) Refrigerant Strainers: Install in refrigerant lines as indicated, and in accessible location for service.
- (B) Moisture-Liquid Indicators: Install in refrigerant liquid lines as indicated, and in accessible location for service.
- (C) Refrigerant Filter-Dryers: Install in refrigerant lines as indicated, and in accessible location for service.

- (D) Evaporator Pressure Regulators: Install in refrigerant suction lines or evaporator outlets as indicated. Adjust, if required, for proper evaporator pressure.
- (E) Refrigerant Discharge Line Mufflers: Install as indicated, in horizontal or downflow portion of hot-gas lines, immediately after leaving compressor; not in riser.

3.05 EQUIPMENT CONNECTIONS

- (A) General: Connect refrigerant piping to mechanical equipment as indicated, and comply with equipment manufacturer's instructions where not otherwise indicated.

3.06 FIELD QUALITY CONTROL

- (A) Refrigerant Piping Leak Test: Prior to initial operation, clean and test refrigerant piping in accordance with ANSI B31.5, "Refrigeration Piping". Perform initial test with dry nitrogen, using soap solution to test all joints. Perform final test with 27-inch Hg vacuum, and then 200 PSI using halide torch. System must be entirely leak-free.
- (B) Repair or replace refrigerant piping as required to eliminate leaks, and retest as specified to demonstrate compliance.

3.07 DEHYDRATION AND CHARGING SYSTEM

- (A) Install core in filter dryer after leak test, but before evacuation.
- (B) Evacuate refrigerant system with vacuum pump until temperature of 35°F is indicated on vacuum dehydration indicator.
- (C) During evacuation, apply heat to pockets, elbows and low spots in piping.
- (D) Maintain vacuum on system for minimum of five (5) hours after closing valve between vacuum pump and system.
- (E) Break vacuum with refrigerant gas; allow pressure to build up to 2 PSI.
- (F) Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

END OF SECTION 23 23 00 REFRIGERANT PIPING AND SPECIALTIES

SECTION 23 25 00 - HYDRONIC SYSTEMS CLEANING AND TREATMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes hydronic systems cleaning and treatment for closed loop hydronic systems, and make-up water for these systems. Contractor shall provide all labor, materials, equipment, instruments and transportation associated with the chemical and glycol-based solutions.

- (B) Hydronic systems cleaning and treatment items specified in this section include the following:

1. Manual Chemical Feeders.
2. System Cleaning and Water Treatment.

1.03 SUBMITTALS

- (A) Shop Drawing Submittals:

1. Product Data: From manufacturers, for solution feeder specified, include rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions.
2. Detail chemical/glycol feeders dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field connection.
 - A. Include the percentage by volume of glycol and the fluid thermal conductivity, density, viscosity, specific heat and compliance with corrosion standards of ASTM D1384.
3. Material Safety Data Sheets (MSDS): Include the MSDS information for chemicals used for system cleaning, freeze protection, corrosion control and bacterial control.

- (B) Closeout Submittals:

1. Maintenance Data: For solution feeder, system cleaning and water treatment, and glycol-based solution handling and storage, for inclusion in operation and maintenance manual.
2. Quality Control Submittals: Submit Hydronic Piping System Testing and Cleaning Reports specified in Part 3 of this Section.

1.04 QUALITY ASSURANCE

- (A) HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

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1.05 MAINTENANCE SERVICE

- (A) Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required to inhibit corrosion, scale formation, and biological growth for hydronic piping systems and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush and clean the systems, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.
- (B) Provide a service agreement proposal to extend the chemical treatment program annually beyond the one year program. The proposal shall include quarterly testing and chemical treatment as necessary to maintain proper water conditions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- (A) Manufacturer: Subject to compliance with requirements, provide hydronic system treatment products from one of the following:
1. Manual Chemical Feeders:
 - A. Amtrol, Inc.
 - B. Armstrong Pumps, Inc.
 - C. General Treatment Products.
 - D. ITT Fluid Technology Corp.; ITT Bell & Gossett.
 - E. J.L. Wingert Co.
 - F. Taco, Inc.

2.02 CHEMICAL FEEDERS

- (A) Manual Chemical Feeders: Bypass type chemical feeders of 5-gallon capacity, welded steel construction; 175 PSIG working pressure; complete with fill funnel and inlet, outlet and drain valves. Quarter-turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

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2.03 HYDRONIC SYSTEM CLEANING SOLUTION

- (A) As required by the specified cleaning methods.

PART 3 - EXECUTION

3.01 SYSTEM PREPARATION

- (A) Install manual chemical feeders in each hydronic system where indicated; in upright position with top of funnel not more than 48 -inches above floor. Install feeder in bypass line with ball valves on each side of feeder. Pipe drain, with ball valve, to nearest floor drain.
- (B) The system shall be cleaned, degreased and thoroughly flushed to remove dirt, weld slag, fillings, solder flux, oil, etc. A new or mildly corroded system shall be cleaned with a solution of trisodium phosphate in water, prepared in a portion of 1 lb/50 gallons of water in the system, or another approved cleaning solution. After system is filled with this solution, the circulation pump shall be started, trapped air vented and system temperature raised to approximately 100°F loop temperature. The cleaning solution shall be circulated for 8-12 hours. Remove, clean and replace strainer screens after circulation is complete.
- (C) Chilled water systems and other hydronic systems that do not utilize a boiler or other means of adding heat to the system shall use a cleaning solution and cleaning method that does not rely on the temperature of the solution to perform its function.
- (D) An extensively corroded system shall be cleaned using a more aggressive commercially available cleaning product as recommended by an industrial cleaning company. All necessary replacements and repairs should be made at this time.
- (E) Complete circulation must be achieved during the cleaning and flushing procedure. A minimum flow rate of 2 ft/sec. shall be maintained to insure the effectiveness of the process. All valves must be open and all dead end piping runs must be looped together to insure complete circulation.
- (F) A ball valve (1-inch minimum) shall be installed in the low point of each system for the purpose of draining the system.
- (G) The system shall be drained completely, refilled with clean water and circulated for a minimum of 72 hours, at which time a sample shall be taken to verify that the system is free of particulates, mil scale, weld scale, solder flux, rust, metal fillings, oil, grease, chlorides, sulfates, silicates and other foreign matter that could degrade the glycol-based solution.
- (H) After system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable methods and left on slightly alkaline side (PH 7.5). If system is still on acid side, cleaning procedure shall be repeated.
- (I) Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of bacteria, scale and corrosion. Perform initial treatment after completion of system cleaning and testing.

3.02 FLUID INSTALLATION

- (A) The system piping shall be hydrostatically tested to ensure that there are no leaks. This may be done using the flush water in the system.
- (B) The Contractor shall provide water treatment necessary for the entire volume of the hydronic system.

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- (C) Air Removal: After flushing, cleaning, testing and fluid installation is complete, system shall be vented to remove all air from the system.

3.03 SYSTEM IDENTIFICATION

- (A) The Contractor shall provide a system nameplate permanently encased in clear plastic with, but not limited to, the following information; date, description of heat transfer fluid, manufacturer's name, address and telephone numbers for normal and emergency contact, total system volume in gallons, and a copy of or reference to the MSDS.

3.04 STARTUP

- (A) Verify that system has been appropriately filled and initial chemical treatment has been performed.
- (B) The Contractor shall take a fluid sample with the manufacturer's supplied test kit after the system has been circulating for a minimum of 24 hours. The manufacturer shall provide a thermal fluid analysis report to the Engineer in writing. The Contractor shall be responsible to complete any changes in the heat transfer solution if it does not meet with these specifications.
- (C) Provide a final water analysis and report for systems indicating appropriate chemical treatment.

END OF SECTION 23 25 00 – HYDRONIC SYSTEMS CLEANING AND TREATMENT

SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Single-wall spiral round and flat-oval ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealants and gaskets.
7. Hangers and supports.

1.03 SUBMITTALS

- (A) Product Data: For each type of the following products:

1. Liners, adhesives, and sealants.
2. Double-wall ducts and fittings.

- (B) Coordination Drawings: Ductwork plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Penetrations of smoke barriers and fire-rated construction.
2. Items penetrating finished ceiling including, but not limited to, the following:
 - A. Lighting fixtures.
 - B. Air outlets and inlets.
 - C. Speakers.
 - D. Sprinklers.
 - E. Access panels.
 - F. Cable tray.

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1.04 QUALITY ASSURANCE

- (A) ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- (B) ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- (A) General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- (B) Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- (C) Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- (D) Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SINGLE-WALL ROUND DUCTS AND FITTINGS

- (A) General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- (B) Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- (C) Longitudinal Seams: Fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- 1. Seam type shall be one of the following:
 - A. RL-2 or RL-3 – Lap and Rivet or Tack weld
 - B. RL-4 – Butt weld or Lap and Seam weld.
 - C. RL-5 – Grooved Seam, Pipe lock, Flat lock, Pittsburgh lock.

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2. Snap-lock seams are not acceptable.
- 2.03 SINGLE-WALL SPIRAL ROUND AND FLAT-OVAL DUCTS AND FITTINGS
- (A) General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - A. Eastern Sheet Metal.
 - B. Lewis & Lambert.
 - C. Lindab Inc.
 - D. McGill AirFlow LLC
 - E. Norlock.
 - F. SEMCO Incorporated.
 - G. Sheet Metal Connectors, Inc.
 - H. Spiral Pipe of Texas.
 - I. W.E.S.C.O.
 - J. Wichita Sheet Metal.
- (B) Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- (C) Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in exposed ductwork: Beaded sleeve slip joint or Keating coupling by Ward Industries or approved equal.
 2. Transverse Joints in Ducts Larger Than 60-Inches in Diameter: Flanged.
- (D) Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Longitudinal seams in exposed ductwork: Spiral lockseam.
 2. Fabricate round ducts larger than 60-inches in diameter with butt-welded or grooved seam/pipe lock longitudinal seams.

3. Fabricate flat-oval ducts larger than 60-inches in width (major dimension) with butt-welded or grooved seam/pipe lock longitudinal seams.
- (E) Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 2.04 SHEET METAL MATERIALS
- (A) General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- (B) Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90 (Z275).
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- (C) Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- (D) Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.
- 2.05 DUCT LINER
- (A) Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - A. CertainTeed Corporation; Insulation Group.
 - B. Johns Manville.
 - C. Knauf Insulation.
 - D. Owens Corning.
 2. Maximum Thermal Conductivity:
 - A. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 - B. Type II, Rigid: 0.24 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 3. Noise Reduction Coefficient (NRC) at 1-inch thickness: 0.70.

4. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 5. Water-Based Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- (B) Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2-inches in diameter.
- (C) Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
- 2.06 SEALANT AND GASKETS
- (A) General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- (B) Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65%.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- (C) Flanged Joint Sealant: Comply with ASTM C 920.
- (D) Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

(E) Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.07 HANGERS AND SUPPORTS

(A) Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

(B) Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

(C) Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

(D) Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

(E) Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

(F) Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

(G) Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.01 PERFORMANCE REQUIREMENTS

(A) Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

(B) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

3.02 DUCT INSTALLATION

(A) Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Coordination Drawings.

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- (B) Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- (C) Install round and flat-oval ducts in maximum practical lengths.
- (D) Install ducts with fewest possible joints.
- (E) Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- (F) Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- (G) Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- (H) Install ducts with a clearance of 1-inch, plus allowance for insulation thickness.
- (I) Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- (J) Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2-inches.
- (K) Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.
- (L) Seal all open ducts to protect duct interiors from moisture, construction debris and dust, and other foreign materials during construction. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.03 INSTALLATION OF EXPOSED DUCTWORK

- (A) Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- (B) Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- (C) Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- (D) Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- (E) Repair or replace damaged sections and finished work that does not comply with these requirements.
- (F) Provide paintable surface finish for ducts designated to be field painted.

3.04 DUCT SEALING

- (A) Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.05 HANGER AND SUPPORT INSTALLATION

- (A) Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- (B) Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- (C) Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24-inches of each elbow and within 48-inches of each branch intersection.
- (D) Hangers Exposed to View: Threaded rod and angle or channel supports.
- (E) Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- (F) Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.06 CONNECTIONS

- (A) Make duct connections to equipment with flexible connectors.
- (B) Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- (C) Provide duct transition fittings as required to connect branch ductwork to diffusers, registers, grilles and terminal units.

3.07 PAINTING

- (A) Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.
- (B) Provide paint grip finish on all exposed ductwork that is designated for field painting. Coordinate with General Contractor.

3.08 DUCT CLEANING

- (A) Clean ductwork as it is installed and seal open ducts during construction.
- (B) Clean exterior surfaces of new duct system(s) of foreign substances that could cause corrosion or deterioration of the ductwork; and where ductwork is designated to be painted.

3.09 START UP

- (A) Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting and Balancing."

3.010 DUCT SCHEDULE (Unless otherwise indicated, construct ducts according to the following:)

- (A) Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

(B) Round and Flat-Oval exposed ductwork: Spiral lockseam.

(C) Supply Ducts:

1. Supply Air Ducts (unless otherwise indicated):
 - A. Pressure Class: Positive 2-inch wg.
 - B. Minimum SMACNA Seal Class: B.
2. Ducts Connected Downstream of Air Terminal Units:
 - A. Pressure Class: Positive 2-inch wg.
 - B. Minimum SMACNA Seal Class: B.
3. Ducts Connected Upstream of Air Terminal Units:
 - A. Pressure Class: Positive 3-inch wg.
 - B. Minimum SMACNA Seal Class: B.

(D) Return Ducts:

1. Return Air Ducts (unless otherwise indicated):
 - A. Pressure Class: Negative 2-inch wg.
 - B. Minimum SMACNA Seal Class: B.

(E) Exhaust Ducts:

1. Exhaust Air Ducts (unless otherwise indicated):
 - A. Pressure Class: Positive or negative 3-inch wg.
 - B. Minimum SMACNA Seal Class: B.

(F) Outdoor-Air and Ventilation Air Ducts:

1. Outside Air and Ventilation Air Ducts:
 - A. Pressure Class: Positive or negative 2-inch wg.
 - B. Minimum SMACNA Seal Class: B.

(G) Duct Liner: Refer to Division 23 Section "Mechanical Insulation".

(H) Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

- A. Radius Type RE 1 with minimum 1.5 centerline radius-to-width ratio.
 - B. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
- A. Round Elbows, 12-Inches and Smaller in Diameter: Stamped or pleated with minimum 1.5 centerline radius-to-diameter ratio
 - B. Round Elbows, 14-Inches and Larger in Diameter: Standing seam or welded with minimum 1.5 centerline radius-to-diameter ratio.
- (I) Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connections."
- A. Rectangular Main to Rectangular Branch: Factory fabricated 45-degree take-off fitting with sealed joints and seams.
 - B. Rectangular Main to Round Branch: Factory fabricated straight-sided high efficiency take-off fitting with sealed joints and seams and gasketed flange.
2. Round and Flat Oval Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
- A. Velocity 1000 fpm or Lower: 90-degree tap.
 - B. Velocity 1000 fpm or Higher: 45-degree lateral or conical tap.

END OF SECTION 23 31 13 – METAL DUCTS

SECTION 23 33 00 - DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Air filters.
2. Manual volume dampers.
3. Fire dampers.
4. Ceiling radiation dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Diffusers, registers and grilles.
8. Louvers
9. Flange connectors.
10. Turning vanes.
11. Remote damper operators.
12. Duct-mounted access doors.
13. Drip pans.
14. Flexible connectors.
15. Flexible ducts.

1.03 SUBMITTALS

- (A) Product Data: For each type of product indicated.

1. Air filters.
2. Manual volume dampers.
3. Fire dampers.

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4. Ceiling radiation dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Diffusers, registers and grilles.
8. Louvers.
9. Remote damper operators.
10. Duct-mounted access doors.
11. Flexible connectors.
12. Flexible ducts.

(B) Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

(C) Closeout Submittals:

1. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

(A) Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

(B) Comply with AMCA 500-D testing for damper rating.

1.05 EXTRA MATERIALS

(A) Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10% of amount installed.

PART 2 - PRODUCTS

2.01 MATERIALS

(A) Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

(B) Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).
2. Exposed-Surface Finish: Mill phosphatized.

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- (C) Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.
- (D) Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- (E) Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- (F) Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- (G) Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

2.02 AIR FILTERS

- (A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Air Filter.
 - 2. Camfil Farr.
 - 3. Flanders.
- (B) Replaceable (Throwaway) Panel Filters: Provide factory-fabricated, viscous-coated, flat panel type replaceable air filters with holding frames; as indicated, in sizes indicated, with 2-inch thick UL Class 2 throwaway media material; construct media of interlaced glass fibers, spray with non-flammable adhesive, frame in throwaway fiberboard casings, and sandwich between perforated metal grills. Construct ductwork-holding frames of 20-gage galvanized-steel, capable of holding media and media frame in place, and gasketed to prevent unfiltered air by-passing between media frames and holding members. Provide filters with rated face velocity of 500 FPM, initial resistance of not greater than 0.30-inch w.g., final rated resistance of 0.50-inch WC and average arrestance of 80%.
- (C) Extended Surface Filters: Provide factory-fabricated, dry, extended surface filters with holding frames; where shown, in sizes indicated. Equip with UL Class 1 fibrous media material formed into 6-inch deep V-shaped pleats and held by self-supporting wire frames. Construct holding frames of 18-gage galvanized-steel and provide suitable fasteners and gasketing to hold media and media frame and to prevent unfiltered air passing between media frames and holding devices. Design holding frames which are suitable for bolting together into built-up filter banks. Provide filters with rated face velocity of 500 FPM, initial resistance of 0.50-inch w.g. with 60-65% dust spot efficiency, and 0.60-inch WC with 90-95% dust spot efficiency and final rated resistance 1.2-inch WC.
- (D) Class 2 30/30 Filters
 - 1. Air Filters - Air filters shall be 2-inch Farr 30/30, medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2.
 - 2. Filter Media - Filter media shall be of the non-woven cotton fabric type. The filter media shall have an efficiency of 30% on ASHRAE Test Standard 52-76. It shall have an average arrestance of 90-92% in accordance with that test standard. The effective filter media shall be not less than 4.6 square feet of media per 1.0 square foot of filter face area and shall contain not less than 15 pleats per linear foot. Initial resistance at 500 FPM approach velocity shall not exceed .28-inch w.g.

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3. Media Support Grid - The media support shall be a welded wire grid with an effective open area of not less than 96%. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull away. The media support grid shall be formed in such a manner that it effects a radial pleat design, allowing total use of filter media.
4. Enclosing Frame - The enclosing frame shall be constructed of a rigid, heavy-duty, high wet-strength beverage board, with diagonal support members bonded to the air entering and air exit side of each pleats, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack, thus, eliminating the possibility of air bypass.
5. Holding Frame - Holding frames shall be Farr Type 8, factory fabricated of 16-gage galvanized-steel and shall be equipped with gaskets and four (4) spring type positive sealing fasteners. Fasteners shall be capable of being attached or removed without the use of tools.

2.03 MANUAL VOLUME DAMPERS

(A) Standard, Steel, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames:
 - A. Hat-shaped, galvanized-steel channels, 16 gauge.
 - B. Mitered and welded corners.
 - C. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - A. Multiple or single blade.
 - B. Parallel- or opposed-blade design.
 - C. Stiffen damper blades for stability.
 - D. Galvanized-steel, 16 gauge.
5. Blade Axles: Stainless steel.
6. Bearings:
 - A. Molded synthetic.
 - B. Dampers in ducts with pressure classes of 3-inch wg or more shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Galvanized steel.

(B) Damper Hardware:

1. Zinc-plated, die-cast core with ¼ turn dial regulator and handle with a handle locking wing nut.
2. INCLUDE ELEVATED STANDOFF PLATFORM FOR EACH DAMPER THAT IS INSTALLED IN EXTERNALLY INSULATED DUCTWORK.

(C) Damper Identification: Include a 12-inch long section of yellow plastic flagging tape securely attached to the operating handle of each manual volume damper.

2.04 FIRE DAMPERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance, Inc.
2. Greenheck.
3. Louvers and Dampers, Inc.
4. Nailor Industries Inc.
5. NCA Manufacturing, Inc.
6. Pottorff.
7. Ruskin Company.
8. United Enertech.

(B) Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

(C) Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

(D) Fire Rating: 1-1/2 and 3 hours, as required.

(E) Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 20 gauge galvanized steel; with mitered and interlocking corners.

(F) Mounting Sleeve: Factory-installed, galvanized sheet steel.

1. Minimum Thickness: 20-gauge, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

(G) Mounting Orientation: Vertical or horizontal as indicated.

(H) Blades: Roll-formed, interlocking, 20-gauge, galvanized sheet steel. In place of interlocking blades, use full-length, 20-gauge, galvanized-steel blade connectors.

(I) Horizontal Dampers: Include blade lock and stainless-steel closure spring.

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(J) Heat-Responsive Device: Replaceable, 165° F rated, fusible links, unless otherwise indicated.

2.05 CEILING RADIATION DAMPERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck.
2. Nailor Industries Inc.
3. NCA Manufacturing, Inc.
4. Pottorff.
5. Ruskin Company.
6. United Enertech.

(B) General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

(C) Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

(D) Blades: Galvanized sheet steel with refractory insulation.

(E) Heat-Responsive Device: Replaceable, 165° F rated, fusible links.

(F) Fire Rating: 1-1/2 and 3 hours, as required.

2.06 SMOKE DAMPERS

(A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dampers
 - A. Greenheck.
 - B. Nailor Industries Inc.
 - C. NCA Manufacturing, Inc.
 - D. Pottorff.
 - E. Ruskin Company.
 - F. United Enertech.

- 2. Damper Actuators
 - A. Belimo
 - B. Siemens
 - (B) General Requirements: Label according to UL 555S by an NRTL.
 - (C) Frame: Multiple-blade type; fabricated with roll-formed, 16-gauge, galvanized steel; with mitered and interlocking corners.
 - (D) Blades: Roll-formed, horizontal, interlocking, 16-gauge, galvanized sheet steel. In place of interlocking blades, use full-length, 16-gauge, galvanized-steel blade connectors.
 - (E) Leakage: Class II.
 - (F) Rated pressure and velocity to exceed design airflow conditions.
 - (G) Mounting Sleeve: Factory-installed, 16-gauge, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
 - (H) Damper Actuator: Direct-coupled, gear type with two-position (power open/spring return) action.
 - 1. Torque: 133 in-lb (min).
 - 2. Provide with fail close operation.
 - 3. Provide with manual override.
 - 4. Electrical Connection: 115 V, single phase, 60 Hz.
 - 5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections
 - (I) Accessories:
 - 1. Test and reset switches, damper mounted.
- 2.07 COMBINATION FIRE AND SMOKE DAMPERS
- (A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Dampers
 - A. Greenheck.
 - B. Nailor Industries Inc.
 - C. NCA Manufacturing, Inc.
 - D. Pottorff.
 - E. Ruskin Company.

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- F. United Enertech.
- 2. Damper Actuators
 - A. Belimo
 - B. Siemens
- (B) Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- (C) Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- (D) Fire Rating: 1-1/2 and 3 hours, as required.
- (E) Frame: Multiple-blade type; fabricated with roll-formed, 16-gauge galvanized steel; with mitered and interlocking corners.
- (F) Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.
- (G) Blades: Roll-formed, horizontal, interlocking, 16-gauge, galvanized sheet steel. In place of interlocking blades, use full-length, 16-gauge, galvanized-steel blade connectors.
- (H) Leakage: Class II.
- (I) Rated pressure and velocity to exceed design airflow conditions.
- (J) Mounting Sleeve: Factory-installed, 16-gauge, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
- (K) Damper Actuator: Direct-coupled, gear type with two-position (power open/spring return) action.
 - 1. Torque: 133 in-lb (min).
 - 2. Provide with fail close operation.
 - 3. Provide with manual override.
 - 4. Electrical Connection: 115 V, single phase, 60 Hz.
 - 5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections
- (L) Accessories: Test and reset switches, damper mounted.
- 2.08 DIFFUSERS, REGISTERS, AND GRILLES
 - (A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carnes.
 - 2. Krueger.
 - 3. Metalaire, Inc.

4. Nailor Industries, Inc.
 5. Price Industries.
 6. Titus.
 7. Tuttle & Bailey.
- (B) General: Except as otherwise indicated, provide manufacturer's standard air diffusers, registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Include seal bearing AMCA certified rating.
- (C) Performance: Provide air diffusers, registers, and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- (D) Ceiling and Wall Compatibility: Provide diffusers, registers, and grilles with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling and wall systems which will contain each type of air diffuser, register and grille.
- (E) Finish: Diffusers, registers and grilles shall have an off-white factory applied finish, unless shown otherwise.
- (F) Dampers and Accessories: See schedule on drawings for required dampers and accessories.
- (G) Types: Unless designated herein, provide diffusers, registers, and grilles of type, capacity and with accessories and finishes as listed on schedules and details, shown on drawings.
- 2.09 LOUVERS
- (A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aerolite.
 2. Airline Products Co.
 3. Airstream Products, division of Penn Ventilator Co.
 4. American Warming and Ventilating.
 5. Greenheck.
 6. Louvers & Dampers, Inc.
 7. Nailor Industries.
 8. NCA Manufacturing.
 9. Pottorff.
 10. Reliable Metal Products.
 11. Ruskin.

12. Safe Air/Dowco.
13. United Enertech.
- (B) General: Except as otherwise indicated, provide manufacturer's standard louvers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated and as required for complete installation.
- (C) Performance: Provide louvers that have 50% minimum free area, and .10-inch maximum pressure drop for each type as listed in manufacturer's current data.
- (D) Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate which will contain each type of louver.
- (E) Materials: Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T5. Louver shall bear the AMCA Seal. Weld units or use stainless steel fasteners. Louver finish and color shall be as scheduled on drawings. Provide five year warranty on finish.
- (F) Louver Screens: On inside face of exterior louvers, provide 1/2-inch square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames unless noted otherwise on drawing schedule.
- (G) Blade: Blade shall be 6-inches in depth and of drainable type construction for sizes larger than 24-inches x 24-inches. Louver sizes below 24-inches x 24-inches shall have a 4-inch blade depth of drainable construction.

2.010 FLANGE CONNECTORS

- (A) Description: Roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- (B) Material: Galvanized steel.
- (C) Gauge and Shape: Match connecting ductwork.

2.011 TURNING VANES

- (A) Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- (B) General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- (C) Vane Construction: Single wall for ducts up to 48-inches wide and double wall for larger dimensions.

2.012 REMOTE DAMPER OPERATORS

- (A) Description: Cable system designed for remote manual damper adjustment.

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- (B) Tubing: Brass.
- (C) Cable: Stainless steel.
- (D) Wall or Ceiling-Box Mounting: Recessed, 3/4-inches deep surface.
- (E) Wall-Box Cover-Plate Material: Stainless steel.
- (F) In lieu of the cable operated system, a remote control system equal to United Enertech may be provided. The Contractor shall furnish a complete and operable system, including damper, remote plate, plenum rated cable, and hand-held power pack. The Contractor shall turn over power pack to owner after completion of balancing.

2.013 DUCT-MOUNTED ACCESS DOORS

- (A) Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
 - 1. Door:
 - A. Double wall, rectangular.
 - B. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - C. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - D. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - A. Access Doors Less Than 12-Inches Square: No hinges and two sash locks.
 - B. Access Doors up to 18-Inches Square: Two hinges and two sash locks.
 - C. Access Doors up to 24- by 48-Inches: Three hinges and two compression latches with outside and inside handles.
 - D. Access Doors Larger Than 24- by 48-Inches: Four hinges and two compression latches with outside and inside handles.
 - 4. Labeling: Label access doors for fire dampers, smoke dampers and fire/smoke dampers with minimum 3/4-inch high letters reading "FIRE DAMPER", "SMOKE DAMPER" or "FIRE/SMOKE DAMPER" to match type of damper being accessed.

2.014 DRIP PANS

- (A) Unless noted otherwise on the drawings, provide drip pans under all rooftop fans, hoods and other mechanical roof penetrations that do not have ductwork attached to them.

- (B) Drip pans shall be 22 gauge (minimum), cross-broken or reinforced galvanized sheet metal with 2-inch welded upturned sides.
- (C) Drip pans shall extend 6-inches beyond the roof opening in all directions and installed 25% of the maximum roof opening dimension below the opening.
- (D) Drip pans installed in unconditioned spaces shall be insulated on the exterior of the pan with ½-inch thick elastomeric foam insulation adhered to pan.

2.015 FLEXIBLE CONNECTORS

- (A) Materials: Flame-retardant or noncombustible fabrics.
- (B) Coatings and Adhesives: Comply with UL 181, Class 1.
- (C) Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2-inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.
- (D) Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200° F.
- (E) Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd..
 - 2. Minimum Tensile Strength: 500 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250° F.
- (F) High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd..
 - 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500° F.
- (G) High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: 14 oz./sq. yd..
 - 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500° F.

2.016 FLEXIBLE DUCTS

(A) Manufacturers: Subject to compliance with requirements, provide products of one of the following:

1. ATCO, Type 1200.
2. Therma Flex, Type M-KE.

(B) Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 20 to plus 175° F.
4. Vapor Transmission: 0.05 perms.
5. Insulation R-Value: Comply with ASHRAE/IESNA 90.1-2004.

(C) Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18-inches, to suit duct size.
2. Straps: Extra heavy duty, 175 lb. tensile strength nylon strap.

PART 3 - EXECUTION

3.01 INSTALLATION

(A) Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

(B) Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

(C) Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts.

1. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
2. **WHERE DAMPERS ARE INSTALLED IN DUCTS HAVING EXTERNAL INSULATION, INSTALL DAMPERS WITH ELEVATED STANDOFF PLATFORM TO ALLOW DAMPER OPERATOR TO BE READILY ACCESSIBLE.**
3. Install flagging tape on operating handle of each volume damper. Tape shall be readily identifiable from the service access point for the damper.
4. Install steel volume dampers in steel ducts.

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5. Install aluminum volume dampers in aluminum ducts.
- (D) Set dampers to fully open position before testing, adjusting, and balancing.
- (E) Install fire, smoke and combination fire/smoke dampers according to UL listing.
- (F) Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
1. On both sides of duct coils.
 2. Downstream from VAV terminal unit reheat coils.
 3. Upstream from duct filters.
 4. At drain pans and seals.
 5. Downstream from control dampers, backdraft dampers, and equipment.
 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 7. Control devices requiring inspection.
 8. Upstream of remote air flow measuring stations.
 9. Elsewhere as indicated.
- (G) Install diffusers, registers and grilles in center of acoustical ceiling modules.
- (H) Install louvers in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that product serves intended function.
- (I) Install access doors with swing against duct static pressure.
- (J) Access Door Sizes:
1. One-Hand or Inspection Access: 8- by 5-inches.
 2. Two-Hand Access: 12- by 6-inches.
 3. Head and Hand Access: 18- by 10-inches.
 4. Head and Shoulders Access: 21- by 14-inches.
 5. Body Access: 25- by 14-inches.
 6. Body plus Ladder Access: 25- by 17-inches.
- (K) Label access doors to indicate the purpose of access door.
- (L) Install flexible connectors to connect ducts to equipment.

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- (M) Connect terminal units to supply ducts with maximum 24-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- (N) Connect diffusers to ducts with maximum 36-inch lengths of flexible duct clamped in place. Do not use flexible ducts to change direction.
- (O) Connect flexible ducts to metal ducts with liquid adhesive plus stainless-steel band clamp or extra heavy duty nylon strap.

3.02 FIELD QUALITY CONTROL

(A) Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00 – DUCT ACCESSORIES

SECTION 23 52 16 - CONDENSING BOILERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) ANSI Z21.13 / CSA 4.9 (GAS FIRED LOW PRESSURE STEAM AND HOT WATER BOILERS)
- (B) ASME SECTION IV ("H" STAMP HEATING BOILERS)
- (C) ASME CSD-1 (CONTROLS AND SAFETY DEVICES)
- (D) NBIC - PART 1 (INSTALLATION)
- (E) NFPA 54/ANSI Z221.3 (NATIONAL FUEL GAS CODE)
- (F) NFPA 70 (NATIONAL ELECTRIC CODE)

1.02 SUMMARY

- (A) THIS SECTION INCLUDES GAS-FIRED, HIGH EFFICIENCY CONDENSING HOT WATER BOILERS WITH STAINLESS STEEL HEAT EXCHANGERS.

1.03 SUBMITTALS

- (A) THE CONTRACTOR SHALL SUBMIT, IN A TIMELY MANNER, ALL SUBMITTALS FOR APPROVAL TO THE ENGINEER. UNDER NO CIRCUMSTANCES SHALL THE CONTRACTOR INSTALL ANY MATERIALS UNTIL THE ENGINEER HAS MADE FINAL APPROVAL ON THE SUBMITTALS.
- (B) PRODUCT DATA AND/OR DRAWINGS SHALL BE SUBMITTED TO THE ENGINEER FOR APPROVAL AND SHALL CONSIST OF:
 - 1. GENERAL ASSEMBLY DRAWING OF THE BOILER INCLUDING PRODUCT DESCRIPTION, MODEL NUMBER, DIMENSIONS, CLEARANCES, WEIGHTS, SERVICE SIZES, ETC.
 - 2. SCHEMATIC FLOW DIAGRAM OF THE BOILER'S GAS VALVE TRAIN(S).
 - 3. SCHEMATIC WIRING DIAGRAM OF THE BOILER'S CONTROL SYSTEM THAT SHOWS ALL COMPONENTS, INTERLOCKS, ETC. AND SHALL CLEARLY IDENTIFY FACTORY WIRING AND FIELD WIRING.
- (C) FULL FUNCTION FACTORY FIRE TEST MUST BE PERFORMED AND DOCUMENTED ON THE BOILER'S FIRE TEST LABEL. A FACTORY AUTHORIZED START-UP MUST BE COMPLETED PRIOR TO FINAL ACCEPTANCE BY THE ENGINEER.
- (D) OPERATION AND MAINTENANCE MANUALS SHALL BE SUBMITTED PRIOR TO FINAL ACCEPTANCE BY THE ENGINEER AND SHALL CONTAIN SHOP DRAWINGS, PRODUCT DATA, OPERATING INSTRUCTIONS, CLEANING PROCEDURES, REPLACEMENT PARTS LIST, MAINTENANCE AND REPAIR DATA, ETC.

1.04 QUALITY ASSURANCE

- (A) THE EQUIPMENT SHALL, AT A MINIMUM, BE IN STRICT COMPLIANCE WITH THE REQUIREMENTS OF THIS SPECIFICATION, SHALL PERFORM AS SPECIFIED AND SHALL BE THE MANUFACTURER'S STANDARD COMMERCIAL PRODUCT UNLESS SPECIFIED OTHERWISE.

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- (B) ELECTRICALLY OPERATED COMPONENTS SPECIFIED ARE TO BE "LISTED" AND/OR "LABELED" AS DEFINED BY NFPA 70, ARTICLE 100.
- (C) BOILER SHALL BEAR AN ASME "H" STAMP IN ACCORDANCE WITH ASME SECTION IV.
- (D) BOILER SHALL BE AHRI LISTED AND CERTIFIED IN ACCORDANCE WITH THE COMMERCIAL BOILER PROGRAM AND THE BTS-2000 TESTING STANDARD.
- (E) BOILER SHALL UNDERGO A FULL FUNCTION FACTORY FIRE TEST AND BEAR A FIRE TEST LABEL.
- (F) BOILER SHALL BE REGISTERED THROUGH THE NATIONAL BOARD FROM THE FACTORY.
- (G) THE MANUFACTURER SHALL MAKE AVAILABLE, UPON REQUEST, ALL QUALITY ASSURANCE DOCUMENTATION AND RESULTS OF FULL FUNCTION FACTORY FIRE TEST BASED ON THE BOILER'S SERIAL NUMBER.

1.05 COORDINATION

- (A) EQUIPMENT SHALL BE HANDLED, STORED AND INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS.
- (B) FACTORY AUTHORIZED START-UP MUST BE COMPLETED AFTER ALL APPLIANCE CONNECTIONS ARE COMPLETED, E.G. GAS PIPING, HYDRONIC PIPING, EXHAUST VENTING & ELECTRICAL.

1.06 WARRANTY

- (A) THE BOILER MANUFACTURER SHALL WARRANT EACH BOILER, INCLUDING BOILER, TRIM, BOILER CONTROL SYSTEM, AND ALL RELATED COMPONENTS, ACCESSORIES, AND APPURTENANCES AGAINST DEFECTS IN WORKMANSHIP AND MATERIAL FOR A PERIOD OF TWELVE (12) MONTHS FROM DATE OF STARTUP, PROVIDED THAT STARTUP IS COMPLETED WITHIN SIX (6) MONTHS OF SHIPMENT AND THE START-UP REPORT IS FURNISHED TO THE MANUFACTURER WITHIN THIRTY (30) DAYS OF STARTUP.
- (B) THE BOILER MANUFACTURER SHALL WARRANT THE BOILER'S FUEL BURNER FOR A PERIOD OF FIVE (5) YEARS FROM DATE OF STARTUP, PROVIDED THAT STARTUP IS COMPLETED WITHIN SIX (6) MONTHS OF SHIPMENT AND THE START-UP REPORT IS FURNISHED TO THE MANUFACTURER WITHIN THIRTY (30) DAYS OF STARTUP.
- (C) THE BOILER MANUFACTURER SHALL WARRANT THE BOILER'S HEAT EXCHANGER FOR A PERIOD OF TEN (10) YEARS FROM DATE OF STARTUP, PROVIDED THAT STARTUP IS COMPLETED WITHIN SIX (6) MONTHS OF SHIPMENT AND THE START-UP REPORT IS FURNISHED TO THE MANUFACTURER WITHIN THIRTY (30) DAYS OF STARTUP.
- (D) THE BOILER MANUFACTURER SHALL ALSO WARRANT THE BOILER'S HEAT EXCHANGER AGAINST FAILURE DUE TO THERMAL SHOCK FOR A PERIOD OF TEN (10) YEARS FROM DATE OF STARTUP, PROVIDED THAT STARTUP IS COMPLETED WITHIN SIX (6) MONTHS OF SHIPMENT AND THE START-UP REPORT IS FURNISHED TO THE MANUFACTURER WITHIN THIRTY (30) DAYS OF STARTUP.

1.07 CERTIFICATION

- (A) MANUFACTURER'S CERTIFICATION - THE BOILER MANUFACTURER SHALL CERTIFY THE FOLLOWING:
 - 1. THE PRODUCTS AND SYSTEMS FURNISHED ARE IN STRICT COMPLIANCE WITH THE SPECIFICATIONS.
 - 2. THE BOILER, BURNER AND OTHER ASSOCIATED MECHANICAL AND ELECTRICAL EQUIPMENT HAVE ALL BEEN PROPERLY COORDINATED AND INTEGRATED TO PROVIDE A COMPLETE AND OPERABLE BOILER.

3. THE BOILER SHALL BE IN COMPLIANCE WITH ANSI Z21.13 / CSA 4.9 (LATEST EDITION).
4. THE BOILER SHALL BE IN COMPLIANCE WITH ASME SECTION IV (LATEST EDITION).
5. THE BOILER SHALL BE IN COMPLIANCE WITH ASME CSD-1 (LATEST EDITION).
6. THE BOILER'S H-3 FORM SHALL BE REGISTERED WITH THE NATIONAL BOARD.
7. THE BOILER SHALL BE AHRI CERTIFIED FOR AT LEAST 92% EFFICIENCY BASED ON OPERATING CONDITIONS SPECIFIED FOR TESTING UNDER BTS-2000.

(B) CONTRACTOR'S CERTIFICATION - THE INSTALLING CONTRACTOR SHALL CERTIFY THE FOLLOWING:

1. THE PRODUCTS AND SYSTEMS INSTALLED ARE IN STRICT COMPLIANCE WITH THE SPECIFICATIONS AND ALL APPLICABLE LOCAL AND/OR STATE CODES.
2. THE SPECIFIED FIELD TESTS HAVE BEEN SATISFACTORILY PERFORMED BY A FACTORY AUTHORIZED STARTUP AGENT.
3. THE EQUIPMENT FURNISHED CONTAINS INTER-CHANGEABLE PARTS WITH THE SPECIFIED EQUIPMENT SO THAT ALL MAJOR EQUIPMENT PARTS CAN BE OBTAINED FROM THE SPECIFIED MANUFACTURER.

PART 2 - PRODUCT

2.01 MANUFACTURERS

(A) FURNISH AND INSTALL FACTORY "PACKAGED" LOW PRESSURE HOT WATER BOILER(S) AS MANUFACTURED BY HARSCO INDUSTRIAL, PATTERSON-KELLEY OR AS APPROVED AND ACCEPTED BY THE ENGINEER.

(B) EACH FACTORY "PACKAGED" BOILER SHALL BE COMPLETE WITH ALL COMPONENTS AND ACCESSORIES NECESSARY FOR A COMPLETE AND OPERABLE BOILER AS HEREINAFTER SPECIFIED. EACH BOILER SHALL BE FURNISHED FACTORY ASSEMBLED WITH THE REQUIRED WIRING AND PIPING AS A SELF-CONTAINED UNIT. EACH BOILER SHALL BE READILY TRANSPORTED AND READY FOR INSTALLATION.

(C) ALL "APPROVED EQUAL" OR "APPROVED ALTERNATE" BOILERS MUST DEMONSTRATE COMPLIANCE WITH THE REQUIREMENTS OF THIS SPECIFICATION.

2.02 COMPONENTS

(A) CABINET ENCLOSURE

1. EACH BOILER SHALL FEATURE A FULLY ASSEMBLED CABINET ENCLOSURE FABRICATED FROM CARBON STEEL OR ALUMINUM SHEET METAL (MINIMUM 18 GAUGE) WITH POWDER COAT FINISH.
2. THE BOILER'S CABINET ENCLOSURE SHALL NOT EXCEED 28" IN WIDTH AND THE COMPLETED BOILER SHALL FIT THROUGH A STANDARD 32" WIDE DOORWAY.
3. THE BOILER'S CABINET ENCLOSURE SHALL FEATURE REMOVABLE ACCESS PANELS / DOORS WITH QUARTER-TURN TYPE LATCHES THAT CAN BE EASILY OPENED WITH A COIN OR FLATHEAD SCREWDRIVER.
4. THE BOILER'S CABINET ENCLOSURE SHALL ELIMINATE THE USE OF REFRACTORY OR OTHER INSULATING MATERIALS OUTSIDE THE HEAT EXCHANGER AND THE ENCLOSURE'S SURFACE TEMPERATURE SHALL NOT EXCEED 20°F ABOVE AMBIENT TEMPERATURE.

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5. THE BOILER'S CABINET ENCLOSURE SHALL PROMINENTLY DISPLAY ALL REQUIRED SAFETY, INSTRUCTION, COMPLIANCE AND FACTORY RUNOUT LABELS.

(B) HEAT EXCHANGER

1. EACH WATER-TUBE BOILER SHALL CONTAIN AN ASME SECTION IV HEAT EXCHANGER WITH AN "H" STAMP DESIGNED FOR A MAXIMUM ALLOWABLE WORKING PRESSURE OF 160 PSIG AND A MAXIMUM ALLOWABLE TEMPERATURE OF 210°F.
2. THE COMPLETED HEAT EXCHANGER SHALL CONSIST OF WELDED 316L SS HELICAL WATER TUBES.
3. EACH COMPLETED HEAT EXCHANGER SHALL INCLUDE AN INTEGRAL STAINLESS STEEL CONDENSATE PAN/COLLECTOR, CONDENSATE DRAIN, REMOVABLE BURNER ASSEMBLY, INLET TEMPERATURE SENSOR, OUTLET TEMPERATURE SENSOR, FLUE GAS TEMPERATURE SENSOR, HEAT EXCHANGER TEMPERATURE SENSOR, AUTOMATIC AIR VENT, THERMOWELL FOR HIGH TEMPERATURE LIMIT CAPILLARY, LOW WATER CUTOFF PROBE OR FLOW SWITCH, AND ALL NECESSARY ASSEMBLY HARDWARE.
4. EACH STAINLESS STEEL HEAT EXCHANGER SHALL BE DESIGNED TO MAINTAIN WATER TURBULENCE AT THE FULL PUBLISHED RANGE OF ACCEPTABLE FLOW RATES AT VARIOUS BOILER CONDITIONS AS DESCRIBED BELOW:
 - A. THE MAXIMUM ALLOWABLE FLOW RATE WILL GENERATE A 20°F ΔT WHEN THE BOILER IS OPERATING AT FULL CAPACITY.
 - B. THE MINIMUM ALLOWABLE FLOW RATE WILL GENERATE A 60°F ΔT WHEN THE BOILER IS OPERATING AT FULL CAPACITY.
5. THE BOILER'S COMPLETED HEAT EXCHANGER SHALL BE CAPABLE OF OPERATING WITH A MINIMUM OUTLET WATER TEMPERATURE OF 42°F.
6. EACH HEAT EXCHANGER MUST BE HYDROSTATICALLY TESTED BY THE MANUFACTURER TO A MINIMUM OF 1-1/2 TIMES THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR A MINIMUM OF 5 MINUTES. DURING THIS HYDROSTATIC PRESSURE TEST, THE OPERATOR WILL INSPECT THE PRESSURE GAUGE AND VISUALLY VERIFY THERE ARE NO WATER LEAKS.

(C) MAIN GAS TRAIN

1. BOILERS CONFIGURED FOR SINGLE FUEL OPERATION SHALL BE EQUIPPED WITH AN INTEGRAL MAIN GAS VALVE TRAIN CAPABLE OF BURNING NATURAL GAS.
2. EACH SINGLE FUEL GAS VALVE TRAIN SHALL INCLUDE AT LEAST THE FOLLOWING:
 - A. ONE (1) UPSTREAM MANUAL SHUTOFF VALVE FOR FIELD-CONNECTION.
 - B. ONE (1) COMBINATION AIR-GAS RATIO CONTROL AND SAFETY SHUTOFF VALVE WITH DUAL SOLENOIDS (IN-SERIES) THAT CAN BE INDEPENDENTLY ENERGIZED FOR LEAK TESTING AND INTEGRATED INTO A SINGLE BODY DESIGN. THE COMBINATION GAS VALVE SHALL OPERATE AS A "ZERO GOVERNOR" AND CONTROL TO A NEUTRAL GAS PRESSURE INSIDE THE GAS VALVE.
 - C. ONE (1) LOW GAS PRESSURE SWITCH (MANUAL RESET).
 - D. ONE (1) HIGH GAS PRESSURE SWITCH (MANUAL RESET).

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E. TWO (2) GAS PRESSURE TEST PORTS.

F. ONE (1) DOWNSTREAM MANUAL SHUTOFF VALVE.

3. THE MAIN GAS VALVE TRAIN SHALL BE FACTORY ASSEMBLED, PIPED, AND WIRED AND ALLOW FOR OPERATION AT FULL RATED BOILER CAPACITY FROM 3.5" W.C. UP TO THE MAXIMUM INLET GAS PRESSURE OF 14.0" W.C.

4. IF THE SUPPLIED GAS PRESSURE EXCEEDS 14" W.C., THE CONTRACTOR SHALL SUPPLY A SUITABLE INTERMEDIATE GAS PRESSURE REGULATOR OF THE LOCK-UP TYPE TO REDUCE THE GAS PRESSURE TO ACCEPTABLE LEVELS.

(D) POWER BURNER

1. THE BOILER MANUFACTURER SHALL FURNISH AN INTEGRAL POWER TYPE FUEL BURNER WITH EACH BOILER. THE COMPLETE POWER FUEL BURNER ASSEMBLY SHALL CONSIST OF A GAS BURNER, COMBUSTION AIR BLOWER, MAIN GAS VALVE TRAIN, AND IGNITION SYSTEM. THE BURNER MANUFACTURER SHALL FULLY COORDINATE THE BURNER DESIGN WITH THE BOILER'S HEAT EXCHANGER AND THE BOILER CONTROL SYSTEM IN ORDER TO PROVIDE THE REQUIRED CAPACITIES, EFFICIENCIES, AND PERFORMANCE SPECIFIED. BOILERS SHIPPED WITHOUT A POWER BURNER AND FIELD-EQUIPPED WITH A 3RD PARTY POWER BURNER ARE NOT ACCEPTABLE.

2. EACH BURNER SHALL BE INSTALLED HORIZONTALLY INSIDE THE COMBUSTION CHAMBER WITH COMBUSTION GASES FLOWING DOWNWARD THROUGH THE HEAT EXCHANGER. THE BURNER SHALL CONSIST OF A STAINLESS STEEL FLANGE AND PERFORATED STAINLESS STEEL CYLINDER.

3. EACH BOILER SHALL BE EQUIPPED WITH DIRECT SPARK IGNITION. MAIN FLAME SHALL BE MONITORED AND CONTROLLED BY A FLAME ROD / IONIZATION PROBE (RECTIFICATION) SYSTEM.

(E) BOILER SAFETY AND TRIM DEVICES

1. THE BOILER MANUFACTURER SHALL FURNISH AND TEST THE FOLLOWING SAFETY AND TRIM DEVICES WITH EACH BOILER:

A. SAFETY RELIEF VALVE SHALL BE PROVIDED IN COMPLIANCE WITH THE ASME CODE. CONTRACTOR IS REQUIRED TO PIPE THE RELIEF VALVE DISCHARGE PIPING TO AN ACCEPTABLE DRAIN.

B. WATER PRESSURE/TEMPERATURE GAUGE.

C. LOW WATER / FLOW CUTOFF SWITCH.

D. MANUAL RESET HIGH LIMIT WATER TEMPERATURE CONTROLLER.

E. OPERATING TEMPERATURE CONTROL TO CONTROL THE SEQUENTIAL OPERATION OF THE BURNER.

F. HIGH AND LOW GAS PRESSURE SWITCHES.

G. FLAME ROD / IONIZATION PROBE FLAME DETECTION.

2. THE BOILER MANUFACTURER SHALL PROVIDE A CSD-1 FORM IDENTIFYING EACH SAFETY AND TRIM DEVICE.

3. THE BOILER SHALL BE CAPABLE OF INTERFACING WITH THE FOLLOWING EXTERNAL SAFETY DEVICES:

- A. AUXILIARY LOW WATER CUTOFF DEVICE.
- B. COMBUSTION AIR DAMPER END LIMIT SWITCH.
- C. EMERGENCY STOP (E-STOP) SWITCH.
- D. EXTERNAL SAFETY DEVICE W/ CONTACT CLOSURE.

(F) BOILER CONTROL SYSTEM

- 1. EACH BOILER SHALL BE PROVIDED WITH ALL NECESSARY CONTROLS, ALL NECESSARY PROGRAMMING SEQUENCES, AND ALL SAFETY INTERLOCKS. EACH BOILER CONTROL SYSTEM SHALL BE PROPERLY INTERLOCKED WITH ALL SAFETIES.
- 2. EACH BOILER SHALL BE PROVIDED WITH A "FULL MODULATING" FIRING CONTROL SYSTEM WHEREBY THE FIRING RATE IS INFINITELY PROPORTIONAL AT ANY FIRING RATE BETWEEN LOW FIRE AND HIGH FIRE AS DETERMINED BY THE PULSE WIDTH MODULATION INPUT CONTROL SIGNAL. BOTH FUEL INPUT AND AIR INPUT MUST BE SEQUENCED IN UNISON TO THE APPROPRIATE FIRING RATE WITHOUT THE USE OF MECHANICAL LINKAGE.
- 3. THE BOILER'S CONTROL SYSTEM SHALL PROVIDE THE MINIMUM CAPABILITIES:
 - A. 7" COLOR TOUCHSCREEN DISPLAY WITH ONE OR MORE USB PORTS.
 - B. STANDARD ON-BOARD ETHERNET PORT FOR WIRED INTERNET CONNECTIVITY AND EMBEDDED WIRELESS DRIVER FOR OPTIONAL WIRELESS INTERNET CONNECTIVITY TO REMOTE MONITORING AND SOFTWARE UPDATE SERVICES.
 - C. PARAMETER UPLOADS AND DOWNLOADS VIA EXTERNAL USB FLASH DRIVE.
 - D. SOFTWARE UPDATES VIA EXTERNAL USB FLASH DRIVE.
 - E. CAPTURE SCREEN SHOTS FROM THE CONTROL'S DISPLAY BY SAVING DIGITAL IMAGE FILES TO EXTERNAL USB FLASH DRIVE.
 - F. LOCAL REPRESENTATIVE SCREEN CAN BE PROGRAMMED TO PROVIDE CONTACT INFORMATION FOR THE LOCAL BOILER MANUFACTURER'S REPRESENTATIVE.
 - G. PROGRAMMABLE RELAY OUTPUTS FOR DIRECT CONTROL OF PUMPS, CONTROL VALVES, DAMPERS AND OTHER AUXILIARY DEVICES.
 - H. MULTIPLE BOILER "CASCADE" NETWORK UP TO 24 BOILERS WITHOUT ANY EXTERNAL CONTROL PANEL. THE INSTALLATION OF EXTERNAL SEQUENCING CONTROL PANELS IS NOT ACCEPTABLE.
 - I. AUTOMATIC HYBRID SYSTEM CONTROL FOR MULTIPLE BOILER "CASCADE" SYSTEMS WITH BOTH CONDENSING AND NON-CONDENSING BOILERS. THIS CONTROL LOGIC PRIORITIZES CONDENSING BOILERS AT LOW WATER TEMPERATURES AND PRIORITIZES NON-CONDENSING BOILERS AT HIGH WATER TEMPERATURES.

- J. AUXILIARY BOILER RELAY FOR MULTIPLE BOILER "CASCADE" SYSTEMS WHICH CAN BE USED TO ENABLE A 3RD PARTY BOILER PLATFORM IN THE EVENT THE "CASCADE" SYSTEM IS UNABLE TO SATISFY THE HEATING LOAD.
 - K. PROGRAMMABLE BOILER AND SYSTEM PUMP CONTROL FOR MULTIPLE BOILER "CASCADE" SYSTEMS INSTALLED IN A PRIMARY-SECONDARY PIPING ARRANGEMENT.
 - L. PROGRAMMABLE CONTROL VALVE LOGIC FOR MULTIPLE BOILER "CASCADE" SYSTEMS INSTALLED IN A PRIMARY-ONLY PIPING ARRANGEMENT.
 - M. INTEGRATION WITH EXTERNAL BUILDING MANAGEMENT SYSTEMS (BMS).
 - N. HARDWIRE INTEGRATION WITH BUILDING MANAGEMENT SYSTEMS (BMS) VIA 4-20MA ANALOG CONTROL SIGNAL FOR TEMPERATURE OR FIRING RATE CONTROL.
 - O. INTUITIVE "SETUP WIZARDS" ASK THE USER A SERIES OF QUESTIONS AND ALLOW FOR STEP-BY-STEP CONFIGURATION OF THE BOILER CONTROL.
 - P. ON-SCREEN ERROR NOTIFICATIONS WITH A COMPREHENSIVE DESCRIPTION OF ALL ALARM CONDITIONS AND SEVERAL TROUBLESHOOTING STEPS.
 - Q. AUTOMATIC FLUE GAS TEMPERATURE AND OUTLET (SUPPLY) TEMPERATURE COMPENSATION TO PREVENT OVER-FIRING OF THE BOILER EQUIPMENT.
 - R. AUTOMATIC DIFFERENTIAL TEMPERATURE COMPENSATION TO PREVENT OVER-FIRING OF THE BOILER EQUIPMENT IN A LOW FLOW CONDITION.
 - S. AUTOMATICALLY ADJUST THE TEMPERATURE SET POINT AND SHUTDOWN THE BOILER BASED ON THE OUTDOOR AIR TEMPERATURE CONDITIONS.
 - T. NIGHT SETBACK FUNCTIONALITY VIA EXTERNAL POINT OF CLOSURE (OR BMS INTEGRATION) FOR UNIQUE "OCCUPIED" AND "UNOCCUPIED" TEMPERATURE SETPOINT VALUES.
 - U. MAINTAIN SINGLE TEMPERATURE SET POINT WITH A MINIMUM OUTLET (SUPPLY) WATER TEMPERATURE OF 42°F UP TO A MAXIMUM OUTLET (SUPPLY) WATER TEMPERATURE OF 194°F.
 - V. ALARM RELAY OUTPUT TO ANNOUNCE ALARM CONDITIONS WHICH REQUIRE MANUAL RESET.
 - W. PROGRAMMABLE LOW FIRE DELAY TO PREVENT EXCESSIVE SHORT-CYCLING OF THE BOILER EQUIPMENT.
 - X. LOCAL MANUAL OPERATION.
4. THE BOILER CONTROL SYSTEM SHALL BE CAPABLE OF INTERFACING WITH THE FOLLOWING EXTERNAL CONTROL DEVICES:
- A. BUILDING MANAGEMENT SYSTEM.
 - B. EXTERNAL HEADER TEMPERATURE SENSOR (12KΩ).
 - C. OUTDOOR AIR TEMPERATURE SENSOR (12KΩ).

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PART 3 - EXECUTION

3.01 INSTALLATION

- (A) INSTALLATION SHALL BE PERFORMED BY THE CONTRACTOR IN ACCORDANCE WITH THE REQUIREMENTS OF THE APPLICABLE CODES. CONTRACTOR SHALL REVIEW THE BOILER AND INSTALLATION FOR COMPLIANCE WITH REQUIREMENTS AND/OR ISSUES THAT MAY AFFECT BOILER PERFORMANCE. INSTALLATION SHOULD NOT PROCEED UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED.
- (B) THE CONTRACTOR SHALL MOUNT THE EQUIPMENT AS DESCRIBED BELOW:
1. INSTALL BOILERS ON CAST-IN-PLACE CONCRETE EQUIPMENT BASE IN COMPLIANCE WITH THE REQUIREMENTS FOR EQUIPMENT BASES AND FOUNDATION SPECIFIED IN SECTION 03 30 00 "CAST-IN-PLACE CONCRETE."
- (C) THE CONTRACTOR SHALL INSTALL GAS-FIRED BOILERS IN ACCORDANCE WITH NFPA 54/ANSI Z223.1.
- (D) THE CONTRACTOR SHALL INSTALL GAS-FIRED BOILERS IN ACCORDANCE WITH NBIC – PART 1 (INSTALLATION), OR ANOTHER INSTALLATION CODE HAVING LOCAL JURISDICTION.
- (E) THE CONTRACTOR SHALL ASSEMBLE AND INSTALL ANY EXTERNAL BOILER SAFETY/TRIM DEVICES.
- (F) THE CONTRACTOR SHALL INSTALL ANY ELECTRICAL DEVICES FURNISHED WITH THE BOILER, BUT NOT SPECIFIED TO BE FACTORY-MOUNTED.
- (G) THE CONTRACTOR SHALL INSTALL CONTROL WIRING TO FIELD MOUNTED ELECTRICAL DEVICES IN ACCORDANCE WITH THE REQUIREMENTS OF NFPA 70.
- (H) THE CONTRACTOR SHALL INSTALL ELECTRICAL (POWER) WIRING TO THE BOILER IN ACCORDANCE WITH THE REQUIREMENTS OF NFPA 70.

3.02 CONNECTIONS

- (A) GAS PIPING
1. EACH BOILER SHALL BE PROVIDED WITH ALL NECESSARY GAS CONNECTIONS. REFER TO THE BOILER'S SPECIFICATION SHEET OR MANUAL FOR CONNECTION SIZES.
 2. INSTALL GAS PIPING IN ACCORDANCE WITH NFPA 54/ANSI Z223.1.
- (B) HYDRONIC PIPING
1. EACH BOILER SHALL FEATURE 2" STEEL PIPING INLET (SUPPLY) AND OUTLET (RETURN) CONNECTIONS. THE STEEL PIPING SHALL TERMINATE WITH 2" GROOVED CONNECTIONS.
 2. CHECK MANUFACTURER'S INSTALLATION MANUAL FOR CLEARANCE DIMENSIONS AND INSTALL PIPING THAT WILL ALLOW FOR SERVICE AND EASE OF MAINTENANCE.
 3. INSTALL PIPING FROM EQUIPMENT DRAIN CONNECTION TO NEAREST FLOOR DRAIN. PIPING SHALL BE AT LEAST FULL SIZE OF CONNECTION AND ADHERE TO PROPER CODES FOR NEUTRALIZATION.

(C) EXHAUST VENTING

1. THE BOILERS SHALL BE DUAL CERTIFIED AS CATEGORY II OR IV APPLIANCES AND ARE CAPABLE OF OPERATING WITH SLIGHTLY NEGATIVE TO SLIGHTLY POSITIVE EXHAUST VENT PRESSURE, AND THE VENT GAS TEMPERATURE IS LIKELY TO CAUSE CONDENSATE PRODUCTION IN THE VENT.
2. INSTALL THE EXHAUST/FLUE VENTING SYSTEM IN ACCORDANCE WITH NFPA 54/ANSI Z223.1 AND PER THE MANUFACTURER'S RECOMMENDATIONS IN THE INSTALLATION MANUAL.

(D) AIR INLET

1. THE BOILERS SHALL BE CERTIFIED FOR DIRECT VENT / SEALED COMBUSTION INSTALLATIONS WHERE THE COMBUSTION AIR IS SUPPLIED DIRECTLY TO THE BOILER THROUGH DUCTWORK.
2. INSTALL THE AIR INLET SYSTEM IN ACCORDANCE WITH NFPA 54/ANSI Z223.1 AND PER THE MANUFACTURER'S RECOMMENDATIONS IN THE INSTALLATION MANUAL.

(E) ELECTRICAL

1. INSTALL AN EXTERNAL DISCONNECT AND OVERLOAD PROTECTION FOR EACH BOILER IN ACCORDANCE WITH THE REQUIREMENTS OF NFPA 70.
2. THE VOLTAGE REQUIREMENTS FOR THE BOILERS SHALL BE 110-120VAC, SINGLE PHASE, 60HZ.

END OF SECTION 23 52 16 – CONDENSING BOILERS

SECTION 23 64 00 - CONDENSING UNIT WITH EVAPORATOR (WATER CHILLER)

PART 1 - GENERAL

1.01 WORK INCLUDED

- (A) Extent of condensing unit and evaporator work required by this section is indicated on drawings and schedules and by requirements of this section.
- (B) Types of condensing unit and evaporator specified in this section include the following:
1. Air-cooled condensing units.
 2. Plate and frame evaporator.
- (C) Electrical Coordination
1. Provide the following electrical work as work of this section, in compliance with electrical specifications:
 - A. Control and interlock wiring between operating controls, indicating devices and chiller condensing unit temperature control panels.
 - B. Unit mounted magnetic starters.
 2. See Mechanical/Electrical Schedule on drawings for further clarification.

1.02 QUALITY ASSURANCE

- (A) Manufacturer's Qualifications: Firms regularly engaged in manufacture of condensing unit and evaporator, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- (B) Codes and Standards:
1. ARI Compliance: Provide capacity ratings for condensing units in accordance with Air-Conditioning and Refrigeration Institute (ARI) Standard 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".
 2. ASHRAE Compliance: Construct refrigeration system of condensing unit and evaporator in accordance with American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard ASHRAE 15 "Safety Code for Mechanical Refrigeration".
 3. ASHRAE Compliance: Condensing units shall meet or exceed the minimum COP/Efficiency levels as prescribed in ASHRAE 90A "Energy Conservation in New Building Design".
 4. UL Compliance: Provide condensing units, which are listed by Underwriters Laboratories (UL) and have UL Label affixed.

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CONDENSING UNIT WITH
EVAPORATOR (WATER
CHILLER)
23 64 00 - 1

1.03 SUBMITTALS

- (A) Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), dimensions, required clearances, and methods of assembly of components, furnished specialties and accessories; and installation and start-up instructions.
- (B) Wiring Diagrams: Submit ladder-type wiring diagrams for power and control wiring required for final installation of condensing units and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- (C) Operation and Maintenance Data: Submit maintenance data and parts list for each condensing unit and evaporator, control, and accessory; including "Trouble-Shooting" Maintenance Guide; plus servicing, and preventive maintenance procedures and schedule. Include this data and product data in Maintenance Manual.
- (D) Refrigerant Piping Schematic: Condensing unit manufacturer shall prepare and submit a customized refrigerant piping schematic for each condensing unit application. Schematic shall include pipe sizing, riser details and all required refrigerant accessories.

1.04 DELIVERY, STORAGE AND HANDLING

- (A) Handle condensing unit, evaporator and components carefully to prevent damage. Follow manufacturer's written instructions for rigging. Replace damaged condensing unit and evaporator or components.
- (B) Store condensing unit and evaporator and components in clean, dry place off the ground. Protect from weather water and physical damage.

1.05 SPECIAL PROJECT WARRANTY

- (A) Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only and does not include labor for removal and reinstallation.

1. Warranty Period: Five (5) years from date of substantial completion.

PART 2 - PRODUCTS

2.01 AIR-COOLED CONDENSING UNITS

- (A) General: Provide factory-assembled and tested, air-cooled condensing units, consisting of casing, compressors, condensers coils, condenser fans and motors and unit controls. Provide capacities and electrical characteristics as scheduled.
- (B) Unit Casings: Design for outdoor installation and provide weather protection for components and controls. Provide removable panels for required access to compressors, controls, condenser fans, motors and drives. Additional features include:
 - 1. Galvanized or zinc-coated steel for exposed casing surfaces, treated, and finished with manufacturer's standard paint coating.

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CONDENSING UNIT WITH
EVAPORATOR (WATER
CHILLER)

2. Lifting lugs to facilitate rigging of units.
 3. Metal grilles, factory-installed, for protection of condenser coil during shipping, installation, and operation.
 4. Control panel door, hinged and gasketed.
- (C) Compressor: The compressors shall be sealed hermetic, scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads. The compressors shall be equipped with an internal module providing compressor protection and communication capability.
1. Install crankcase heater in well within crankcase.
- (D) Refrigeration Circuits: Each unit shall have a minimum of two (2) independent refrigerant circuits, with one or two compressors per circuit. Each refrigerant circuit shall include a compressor suction and discharge service valve, liquid line shutoff valve, removable core filter drier, liquid line sight glass with moisture indicator, charging port and an electronic expansion valve. Fully modulating compressors and electronic expansion valves shall be provided to provide variable capacity modulation over the entire operating range.
- (E) Unit Controls: All unit controls shall be housed in a weathertight enclosure with removable plates to allow for customer connection of power wiring and remote interlocks. All controls, including sensors, shall be factory mounted and tested prior to shipment. All cataloged units shall be UL Listed.
1. Microcomputer controls shall be provided to all control functions including start-up and shut-down, leaving chilled water temperature control, compressor and electronic expansion valve modulation, fan sequencing, anti-recycle logic, automatic lead/lag compressor starting and load limiting.
 2. The unit control module, utilizing Adaptive control microprocessor shall automatically take action to avoid unit shutdown due to abnormal operating conditions associated with low refrigerant temperature, high condensing temperature motor current overload. Should the abnormal operating condition continue until a protective limit is violated, the unit will be shut down.
 3. Unit protective functions shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low refrigerant pressure, high refrigerant pressure, reverse rotation, compressor starting and running over current, phase loss, phase imbalance, phase reversal and loss of oil flow.
 4. A menu driven digital display shall indicate over 20 operating data points including chilled water setpoint, current limit setpoint, leaving chilled water temperature, evaporator and condenser refrigerant pressures and temperatures. Over six (6) diagnostic checks shall be made and displayed when a problem is detected. The digital display can be read and advanced on the unit without opening any control panel doors.
 5. Single point power connections to include main three phase power and unit shall be equipped with control power transformer to provide 115-volt control power.
 6. In addition to controlling chiller operation from a location within the building, the remote display shall provide the capability to monitor unit alarms and diagnostics. Only one twisted-pair wire shall be required between the chiller and the remote display. A digital cycle counter and hour meter for each compressor, under/over voltage protection, remote alarm and compressor run indication contacts and a percentage of volts display shall be provided.

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**CONDENSING UNIT WITH
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- (F) Condenser Coils: The condenser coil shall be microchannel design and shall have a series of flat tubes containing multiple, parallel flow microchannels layered between the refrigerant manifolds. Tubes shall be 9153 aluminum alloy. Tubes made of 3102 alloy or other alloys of lower corrosion resistance shall not be accepted. Coils shall consist of a two-pass arrangement. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils shall withstand 1000+ hour acidified synthetic sea water fog (SWAAT) test (ASTM G85-02) at 120°F (49°C) with 0% fin loss and develop no leaks.
- (G) Condenser Fans and Motors: Condenser fans shall be propeller type arranged for vertical air discharge and individually driven by direct drive fan motors. Fan blades shall be a painted steel or unpainted aluminum. Each fan shall be protected by a heavy-gauge fan guard.
1. Condenser fan motors shall be TEAO type with permanently lubricated ball bearings, inherent overload protection, three-phase, direct drive, 1140 rpm. Each fan section shall be partitioned to avoid cross circulation.
- (H) Manufacturer: Subject to compliance with requirements, provide air-cooled condensing units of one (1) of the following:
1. Daikin Applied.
 2. Trane Company (The).
 3. United Technologies Corp.; Carrier Corporation Subsidiary.
 4. York; Div. of York International.

2.02 EVAPORATOR

- (A) Evaporator: The evaporator shall be a compact, high efficiency, dual circuit, brazed plate-to-plate type heat exchanger consisting of parallel stainless steel plates. Vent and drain connections shall be provided in the inlet and outlet chilled water piping by the installing contractor. Evaporators shall be designed and constructed according to, and listed by, Underwriters Laboratories (UL).

2.03 CHILLER ACCESSORIES

- (A) Refrigerant Detection Device: Chiller manufacturer shall supply a refrigerant detection device and alarm capable of monitoring at a level of 10 PPM.
- (B) Low Ambient Control: Provide fan cycling control to allow unit operation down to 0°F.
- (C) Ground Fault Protection: Factory installed circuit breaker to protect equipment from damage from line-to-ground fault currents less than those required for conductor protection.
- (D) Phase loss with under/over voltage protection and with LED indication of the fault type to guard against compressor motor burnout.
- (E) BAS interface module to provide interface with the BACnet MSTP protocol.
- (F) Compressor Sound Reduction: Acoustic reduction blankets shall be factory installed on each compressor.
- (G) The following accessories are to be included:
1. Rubber-in-shear vibration isolators for field installation.

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CONDENSING UNIT WITH EVAPORATOR (WATER CHILLER)

2. Factory-mounted thermal dispersion type flow switch.
3. Wye strainer, to be installed at the evaporator inlet and sized for the design flow rate with blowdown valve and Victaulic couplings.
4. 115V GFI convenience outlet.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Verify that areas condensing unit and evaporator shall be installed, have adequate service and installation space. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- (A) General: Install condensing units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated and maintain manufacturer's recommended clearances.
- (B) Support: Install ground-mounted condensing unit on 4-inch thick reinforced concrete pad, with pad supplied by Mechanical Contractor. Anchor unit to pad using inserts or anchor bolts. Install evaporator on mechanical equipment stand, constructed in accordance with NRCA Handbook. Anchor unit to structural frame with removable fasteners.
- (C) Air-Cooled Condensing Units: Connect refrigerant piping to unit in accordance with customized refrigerant piping diagram to be provided by chiller manufacturer and in accordance with—Refrigerant Piping Specifications. Maintain required access to unit.
1. Install furnished field-mounted accessories.
- (D) Evaporator Chilled Water Piping: Refer to Division 23 Section Hydronic Piping and Specialties. Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, flexible pipe connector, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, thermometer, flexible pipe connection, pressure gage, and union or flange. Provide drain valves and vent cocks for each water box.

3.03 ELECTRICAL CONNECTIONS

- (A) Install and connect remote flow switches and remote chiller control panel.
- (B) Ground Equipment: Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

- (A) Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise field assembly of components and installation of chillers, including piping and electrical connections and to report results in writing.
1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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CONDENSING UNIT WITH
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3.05 CLEANING

- (A) Clean finishes to remove dust and dirt.
- (B) Touch up scratches in unfinished surfaces to restore corrosion resistance.
- (C) Touch up scratches in finished surfaces to restore finish.

3.06 COMMISSIONING

- (A) Energize chiller and operate controls and safeties.
- (B) Lubricate rotating parts.
- (C) Verify that motor amperage conforms to manufacturer's data.
- (D) Start chiller and verify performance. Demonstrate operation to Owner.

3.07 DEMONSTRATION

- (A) Startup Services: Engage a factory-authorized service representative to provide startup services and to demonstrate and train Owner's maintenance personnel as specified below.
 - 1. Train Owner's maintenance personnel on procedures and schedules related to startup, shutdown, troubleshooting, servicing and preventive maintenance.
 - 2. Review data in the operation and maintenance manuals.
 - 3. Schedule training with Owner, through Architect, with at least seven (7) days' advance notice.

END OF SECTION 23 64 00 – CONDENSING UNIT AND EVAPORATOR (WATER CHILLER)

SECTION 23 72 00 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section Includes:

1. Packaged energy recovery units (without heating or cooling).

1.03 SUBMITTALS

- (A) Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

- (B) Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

- (C) Closeout Submittals:

1. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.04 ELECTRICAL COORDINATION

- (A) Provide the following electrical work as work of this section, in compliance with electrical specifications:

1. Control and interlock wiring between operating controls, indicating devices and unit control panels.

- (B) See Mechanical/Electrical Coordination Schedule on drawings for further clarification.

1.05 QUALITY ASSURANCE

- (A) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- (B) AHRI Compliance:

1. Capacity ratings for air-to-air recovery equipment shall comply with AHRI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."

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2. Capacity ratings for air coils shall comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."

(C) ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1-2004, Section 5 – "Systems and Equipment" and Section 7 – "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

(D) NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

(E) UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Non-ducted Heat Recovery Ventilators."
2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.06 COORDINATION

- (A)** Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression systems, and partition assemblies.
- (B)** Coordinate sizes and locations of concrete bases with actual equipment provided.
- (C)** Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.07 WARRANTY

- (A)** Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Packaged Energy Recovery Units: Two years.
 2. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

1.08 EXTRA MATERIALS

- (A)** Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters: One set of each type of filter specified.

PART 2 - PRODUCTS

2.01 PACKAGED ENERGY RECOVERY UNITS (WITHOUT HEATING OR COOLING)

(A) Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Addison.
2. Carnes.
3. Des Champs Technologies.
4. Desert Air.
5. Engineered Air.
6. Govern Air.
7. Greenheck.
8. Loren Cook Company.
9. Mitsubishi.
10. RenewAire LLC.
11. Reznor.
12. SEMCO Incorporated.
13. Soler & Palau.
14. Trane.
15. Venmar CES Inc.

(B) General:

1. Factory assembled and tested unit designed specifically for air to air energy recovery application. Consisting of fans, energy recovery wheel, controls, filters and dampers all incorporated into a single factory assembled package.
2. Unit shall be completely factory assembled, wired, and shipped in one piece by the manufacturer including all standard items and optional items.
3. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
4. Units shall be UL listed and bear the UL label. Energy transfer ratings shall be in accordance with ASHRAE Standard 84. The ERV units shall bear the AMCA Certified Rating Seals for air performance.

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- (C) Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 1-inch thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs. All components shall be easily accessible through access doors for both exhaust and supply compartments. Energy recovery wheel shall be mounted in a slide-out track for ease of inspection, removal and cleaning. Provide weatherproof hood or louver, with damper for exhaust and supply.
- (D) Energy Recovery Device: Fixed-plate heat exchanger.
- (E) Fans: Blower wheels shall be statically and dynamically balanced. Motors shall be permanently lubricated, heavy-duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast type, keyed and securely attached to the wheel and motor shafts. Blowers shall be forward curved type and enable independent balancing of exhaust and supply airflows by providing separate motors for exhaust and supply blowers with adjustable sheaves.
- (F) Filters:
1. Comply with NFPA 90A.
 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 3. Extended-Surface, Disposable Panel Filters:
 - A. Minimum Merv: 8 according to ASHRAE 52.2.
- (G) Frost Protection: Unit shall be furnished with timed defrost system with integral recirculation damper. Factory-mounted temperature sensor shall enable defrost system and recirculation damper when exhaust air temperature falls below 35°F (adjustable).
- (H) Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls so only external connections are required during installation.
1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
 2. Outdoor Enclosures: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
 3. Weather-proof disconnect and motor starters shall be supplied as standard components. Internal electrical components shall be prewired for single point power connection.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- (B) Examine casing insulation materials and filter media air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or molded damaged.

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(C) Examine roughing-in for electrical services to verify actual locations of connections before installation.

(D) Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

(A) Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.

1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger.

(B) Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices.

(C) Install units with clearances for service and maintenance.

(D) Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

(E) Pipe drains from units and drain pans to nearest floor drain or roof drain.

3.03 CONNECTIONS

(A) Install piping adjacent to unit to allow service and maintenance.

(B) Connect piping to units mounted on vibration isolators with flexible connectors.

(C) Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

(D) Electrical Connections: Comply with applicable requirements in Division 26 Sections.

1. Install electrical devices furnished with units but not factory mounted.

3.04 FIELD QUALITY CONTROL

(A) Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

(B) Perform tests and inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

(C) Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Adjust seals and purge.
3. Test and adjust controls and safeties: Replace damaged and malfunctioning controls and equipment.

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- 4. Set initial temperature and humidity set points.
- 5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- (D) Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- (E) Prepare test and inspection reports.
- 3.05 DEMONSTRATION
- (A) Engage a factory –authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 00 – AIR TO AIR ENERGY RECOVERY EQUIPMENT

SECTION 23 81 26 - DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This Section includes ductless split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components.

1.03 SUBMITTALS

- (A) Shop Drawing Submittals:

1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Warranty: Special warranty specified in this Section.

- (B) Closeout Submittals:

1. Operation and Maintenance Data: For ductless split-system air-conditioning units to include in emergency, operation, and maintenance manuals.
2. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

- (A) Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- (B) ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- (C) ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.05 ELECTRICAL COORDINATION

- (A) Refer to Division 26 Sections for the following.

1. Power supply wiring from power source to power connection on ductless split-system air-conditioning units.

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- (B) Provide the following electrical work as work of this section, complying with requirements of Division 26 Sections:

1. Electrical disconnect switches.

1.06 WARRANTY

- (A) Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

1.07 EXTRA MATERIALS

- (A) Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One (1) set of filters for each unit.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- (A) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Carrier Air Conditioning; Div. of Carrier Corporation.
2. Daikin.
3. Friedrich Air Conditioning Company.
4. Lennox Industries Inc.
5. Mitsubishi Electronics America, Inc.; HVAC Division.
6. Sanyo Fisher (U.S.A.) Corp..
7. Trane Company (The); Unitary Products Group.

2.02 WALL-MOUNTED, EVAPORATOR-FAN COMPONENTS

- (A) Cabinet: Manufacturer's standard construction and finish with removable panels on front and ends, and discharge drain pans with drain connection.

1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2004. Provide integral condensate pump.

- (B) Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

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(C) Fan: Direct drive, centrifugal fan.

1. Special Fan Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

(D) Filters: Permanent, cleanable or disposable, with ASHRAE 52.2 MERV rating of 6 or higher.

2.03 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

(A) Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gauge ports on exterior of casing.

(B) Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

1. Manual-reset high-pressure switch and automatic-reset low-pressure switch.

2. Refrigerant: R-407C or R-410A.

(C) Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid sub-cooler.

(D) Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

(E) Fan: Aluminum-propeller type, directly connected to motor.

(F) Motor: Permanently lubricated, with integral thermal-overload protection.

(G) Low Ambient Kit: Permits operation down to 0° F with all required accessories for low ambient operation.

(H) Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.04 ACCESSORIES

(A) Thermostat: Wall mounted low voltage with subbase to control compressor and evaporator fan.

(B) Automatic-reset timer to prevent rapid cycling of compressor.

(C) Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

PART 3 - EXECUTION

3.01 INSTALLATION

(A) Install units level and plumb.

(B) Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

(C) Install ground-mounted, compressor-condenser components on 4-inch thick, reinforced concrete base; 4-inches larger on each side than unit. Coordinate anchor installation with concrete base.

(D) Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

(A) Install piping adjacent to unit to allow service and maintenance.

(B) Electrical: Comply with requirements in Division 26.

3.03 FIELD QUALITY CONTROL

(A) Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

(B) Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

(C) Remove and replace malfunctioning units and retest as specified above.

3.04 STARTUP SERVICE

(A) Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.05 DEMONSTRATION

(A) Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 81 26 – DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS

SECTION 23 82 00 - HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section includes:

1. Fan Coils

- (B) In compliance with electrical specifications provide the following electrical work as work of this section.

1. HVAC Equipment: Control and interlock wiring between operating controls, indicating devices and control panels.
2. Fan Coils: Motor starting device and electrical disconnect means at each unit.

1.03 SUBMITTALS

- (A) Product Data: Submit manufacturer's specifications for HVAC equipment showing dimensions, weights, capacities, ratings, performance characteristics, gages and finishes of materials and installation instructions.
- (B) Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, construction details, required clearances and field connection details.
- (C) Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- (D) Samples: Submit three (3) samples of each type of cabinet finish furnished.
- (E) Maintenance Data: Submit maintenance instructions, including lubrication instructions, "trouble-shooting" maintenance guide filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, and shop drawings in Maintenance Manuals.

1.04 QUALITY ASSURANCE

- (A) Manufacturer's Qualifications: Firms who regularly engaged in manufacture of HVAC equipment, of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- (B) Installer's Qualifications: Firm with at least three (3) years of successful installation experience on projects with HVAC equipment similar to that required for Project.
- (C) Codes and Standards:
1. I=B=R Compliance: Test and rate baseboard and finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.

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2. ARI Compliance: Provide coil ratings in accordance with Air-Conditioning and Refrigeration Institute (ARI) Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".
3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 410 "Forced-Circulation Air Cooling and Air-Heating Coils".
4. ARI Compliance: Test and rate fan-coil units in accordance with ARI Standard 440 "Room Fan-Coil Air-Conditioners".
5. UL Compliance: Construct and install fan-coil units in compliance with UL 883 "Safety Standards for Fan Coil Units and Room Fan Heater Units".

1.05 DELIVERY, STORAGE, AND HANDLING

- (A) Handle HVAC equipment and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged HVAC equipment or components; replace with new.
- (B) Store HVAC equipment and components in clean, dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.
- (C) Comply with manufacturer's rigging and installation instructions for unloading HVAC equipment and moving them to final location.

PART 2 - PRODUCTS

2.01 FAN-COIL UNITS

- (A) Manufacturer: Subject to compliance with requirements, provide fan-coil units of one (1) of the following:
1. Carrier A/C Group, Carrier Corp.
 2. Daikin Applied.
 3. Nailor Industries
 4. Trane (The) Co.
 5. York Div., Borg-Warner Corp.
- (B) General: Provide fan-coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coils, fan board, drain pan assembly, fans, housing, motor, filter and insulation.
- (C) Casing: Fan coil unit casing shall be constructed with a corrosion resistant aluminum frame with 1" thick, double wall panels. Extruded aluminum frame and polymeric corner pieces are required for casing protection and rigidity. Unit panels shall consist of injected polyurethane foam insulation sandwiched between galvanized steel exterior and interior sheets. Formed "thermal break" panels shall have a plastic molded edge to eliminate inner and outer panels from contacting each other. Panels shall be fastened to frame with perimeter screws with a neoprene gasket in between the panel and the frame to minimize air leakage and prevent thermal bridging from unit interior to unit exterior. Removable panels for blower and filter sections shall be furnished on both sides to allow full access to unit interior. Blower and filter access panels shall include a pocket handle to assist in panel removal.

- (D) Coils: Water coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins. Water coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point.
- (E) Drain Pans: Drain pans shall be constructed from antimicrobial coated galvanized steel, pitched and sloped in direction of airflow to drain connection to allow for condensate drainage. Condensate drain connections shall be provided on both sides of drain pan. Secondary drain connection shall be provided.
- (F) Fans: The supply fan shall be a DWDI forward-curved type. Fan assemblies including fan, motor and sheaves shall be dynamically balanced by the manufacturer on all three planes at all bearing supports. Manufacturer must ensure maximum fan RPM is below the first critical speed. Fan and motor assembly shall be mounted on vibration type isolators inside cabinetry.
- (G) Motors: Provide motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords.
- (H) Filters: Provide 2-inch deep MERV 8 pleated filter.
- (I) Dampers: Provide 18-gage steel damper blades with polyurethane stop across entire blade length.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) Examine areas and conditions under which HVAC equipment is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 INSTALLATION OF FAN COILS

- (A) General: Install units as indicated, and in accordance with manufacturer's installation instructions.
- (B) Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- (C) Coordinate with other trades to assure correct recess size for recessed units.
- (D) Install piping as indicated.
- (E) Protect units with protective covers during balance of construction.

3.03 ADJUSTMENT AND CLEANING

- (A) General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
- (B) Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

END OF SECTION 23 82 00 – HVAC EQUIPMENT

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HVAC EQUIPMENT
23 82 00 - 3

SECTION 23 82 39 - ELECTRIC HEATING EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) This section includes the followings:

1. Cabinet unit heaters
2. Electric Unit Heaters

- (B) Refer to Division 26 sections for the following work:

1. Power supply wiring from power source to power connection on unit.

- (C) Provide the following electrical work as work of this section, complying with requirements of Division 26 sections.

1. Cabinet and Unit Heaters: Provide motor starting device and electrical disconnect means at each unit.

1.03 DEFINITIONS

- (A) CWP: Cold working pressure.

- (B) DDC Direct digital control.

- (C) PTFE: Polytetrafluoroethylene plastic.

- (D) TFE: Tetrafluoroethylene plastic.

1.04 SUBMITTALS

- (A) Product Data: Submit manufacturer's specifications for electric heaters showing dimensions, weights, capacities, ratings, performance characteristics, gages and finishes of materials and installation instructions.

- (B) Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, construction details, required clearances and field connection details.

- (C) Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electric heaters. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

- (D) Maintenance Data: Submit maintenance instructions, "trouble-shooting" maintenance guide, motor and drive replacement and spare parts lists. Include this data, product data and shop drawings in maintenance manuals; in accordance with requirements of Division 23 Section 23 05 00.

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ELECTRIC HEATING EQUIPMENT 23 82 39 - 1

1.05 QUALITY ASSURANCE

- (A) Manufacturer's Qualifications: Firms who regularly engaged in manufacture of electric heaters, of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- (B) Installer's Qualifications: Firm with at least three (3) years of successful installation experience on projects with electric heaters similar to that required for project.
- (C) Codes and Standards:
1. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.06 DELIVERY, STORAGE AND HANDLING

- (A) Handle electric heaters carefully to prevent damage, breaking, denting and scoring. Do not install damaged electric equipment or components; replace with new.
- (B) Store electric heaters in clean, dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.
- (C) Comply with manufacturer's rigging and installation instructions for unloading electric heaters and installing them to final location.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- (A) Manufacturer: Subject to compliance with requirements, provide electric heaters of one (1) of the following:
1. Berko
 2. Chromalux
 3. Indeeco
 4. King
 5. Markel
 6. Qmark
 7. Raywall
 8. Redd-i
 9. Warren

2.02 CABINET HEATERS

- (A) General: Provide cabinet heaters in locations as indicated and of capacities, style and having accessories as scheduled. Include in basic unit chassis, coil, fan wheels, housing, motor and insulation.

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ELECTRIC HEATING
EQUIPMENT
23 82 39 - 2

- (B) Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass-reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
- (C) Electric Resistance Heating Elements: Steel fins shall be copper brazed to steel-sheath tubular heating elements. Element shall be finished with aluminized paint. Arrange fins and elements in uniform grid pattern mounted adjacent to discharge opening.
- (D) Motors: Provide two-speed motors with automatic overload protection.
- (E) Cabinet: Die-formed 16 gauge furniture-grade steel. All metal surfaces of the cabinet shall be phosphatized and finished in baked enamel. Provide surface mounted unit with up-flow discharge air direction.

2.03 **ELECTRIC UNIT HEATERS**

- (A) General: Provide electric unit heaters in locations as indicated and of capacities, style and having accessories as scheduled. Include in basic unit chassis, coil, fan wheels, housing, motor and insulation.
- (B) Fan: Propeller type, aluminum wheel directly mounted on motor shaft venture.
- (C) Electric Resistance Heating Elements: Steel fins shall be copper brazed to steel-sheath tubular heating elements. Element shall be finished with aluminized paint. Arrange fins and elements in uniform grid pattern mounted adjacent to discharge opening.
- (D) Motors: Provide totally enclosed motors including permanently lubricated ball bearings and built-in thermal overload protection.
- (E) Cabinet: Die-formed 14 gauge industrial-grade steel. Adjustable individual louvers with minimum opening stops. All metal surfaces of the cabinet shall be epoxy-coated. Provide mounting bracket for wall or ceiling installation.
- (F) Controls: Provide dual automatic reset thermal cutouts for redundant overtemperature protection, magnetic contactor and 24 volt control circuit transformer.

PART 3 - EXECUTION

3.01 **EXAMINATION**

- (A) Examine areas and conditions under which electric heaters are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Architect.

3.02 **INSTALLATION OF ELECTRIC HEATERS**

- (A) General: Install units as indicated and in accordance with manufacturer's installation instructions.
- (B) Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- (C) Hang unit heaters from building substrate. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
- (D) Support units with mounting brackets anchored to building substrate.
- (E) Coordinate with other trades to assure correct size for wall mounted units.

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**ELECTRIC HEATING
EQUIPMENT
23 82 39 - 3**

(F) Protect units with protective covers during balance of construction.

3.03 ADJUSTMENT AND CLEANING

(A) General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean coils and inside of unit.

(B) Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

END OF SECTION 23 82 39 - ELECTRIC HEATING EQUIPMENT

SECTION 26 05 00 - GENERAL ELECTRICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 RESPONSIBILITIES

- (A) THE BIDDING REQUIREMENTS, CONDITIONS OF CONTRACT, GENERAL SPECIFICATIONS AND GENERAL REQUIREMENTS, AND THIS DIVISION SHALL BE BINDING ON THE CONTRACTOR AND SHALL APPLY TO ALL ELECTRICAL WORK TO BE COMPLETED UNDER THIS SECTION.
- (B) THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE WORK FROM THE DATE OF HIS CONTRACT UNTIL ITS ACCEPTANCE BY THE OWNER AND MUST MAKE GOOD ALL DAMAGES SUSTAINED FROM WHATEVER CAUSE. HE SHALL USE PROPER CARE AND DILIGENCE IN BRACING AND SECURING ALL PARTS OF THE WORK AND SHALL IN ALL CASES JUDGE AS TO THE AMOUNT OF PROTECTION REQUIRED.

1.03 ORDINANCES, LAWS AND CODES

- (A) ALL WORK SHALL CONFORM TO THE RULES AND REGULATIONS OF THE NATIONAL ELECTRICAL CODE, LOCAL CODE, "OCCUPATIONAL SAFETY AND HEALTH ACT" AND THE STATE FIRE MARSHAL'S OFFICE. ALL CERTIFICATES OF APPROVAL SHALL BE DELIVERED TO THE ARCHITECT BEFORE FINAL PAYMENT WILL BE MADE.
- (B) SHOULD ANY CHANGE IN THE DRAWINGS AND/OR SPECIFICATIONS BE REQUIRED TO CONFORM TO THE ABOVE MENTIONED LAWS AND ORDINANCES, THE ARCHITECT SHALL BE NOTIFIED BY THE BIDDER PRIOR TO THE BID DATE, THAT THE NECESSARY CHANGES MAY BE COMPLETED. AFTER THE BID DATE, ALL WORK NECESSARY TO MEET THE REQUIREMENTS SHALL BE AT CONTRACTOR'S EXPENSE, WITH NO ADDITIONAL COST TO THE OWNER.
- (C) THE CONTRACTOR SHALL PAY ALL FEES, PERMITS OR TAXES FOR INSPECTIONS, ETC., IN CONNECTION WITH THE WORK UNDER THIS CONTRACT. [ANY COSTS, CHARGES OR CONNECTION FEES WHICH THE POWER COMPANY ASSESSES THE OWNER OR CONTRACTOR IN ORDER TO OBTAIN PERMANENT AND TEMPORARY ELECTRICAL SERVICE TO THE PROJECT FACILITY WILL BE PAID BY THE CONTRACTOR AS PART OF THIS CONTRACT.

1.04 DATA AND MEASUREMENT

- (A) THE DATA GIVEN HEREIN AND ON THE DRAWINGS IS AS EXACT AS COULD BE SECURED INSOFAR AS BUILDING CONSTRUCTION AND EXISTING CONDITIONS ARE CONCERNED. EXTREME ACCURACY IS NOT GUARANTEED. THE DRAWINGS AND SPECIFICATIONS ARE INTENDED FOR THE ASSISTANCE OF THE CONTRACTOR IN ACHIEVING THE END RESULT. EXACT LOCATIONS, MEASUREMENTS, DISTANCE, LEVELS, ETC., WILL BE GOVERNED BY CONDITIONS AT THE JOB SITE.
- (B) THE CONTRACTOR SHALL VERIFY THAT THE SIZE OF THE EQUIPMENT SUPPLIED BY THE SELECTED MANUFACTURERS DOES NOT EXCEED THE AVAILABLE MOUNTING SPACE.
- (C) THE ARCHITECT RESERVES THE RIGHT TO CHANGE LOCATION OR SIZE OF CONDUITS, OUTLETS, LUMINAIRES OR OTHER PIECES OF EQUIPMENT AS MAY BE NECESSARY TO AVOID CONFLICTS. NO EXTRA COMPENSATION WILL BE ALLOWED FOR SUCH CHANGES UNLESS ADDITIONAL COST TO THE CONTRACTOR IS CAUSED.
- (D) THE BIDDER SHALL VISIT THE PROJECT SITE THAT HE MAY HAVE KNOWLEDGE OF CONDITIONS AT THE JOB SITE AND ADAPT HIS WORK TO SUCH CONDITIONS.

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1.05 DRAWINGS AND SPECIFICATIONS

- (A) ANYTHING MENTIONED IN THIS SPECIFICATION AND NOT SHOWN ON THE DRAWINGS OR VICE VERSA SHALL BE OF LIKE EFFECT, AS SHOWN OR MENTIONED IN BOTH. IN ANY CASE OF DISCREPANCY OR DIFFERENCES IN THE FIGURES, DRAWINGS OR SPECIFICATIONS, THE BIDDER SHALL PROMPTLY REPORT SUCH DISCREPANCIES TO THE ARCHITECT WHO SHALL MAKE A DECISION IN WRITING. ANY ADJUSTMENT BY THE CONTRACTOR WITHOUT THIS DECISION SHALL BE AT THE EXPENSE OF THE CONTRACTOR.

1.06 QUALITY OF WORKMANSHIP

- (A) THE CONTRACTOR SHALL GIVE HIS PERSONAL SUPERINTENDENCE AND DIRECTION TO THE WORK. HE SHALL ALSO KEEP A COMPETENT FOREMAN OR SUPERINTENDENT ON THE PROJECT.
- (B) ALL EQUIPMENT, CONTROLS AND JUNCTION BOXES SHALL BE LOCATED FOR READY ACCESS, OPERATION, REPAIR OR MAINTENANCE.
- (C) ANY ADDITIONAL DRAWINGS NECESSARY FOR THE PROSECUTION OF THE WORK WILL BE FURNISHED BY THE ARCHITECT AS PROMPTLY AS POSSIBLE. THE CONTRACTOR SHALL REQUEST ANY ADDITIONAL INSTRUCTIONS NEEDED AND SHALL DO NO WORK WITHOUT DRAWINGS AND INSTRUCTIONS.
- (D) ANY DISCREPANCIES BETWEEN THE MECHANICAL, ELECTRICAL AND ARCHITECTURAL DRAWINGS SHALL BE REPORTED TO THE ARCHITECT PRIOR TO THE BID DATE.

1.07 GUARANTEE

- (A) THIS CONTRACTOR SHALL GUARANTEE ALL MATERIALS, WORKMANSHIP AND THE SUCCESSFUL OPERATION OF ALL APPARATUS FURNISHED AND INSTALLED BY HIM FOR A PERIOD OF ONE (1) YEAR FROM THE DATE OF THE FINAL ACCEPTANCE OF THE WHOLE WORK, AND SHALL GUARANTEE TO REPAIR OR REPLACE AT HIS OWN EXPENSE ANY PART OF THE APPARATUS WHICH MAY SHOW DEFECT DURING THAT TIME, PROVIDED SUCH DEFECT IS, IN THE OPINION OF THE ARCHITECT, DUE TO IMPERFECT MATERIAL OR WORKMANSHIP AND NOT TO CARELESSNESS OR IMPROPER OPERATION. GUARANTEE PERIOD FOR THE REPLACEMENT SHALL BEGIN WITH THE DATE OF REPLACEMENT.
- (B) THE OWNER SHALL NOTIFY THE CONTRACTOR OF ANY FAILURE OF ANY PART OR PARTS WHICH OCCUR DURING THE GUARANTEE PERIOD.
- (C) THE CONTRACTOR SHALL ALSO GUARANTEE THE SYSTEMS AND THE APPARATUS TO BE WORKING PROPERLY TO MEET ALL CONDITIONS AS SPECIFIED.

1.08 SHOP DRAWINGS

- (A) SHOP DRAWINGS SHALL BE SUBMITTED IN ACCORDANCE WITH THE REQUIREMENTS OF PARAGRAPH "SHOP DRAWINGS" OF THE GENERAL CONDITIONS. THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS OF ALL FABRICATED WORK AND EQUIPMENT TO BE PURCHASED. DATA SHALL BE SUFFICIENTLY COMPLETED TO PERMIT EVALUATION AND COMPARISON WITH SPECIFIED EQUIPMENT AND MATERIAL. EACH ITEM SHALL BE PREPARED AS A SEPARATE SUBMITTAL, NOT GROUPED OR BOUND WITH OTHER ITEMS.
- (B) ALL DRAWINGS SHALL BEAR THE CONTRACTOR'S STAMP OF APPROVAL AND MUST BE DATED.
- (C) SHOP DRAWINGS SHALL INCLUDE, BUT NOT BE LIMITED TO THE FOLLOWING:
1. LUMINAIRES.
 2. LAMPS.

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3. SWITCHBOARD.
 4. PANELBOARDS.
 5. CIRCUIT AND MOTOR DISCONNECTS.
 6. EMERGENCY ENGINE GENERATOR, TRANSFER SWITCH, AUXILIARY EQUIPMENT.
 7. FIRE ALARM SYSTEMS.
 8. DOOR ALARM SYSTEM.
 9. SOUND SYSTEMS.
 10. SECURITY SYSTEM.
 11. TELECOMMUNICATION CABLING SYSTEM.
 12. TELEPHONE CABLING SYSTEM.
 13. TELEVISION CABLING SYSTEM.
 14. CABLE TRAY.
 15. FUSES.
 16. WIRING DEVICES – SWITCHES, RECEPTACLES, DEVICE WALLPLATES.
 17. OCCUPANCY SENSORS.
- (D) A NOTATION SHALL BE MADE ON EACH ITEM SUBMITTED AS TO ITS SPECIFIED USE OR DESCRIPTION OF SPECIFIC LOCATION IN THE WORK.
- (E) NONE OF THE PRECEDING ITEMS SHALL BE PURCHASED, DELIVERED TO THE SITE OR INSTALLED UNTIL THE ITEM HAS BEEN PROPERLY SUBMITTED IN WRITING AND REVIEWED BY THE ARCHITECT.
- (F) SUBMITTALS SHALL BE MADE EVEN THOUGH THE ITEM IS EXACTLY AS SPECIFIED.
- (G) SHOULD THE CONTRACTOR FAIL TO COMPLY WITH ANY OF THE REQUIREMENTS AS STATED, THE ARCHITECT RESERVES THE RIGHT TO SELECT A FULL LINE OF MATERIALS, APPLIANCES AND EQUIPMENT, WHICH SHALL BE FINAL AND BINDING UPON THE CONTRACTOR.
- 1.09 SUBMITTAL DATA
- (A) REVIEW OF SUBMITTAL DATA IS ONLY FOR GENERAL CONFORMANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND GENERAL COMPLIANCE WITH THE INFORMATION GIVEN IN THE CONTRACT DOCUMENTS. ANY ACTION SHOWN IS SUBJECT TO THE REQUIREMENTS OF THE PLANS AND SPECIFICATIONS. CONTRACTOR IS RESPONSIBLE FOR: DIMENSIONS, WHICH SHALL BE CONFIRMED AND CORRELATED AT THE JOB SITE; FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION; COORDINATION OF HIS WORK WITH THAT OF ALL OTHER TRADES AND THE SATISFACTORY PERFORMANCE OF HIS WORK.
- (B) CONTRACTOR WILL BE LIMITED TO ONE (1) REVIEW ON A SINGULAR PIECE OF EQUIPMENT.

- (C) THE LISTING OF A MANUFACTURER AS "ACCEPTABLE" DOES NOT IMPLY AUTOMATIC COMPLIANCE WITH CONTRACT DOCUMENTS. IT IS THE SOLE RESPONSIBILITY OF THE CONTRACTOR TO INSURE THAT ANY PRICE QUOTATIONS RECEIVED AND SUBMITTALS MADE ARE FOR EQUIPMENT/SYSTEMS, WHICH MEET OR EXCEED THE SPECIFICATIONS INCLUDED HEREIN.

1.10 EQUAL MANUFACTURERS/EQUIPMENT

- (A) ANY REQUESTS FOR MANUFACTURER/EQUIPMENT TO BE CONSIDERED AS EQUAL OTHER THAN AS SPECIFIED HEREIN SHALL BE SUBMITTED TO THE ENGINEER NOT LESS THAN 10 DAYS PRIOR TO BID DATE.
- (B) REQUESTS FOR REVIEW SHALL BE SUFFICIENTLY COMPLETE TO PERMIT EVALUATION AND COMPARISON WITH SPECIFIED EQUIPMENT AND MATERIAL.

1.11 AUTOCAD DRAWING FILE REQUESTS

- (A) AS AN INSTRUMENT OF SERVICE TO AID IN SHOP DRAWING SUBMITTALS, FARRIS ENGINEERING (FE) WILL PROVIDE AUTOCAD DRAWING FILES UPON REQUEST. THE FILES WILL BE SENT UPON RETURN RECEIPT OF THE "REQUEST FOR DRAWINGS" AGREEMENT SIGNED BY AN OFFICER OF THE REQUESTING FIRM. FE DOES NOT ASSURE THAT THE DRAWINGS REPRESENT ALL CHANGES, ADDENDA ITEMS, CHANGE ORDERS OR MODIFICATIONS THAT MAY HAVE OCCURRED. THE DRAWINGS ARE SIMPLY A TOOL FOR USE IN PRODUCING SHOP DRAWING SUBMITTALS.
- (B) THE DRAWING FILES WILL BE "CLEANED-UP" BY HAVING THE FE LOGO, PROFESSIONAL ENGINEER SEAL AND ALL EXTRANEOUS NOTES AND DETAILS REMOVED. FE MUST BE COMPENSATED FOR THIS ADDITIONAL SERVICE BY THE REQUESTING FIRM. A MINIMUM FEE OF \$400.00 FOR UP TO EIGHT (8) SHEETS AND \$50.00 PER SHEET FOR EACH ADDITIONAL REQUESTED DRAWING WILL BE INVOICED TO THE REQUESTING FIRM ONCE THE SIGNED AGREEMENT IS RECEIVED.

PART 2 - PRODUCTS

2.01 PROTECTION OF LUMINAIRES AND WARES

- (A) THIS CONTRACTOR SHALL APPLY THE NECESSARY PROTECTIVE COVERAGE TO LUMINAIRES AND OTHER EQUIPMENT TO PREVENT SCRATCHES AND MARS TO SUCH EQUIPMENT AS A RESULT OF FALLING OBJECTS OR WORK OF OTHER TRADES.

2.02 STORAGE

- (A) THIS CONTRACTOR SHALL PROVIDE AND BE RESPONSIBLE FOR SAFE STORAGE OF HIS MATERIALS AND SUCH STORAGE SHALL NOT INTERFERE WITH THE WORK OF OTHERS OR PROGRESS OF THE PROJECT IN ANY MANNER.

2.03 EQUIPMENT ENCLOSURES

- (A) PROVIDE ENCLOSURES, WHICH MATE PROPERLY WITH THE EQUIPMENT TO BE ENCLOSED AND ARE NEMA RATED TO SUIT THE ATMOSPHERIC CONDITIONS OF THE EQUIPMENT SURROUNDINGS.
- (B) EQUIPMENT IN CORROSIVE ATMOSPHERE SHALL BE RATED NEMA 4X. ALL NEMA 4X EQUIPMENT SHALL BE FABRICATED FROM SUITABLE NON-METALLIC MATERIAL OR SHALL BE STAINLESS STEEL. PAINTED STEEL IS NOT ACCEPTABLE FOR NEMA 4X APPLICATIONS.

PART 3 - EXECUTION

3.01 COORDINATION

- (A) BEFORE INSTALLING ANY WORK, THIS CONTRACTOR SHALL COORDINATE THE ELECTRICAL WORK WITH ALL OTHER CONTRACTORS ON THE PROJECT, WITH THE ELECTRIC UTILITY COMPANY AND THE CITY CODE ENFORCING DEPARTMENT.
- (B) ALL ELECTRICAL WORK SHALL BE INSTALLED IN PROPER SEQUENCE AND SO ARRANGED WITH OTHER TRADES THAT THERE WILL BE NO DELAY IN THE PROPER INSTALLATION AND COMPLETION OF ANY PART OR PARTS OF ALL PIPING SYSTEMS AND MECHANICAL EQUIPMENT.
- (C) THIS CONTRACTOR SHALL CAREFULLY EXAMINE THE DRAWINGS AND SHALL BE RESPONSIBLE FOR THE PROPER FITTING OF EQUIPMENT AND CONDUIT AS INDICATED WITHOUT MAJOR ALTERATION. IF ALTERATIONS ARE REQUIRED, A DETAILED DRAWING OF THE PROPOSED DEPARTURE DUE TO ACTUAL FIELD CONDITIONS OR OTHER CAUSES SHALL BE SUBMITTED TO THE ARCHITECT FOR APPROVAL.
- (D) WHENEVER INTERFERENCES MIGHT OCCUR, BEFORE INSTALLING ANY OF THE WORK IN QUESTION, THE ELECTRICAL CONTRACTOR SHALL CONSULT WITH OTHER CONTRACTORS AND SHALL COME TO AN AGREEMENT WITH THEM AS TO THE EXACT LOCATION AND LEVEL OF HIS CONDUIT BUS DUCT, LUMINAIRES AND/OR PARTS OF HIS INSTALLATION.
- (E) WHERE RECESSED ELECTRICAL DEVICES (SPEAKERS, LUMINAIRES, ETC.) ARE INSTALLED IN FIRE-RATED CEILINGS, CONTRACTOR SHALL PROVIDE AN ENCLOSURE APPROVED BY AUTHORITIES HAVING JURISDICTION TO SURROUND EACH DEVICE AS REQUIRED TO MAINTAIN THE FIRE INTEGRITY RATING OF THE CEILING. ADEQUATE CLEARANCE BETWEEN DEVICE AND ENCLOSURE SHALL BE PROVIDED IN ACCORDANCE WITH DEVICE MANUFACTURER'S RECOMMENDATIONS. VERIFY CLEARANCE REQUIREMENTS WITH DEVICE MANUFACTURER PRIOR TO INSTALLATION OF LUMINAIRE.
- (F) MULTIWIRE BRANCH CIRCUITS AS DEFINED BY THE NATIONAL ELECTRICAL CODE (CIRCUITS WITH COMMON NEUTRAL) SHALL NOT BE USED. EXCEPTION: WHERE AN EQUIPMENT MANUFACTURER REQUIRES A MULTIWIRE BRANCH CIRCUIT FOR ONLY ONE UTILIZATION EQUIPMENT AND WHERE ALL UNGROUNDED CONDUCTORS OF THAT CIRCUIT ARE OPENED SIMULTANEOUSLY BY THE BRANCH CIRCUIT OVERCURRENT DEVICE.
- (G) A CABLE RACEWAY TYPE WIRING METHOD, INSTALLED IN EXPOSED OR CONCEALED LOCATIONS NEAR METAL-CORRUGATED SHEET ROOF DECKING, SHALL BE INSTALLED AND SUPPORTED SO THE NEAREST OUTER SURFACE OF THE CABLE RACEWAY IS NOT LESS THAN 6-INCHES FROM THE NEAREST SURFACE OF THE ROOF DECKING. EXCEPTION: RIGID METAL CONDUIT AND INTERMEDIATE METAL CONDUIT SHALL NOT BE REQUIRED TO MAINTAIN THIS CLEARANCE.
- (H) ALL CHANGES IN THE WORK OF THIS CONTRACTOR, CAUSED BY HIS NEGLECT TO FOLLOW THESE INSTRUCTIONS, SHALL BE MADE AT THIS CONTRACTOR'S EXPENSE.

3.02 DITCHING, EXCAVATION AND BACKFILLING

- (A) CONTRACTOR SHALL DO ALL EXCAVATION REQUIRED TO INSTALL CONDUITS AND EQUIPMENT SHOWN ON DRAWINGS OR REQUIRED FOR PROPER OPERATION. EXCESS EXCAVATION BELOW THE REQUIRED LEVEL SHALL BE BACKFILLED WITH EARTH AND THOROUGHLY TAMPED.

3.03 CONNECTIONS FOR EQUIPMENT

- (A) COORDINATE THE HOOK UP OF THE FOLLOWING EQUIPMENT WITH THE CONTRACTOR REQUIRED TO FURNISH AND INSTALL THEM. SEE THE APPROPRIATE SECTIONS IN THE GENERAL CONSTRUCTION WORK SPECIFICATIONS FOR FURTHER INFORMATION.

MECHANICAL EQUIPMENT

CABINETRY EQUIPMENT

OWNER FURNISHED EQUIPMENT

- (B) VERIFY FUSE AND/OR CIRCUIT BREAKER REQUIREMENTS FOR ELECTRICAL CONNECTIONS TO EQUIPMENT AND PROVIDE OVERCURRENT DEVICES ACCORDINGLY.
- (C) THE PLANS INDICATE THE LOCATIONS OF SYSTEM DEVICES. THE CONTRACT SHALL INCLUDE THE WIRING SYSTEM REQUIRED TO INTERCONNECT THE INDICATED DEVICES TO RESULT IN A COMPLETE, OPERATING SYSTEM. THE INTERCONNECTING WIRING SHALL BE IN CONFORMITY WITH THE REQUIREMENTS OF THE MANUFACTURER OF THE EQUIPMENT AS WELL AS WITH OTHER REQUIREMENTS SET OUT HEREIN. THE BASIC WIRING METHOD TO BE EMPLOYED IS INDICATED HEREIN. THE CONTRACTOR'S SHOP DRAWING SUBMITTAL SHALL INDICATE THE SPECIFIC ROUTING AND TYPE OF WIREWAY AND THE NUMBER AND TYPE OF CONDUCTORS TO BE INSTALLED.

3.04 TEMPORARY WIRING

(SEE DIVISION 01 FOR ADDITIONAL ELECTRICAL CONTRACTOR'S RESPONSIBILITIES).

- (A) THIS CONTRACTOR IS TO PROVIDE A TEMPORARY ELECTRICAL SERVICE HAVING A MAIN DISCONNECT AND DISTRIBUTION PANEL. THE SIZE OF THE SERVICE SHALL BE COORDINATED WITH THE GENERAL CONTRACTOR. FROM THE PANEL PROVIDE WIRING FOR LUMINAIRES AND RECEPTACLES. ALL RECEPTACLES SHALL BE EQUIPPED WITH GROUND FAULT CIRCUIT PROTECTION IN ACCORDANCE WITH NEC REQUIREMENTS. PROVIDE WELDING CIRCUITS AS REQUIRED.
- (B) THE CONTRACTOR SHALL VERIFY WITH THE SERVING UTILITY EXISTING CONDITIONS AVAILABLE FOR TEMPORARY POWER.
 - 1. THE ELECTRICAL CONTRACTOR SHALL PAY ALL INSTALLATION CHARGES BY UTILITY COMPANY TO CONNECT AND DISCONNECT THE TEMPORARY SERVICE.
 - 2. ALL CHARGES FOR ELECTRICAL ENERGY WILL BE PAID BY THE GENERAL CONTRACTOR.
- (C) ALL MATERIALS FOR THE TEMPORARY SERVICE AND WIRING MAY BE USED AND REMAINS THE PROPERTY OF THE ELECTRICAL CONTRACTOR.
 - 1. TEMPORARY WIRING MATERIALS ARE NOT TO BE INSTALLED AS PART OF THE PERMANENT WIRING SYSTEM.
- (D) WIRING NEED NOT BE INSTALLED IN CONDUIT BUT MUST BE ADEQUATELY INSULATED AND PROTECTED FROM MECHANICAL INJURY TO PREVENT SHOCK.
 - 1. PERMANENT WIRING INCLUDING FEEDERS, PANELS, RECEPTACLES, ETC., MAY BE USED AS SOON AS INSTALLED.

3.05 CLEANING

- (A) THIS CONTRACTOR SHALL AT ALL TIMES KEEP THE PREMISES FREE OF ALL WASTE OR SURPLUS MATERIALS, RUBBISH AND DEBRIS WHICH IS CAUSED BY HIS EMPLOYEES OR RESULTING FROM HIS WORK.
- (B) AFTER ALL EQUIPMENT AND LUMINAIRES HAVE BEEN INSTALLED AND BUILDING IS READY FOR OCCUPANCY, THE ELECTRICAL CONTRACTOR SHALL REMOVE ALL STICKERS, RUST STAINS, LABELS, TEMPORARY COVERS, PLASTER MARKS, PAINT SPOTS, ETC. ALL FOREIGN MATTER SHALL BE VACUUMED OUT OF ALL CONDUITS, PANELS, MOTORS, DEVICES, SWITCHES, LUMINAIRES, ETC.

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- (C) IDENTIFICATION PLATES AND TRIMS ON ALL EQUIPMENT SHALL BE FREE OF PAINT AND POLISHED.
- (D) THE CONTRACTOR SHALL LEAVE THE ELECTRICAL PORTION OF THE WORK IN A SAFE CLEAN AND VERY NEAT CONDITION READY FOR OPERATION.

3.06 REBATES

- (A) THE CONTRACTOR SHALL ASSIST THE OWNER WITH FILING OF APPLICABLE FORMS TO OBTAIN REBATES. THIS SHALL INCLUDE BUT NOT BE LIMITED TO DETERMINATION OF QUALIFYING MATERIALS AND FURNISHING INVOICES FOR MATERIALS WITH CORRESPONDING QUANTITIES.

3.7 RECORD DRAWINGS

- (A) THE CONTRACTOR SHALL MAINTAIN AN UP-TO-DATE SET OF PLANS AND SPECIFICATIONS ON THE JOB SITE. HE SHALL MARK ALL ADDENDUM ITEMS AND ANY FIELD CHANGES ON THIS SET AND SEE THAT A COPY OF ALL CHANGES IS FURNISHED TO THE ARCHITECT AT THE END OF THE PROJECT.
- (B) THE DRAWINGS SHALL ALSO INCLUDE AS-BUILT CONDITIONS SUCH AS EQUIPMENT LOCATIONS, ROUTING OF SERVICE ENTRANCE AND MAJOR FEEDERS, ETC.

3.8 INSTRUCTION IN OPERATION BOOKS AND SPARE PARTS

- (A) AFTER ALL TESTS AND ADJUSTMENTS HAVE BEEN MADE, THE CONTRACTOR SHALL FURNISH THE NECESSARY QUALIFIED PERSONNEL TO PLACE THE SPECIAL SYSTEMS IN CONTINUOUS OPERATION, DURING WHICH TIME HE SHALL PROVIDE COMPLETE OPERATING AND MAINTENANCE INSTRUCTIONS TO THE OWNER'S REPRESENTATIVE WITH AN OUTLINE OF INSTRUCTIONS IN WRITTEN FORM. THESE PERSONNEL SHALL RESERVE ADEQUATE TIME TO INSTRUCT AN OWNER'S REPRESENTATIVE ON PROPER OPERATION (INCLUDING ALL PHASES OF THE SYSTEM AND EACH OF ITS COMPONENT PARTS).
- (B) CONTRACTOR SHALL FURNISH OWNER WITH TWO (2) SETS OF ALL OPERATING INSTRUCTIONS, MAINTENANCE INSTRUCTION AND SPARE PARTS LISTS OF ALL EQUIPMENT FURNISHED UNDER THIS CONTRACT. LISTS SHALL INCLUDE CURRENT UNIT PRICES AND SOURCE OF SUPPLY FOR EACH ITEM OF OPERABLE EQUIPMENT.

3.9 FIRESTOPPING

- (A) OPENINGS AROUND ELECTRICAL PENETRATIONS THROUGH FIRE-RESISTANT RATED WALLS, PARTITIONS, FLOORS OR CEILINGS SHALL BE FIRESTOPPED USING LISTED MATERIALS TO MAINTAIN THE FIRE RATING. INSTALLATION SHALL BE DONE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS. MATERIALS SHALL BE UL LISTED AND LABELED AND FM APPROVED FOR FIRE RATINGS CONSISTENT WITH PENETRATED BARRIERS.
 - 1. FOAMED-IN-PLACE TYPE FIRESTOPPING SHALL ONLY BE PERMITTED IN CONCEALED-FROM-VIEW LOCATIONS. SEALANT TYPE FIRESTOPPING SHALL BE USED IN EXPOSED-TO-VIEW LOCATIONS.
 - 2. CABLE TRAY, CONDUIT SLEEVES (2-INCH AND LARGER) AND SIMILAR PENETRATIONS OF FIRE-RATED WALLS, FLOORS OR CEILINGS SHALL BE SEALED BY A METHOD THAT PERMITS CABLES TO BE EASILY ADDED OR REMOVED WITHOUT DAMAGE TO THE FIRESTOPPING MATERIALS. PRODUCTS SIMILAR TO GRACE CONSTRUCTION PRODUCTS FLAMESAFE BAGS, SPECIFIED TECHNOLOGIES, INC. EZ PATH FIRE RATED PATHWAY AND WIREMOLD FLAMESTOPPER FS SERIES ARE ACCEPTABLE WHEN RATED FOR THE APPLICATION. COORDINATE REQUIREMENTS WITH PRODUCT MANUFACTURER AND AUTHORITY HAVING JURISDICTION. FOAMED IN PLACE OR SEALANT TYPE FIRESTOPPING ARE NOT ACCEPTABLE AT THESE LOCATIONS.

3.10 TESTS AND ADJUSTMENTS

- (A) UPON COMPLETION OF INSTALLATION OF ELECTRICAL CONNECTIONS, AND AFTER CIRCUITRY HAS BEEN ENERGIZED WITH RATED POWER SOURCE TEST CONNECTIONS TO DEMONSTRATE CAPABILITY AND COMPLIANCE WITH REQUIREMENTS. ENSURE THAT DIRECTION OF ROTATION OF EACH MOTOR FULFILLS REQUIREMENT. CORRECT MALFUNCTIONING UNITS AT SITE, THEN RETEST TO DEMONSTRATE COMPLIANCE.
- (B) DURING THE PROGRESS AND AFTER COMPLETION OF THE WORK INCLUDED UNDER THIS SPECIFICATION, THE CONTRACTOR SHALL MAKE ALL REQUIRED TESTS AT HIS OWN EXPENSE IN THE PRESENCE OF THE ARCHITECT AS REQUIRED HEREINAFTER AND BY LOCAL ORDINANCES, CODES, LAWS AND REGULATIONS. SUCH TESTS SHALL BE IN ACCORDANCE WITH OTHER SECTIONS OF THIS DIVISION. THE ARCHITECT SHALL BE NOTIFIED FIVE (5) DAYS IN ADVANCE AS TO THE TIME WHEN SUCH TESTS ARE TO BE PERFORMED THAT A REPRESENTATIVE OF THE ARCHITECT MAY BE PRESENT.

END OF SECTION 26 05 00 – GENERAL ELECTRICAL

SECTION 26 05 19 - WIRES AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF ELECTRICAL WIRE AND CABLE WORK IS INDICATED BY DRAWINGS AND SCHEDULES. WIRES AND CABLES SHALL BE SINGLE, INSULATED CONDUCTORS, FIELD-INSTALLED IN CONTINUOUS RACEWAYS UNLESS SPECIFIED OTHERWISE.
- (B) Wiring within each apartment unit originating at the load center for each unit shall be nonmetallic-sheathed cable, Type NM.
- (C) TYPES OF ELECTRICAL WIRE, CABLE AND CONNECTORS SPECIFIED IN THIS SECTION INCLUDE THE FOLLOWING:
1. COPPER CONDUCTORS.
 2. TAP TYPE CONNECTORS.
 3. WIRENUT CONNECTORS.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS OF ONE (1) OF THE FOLLOWING (FOR EACH TYPE OF WIRE, CABLE AND CONNECTOR):
1. WIRE AND CABLE:
 - A. APEX WIRE AND CABLE CORP.
 - B. AMERICAN INSULATED WIRE CORP.
 - C. AMERICAN WIRE AND CABLE CO.
 - D. BELDEN DIV; COOPER INDUSTRIES.
 - E. BRAND-REX DIV; PYLE NATIONAL CO.
 - F. CERRO WIRE AND CABLE CORP.
 - G. CLEVELAND INSULATED WIRE CO.
 - H. GENERAL CABLE CORPORATION.
 - I. HELIX WIRE CORPORATION.
 - J. HOUSTON WIRE

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WIRES AND CABLES
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- K. INDIANA INSULATED WIRE INC.
- L. LARIBEE WIRE MANUFACTURING CO., INC.
- M. MADISON WIRE AND CABLE CORP.
- N. OKONITE CO.
- O. PIRELLI CABLE CORP.
- P. RADIX WIRE CO.
- Q. ROME CABLE CORP.
- R. SOUTHWIRE COMPANY.
- S. TRIANGLE PWC, INC.

2. CONNECTORS:

- A. AMP, INC.
- B. APPLETON ELECTRIC CO; EMERSON ELECTRIC CO.
- C. BUCHANAN CO.
- D. BURNDY CORPORATION.
- E. BRAND-REX DIV. PYLE NATIONAL CO.
- F. ELECTRICAL PRODUCTS DIV; MIDLAND-ROSS CORP.
- G. GENERAL ELECTRIC CO.
- H. GOULD, INC.
- I. IDEAL INDUSTRIES, INC.
- J. LEVITON MFG COMPANY.
- K. 3M COMPANY
- L. O-Z/GEDNEY CO.
- M. SOUTHPORT INDUSTRIES INC.
- N. SQUARE D COMPANY.
- O. THOMAS AND BETTS CORP.

2.02 WIRES, CABLES AND CONNECTORS

- (A) GENERAL: ALL REFERENCE TO SIZE IN THESE SPECIFICATIONS OR ON DRAWINGS IS FOR COPPER CONDUCTORS. PROVIDE ELECTRICAL WIRES, CABLES AND CONNECTORS OF MANUFACTURER'S STANDARD MATERIALS, AS INDICATED BY PUBLISHED PRODUCT INFORMATION; DESIGNED AND CONSTRUCTED AS RECOMMENDED BY MANUFACTURER, FOR A COMPLETE INSTALLATION AND FOR APPLICATION INDICATED. EXCEPT AS OTHERWISE INDICATED, PROVIDE COPPER CONDUCTORS WITH CONDUCTIVITY OF NOT LESS THAN 98% AT 20°C (68°F).
- (B) BUILDING WIRES: PROVIDE FACTORY-FABRICATED WIRES OF SIZES, AMPACITY RATING, AND MATERIALS FOR APPLICATIONS AND SERVICES INDICATED. WHERE NOT INDICATED, PROVIDE PROPER WIRE SELECTION AS DETERMINED BY INSTALLER TO COMPLY WITH PROJECT'S INSTALLATION REQUIREMENTS, NEC AND NEMA STANDARDS.
- (C) CABLES: PROVIDE UL-TYPE FACTORY-FABRICATED CABLES OF SIZES, AMPACITY RATINGS, AND MATERIALS AND JACKETING/SHEATHING AS INDICATED FOR SERVICES INDICATED. WHERE NOT INDICATED, PROVIDE PROPER SELECTION AS DETERMINED BY INSTALLER TO COMPLY WITH INSTALLATION REQUIREMENTS, NEC AND NEMA STANDARDS.
- (D) CONNECTORS: PROVIDE UL-TYPE FACTORY-FABRICATED, METAL CONNECTORS OF SIZES, AMPACITY RATINGS, MATERIALS, TYPES AND CLASSES FOR APPLICATIONS AND FOR SERVICES INDICATED. WHERE NOT INDICATED, PROVIDE PROPER SELECTION AS DETERMINED BY INSTALLER TO COMPLY WITH PROJECT'S INSTALLATION REQUIREMENTS, NEC AND NEMA STANDARDS.

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRES AND CABLES

- (A) GENERAL: INSTALL ELECTRICAL CABLES, WIRES AND WIRING CONNECTORS AS INDICATED, IN COMPLIANCE WITH APPLICABLE REQUIREMENTS OF NEC, NEMA, UL AND NECA'S "STANDARD OF INSTALLATION" AND IN ACCORDANCE WITH RECOGNIZED INDUSTRY PRACTICES.
- (B) THE NORMAL MINIMUM SIZE SHALL BE 12 AWG. ALL WIRE NO. 10 AND SMALLER TO BE SOLID, ALL NO. 8 AND LARGER SHALL BE STRANDED.
- (C) ALL SERVICE ENTRANCE, FEEDER AND BRANCH CIRCUIT WIRING SHALL BE TYPE THHN/THWN.
- (D) PULL CONDUCTORS SIMULTANEOUSLY WHERE MORE THAN ONE (1) IS BEING INSTALLED IN SAME RACEWAY.
- (E) USE POLYWATER DYNA BLUE WATER BASED PULLING LUBRICANT OR EQUAL WHERE NECESSARY.
- (F) INSULATION ON CONDUCTORS SHALL BE PERMANENTLY MARKED WITH WIRE SIZE, INSULATION TYPE, VOLTAGE RANGE AND MANUFACTURER'S NAME. THE INSULATION ON CONDUCTORS SHALL BE COLOR CODED AS FOLLOWS:
 - 1. 120/208-VOLT CIRCUIT: PHASE A - BLACK; PHASE B - RED; PHASE C - BLUE.
- (G) THE PHASE CONDUCTORS SHALL BE TAGGED AND SHALL REMAIN THE SAME THROUGHOUT THE CIRCUIT.
- (H) SWITCH LEGS SHALL BE COLOR CODED TO DISTINGUISH THEM FROM HOT OR PHASE CONDUCTORS.
- (I) SWITCH LEGS OCCURRING IN THE SAME BOX OR ENCLOSURE SHALL BE COLOR CODED SEPARATELY.

- (J) EXCEPTIONS TO THE COLOR CODING AS LISTED ABOVE SHALL BE AS FOLLOWS:
1. WIRING FOR SPECIAL SYSTEMS SHALL BE COLOR CODED OR LABELED AS REQUIRED BY THE MANUFACTURER.
- (K) USE PULLING MEANS INCLUDING, FISH TAPE, CABLE, ROPE AND BASKET WEAVE WIRE/CABLE GRIPS WHICH WILL NOT DAMAGE CABLES OR RACEWAY.
- (L) INSTALL EXPOSED CABLE, PARALLEL AND PERPENDICULAR TO SURFACES, OR EXPOSED STRUCTURAL MEMBERS AND FOLLOW SURFACE CONTOURS, WHERE POSSIBLE.
- (M) KEEP CONDUCTOR SPLICES TO MINIMUM.
- (N) INSTALL SPLICES AND TAPS WHICH POSSESS EQUIVALENT-OR-BETTER MECHANICAL STRENGTH AND INSULATION RATINGS THAN CONDUCTORS BEING SPICED.
- (O) USE SPlice AND TAP CONNECTORS WHICH ARE COMPATIBLE WITH CONDUCTOR MATERIAL.
- (P) ALL SPLICES AND TAPS SHALL BE MADE IN OUTLET, JUNCTION AND PULL BOXES. SPLICES ON CIRCUIT WIRING SHALL BE OF THE PIGTAIL TYPE USING SOLDERLESS CONNECTORS. LARGER SIZES OF CONDUCTORS REQUIRING UNINSULATED CONNECTORS OF THE BOLT TYPE SHALL BE TAPED WITH PRESSURE SENSITIVE VINYL TAPE.
- (Q) FOR BRANCH CIRCUIT WIRING, CONDUCTOR FILL PER CONDUIT RUN SHALL NOT CONTAIN MORE THAN EIGHT (8) CURRENT CARRYING WIRES, PROVIDED THE WIRE SIZE IS DERATED AS REQUIRED BY THE NATIONAL ELECTRICAL CODE. CONDUITS CONTAINING BOTH CIRCUIT SWITCH LEGS AND/OR TRAVELER WIRES MAY CONTAIN MORE THAN THE NUMBER STATED ABOVE, PROVIDING THE CONDUIT IS OF ADEQUATE SIZE AND THE WIRE SIZE IS DERATED AS REQUIRED BY THE NATIONAL ELECTRICAL CODE. WHENEVER A 120-VOLT, SINGLE PHASE BRANCH CIRCUIT IS OVER 70-Feet IN LENGTH OR A 277-VOLT, SINGLE PHASE BRANCH CIRCUIT IS OVER 150-Feet, AND THE LOAD IS IN EXCESS OF 50% OF THE BRANCH CIRCUIT PROTECTIVE DEVICE, THE CONDUCTORS SHALL BE INCREASED ONE (1) SIZE TO THE FIRST OUTLET BOX UNLESS SPECIFICALLY NOTED OTHERWISE. FOR SPECIAL SYSTEMS CONDUCTOR FILL OF CONDUIT IS PER MANUFACTURERS SPECIFICATIONS FURNISHED WITH EACH SYSTEM, NOTED ON THE DRAWINGS OR SHALL BE AS REQUIRED BY CODE.
- (R) TIGHTEN ELECTRICAL CONNECTORS AND TERMINALS, INCLUDING SCREWS AND BOLTS, IN ACCORDANCE WITH MANUFACTURER'S PUBLISHED TORQUE TIGHTENING VALUES. WHERE MANUFACTURER'S TORQUING REQUIREMENTS ARE NOT INDICATED, TIGHTEN CONNECTORS AND TERMINALS TO COMPLY WITH TIGHTENING TORQUES SPECIFIED IN UL STANDARD 486A AND B.

3.02 FIELD QUALITY CONTROL

- (A) PRIOR TO ENERGIZATION OF CIRCUITRY, CHECK INSTALLED WIRES AND CABLES WITH MEGOHM METER TO DETERMINE INSULATION RESISTANCE LEVELS TO ENSURE REQUIREMENTS ARE FULFILLED.
- (B) PRIOR TO ENERGIZATION, TEST WIRES AND CABLES FOR ELECTRICAL CONTINUITY AND FOR SHORT-CIRCUITS.
- (C) SUBSEQUENT TO WIRE AND CABLE HOOK-UPS, ENERGIZE CIRCUITRY AND DEMONSTRATE FUNCTIONING IN ACCORDANCE WITH REQUIREMENTS. WHERE NECESSARY, CORRECT MALFUNCTIONING UNITS AND THEN RETEST TO DEMONSTRATE COMPLIANCE.

END OF SECTION 26 05 19 – WIRES AND CABLES

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WIRES AND CABLES
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SECTION 26 05 26 - GROUNDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF GROUNDING WORK IS INDICATED BY DRAWINGS, SCHEDULES AND AS SPECIFIED HEREIN.
- (B) TYPES OF GROUNDING SPECIFIED IN THIS SECTION INCLUDE THE FOLLOWING:
1. SOLID GROUNDING.
- (C) REQUIREMENTS OF THIS SECTION APPLY TO ELECTRICAL GROUNDING WORK SPECIFIED ELSEWHERE IN THESE SPECIFICATIONS.

PART 2 - PRODUCTS

2.01 GROUNDING SYSTEMS

- (A) MATERIALS AND COMPONENTS:
1. GENERAL: EXCEPT AS OTHERWISE INDICATED, PROVIDE ELECTRICAL GROUNDING SYSTEMS INDICATED; WITH ASSEMBLY OF MATERIALS, INCLUDING, BUT NOT LIMITED TO, CABLES/WIRES, CONNECTORS, TERMINALS (SOLDERLESS LUGS), GROUNDING RODS/ELECTRODES AND PLATE ELECTRODES, BONDING JUMPER BRAID AND ADDITIONAL ACCESSORIES NEEDED FOR COMPLETE INSTALLATION. WHERE MORE THAN ONE TYPE UNIT MEETS INDICATED REQUIREMENTS, SELECTION IS INSTALLER'S OPTION. WHERE MATERIALS OR COMPONENTS ARE NOT INDICATED, PROVIDE PRODUCTS COMPLYING WITH NEC, UL, IEEE AND ESTABLISHED INDUSTRY STANDARDS FOR APPLICATIONS INDICATED.
- (B) CONDUCTORS: PROVIDE COPPER ELECTRICAL GROUNDING CONDUCTORS FOR GROUNDING CONNECTIONS MATCHING POWER SUPPLY WIRING MATERIALS AND SIZED ACCORDING TO NEC. ALL CONDUITS SHALL CONTAIN A MINIMUM OF ONE (1) SEPARATE EQUIPMENT GROUNDING CONDUCTOR IDENTIFIED AND SIZED ACCORDING TO NEC.
- (C) BONDING JUMPER BRAID: COPPER BRAIDED TAPE, CONSTRUCTED OF 30-GAGE BARE COPPER WIRES AND PROPERLY SIZED FOR INDICATED APPLICATIONS.
- (D) FLEXIBLE JUMPER STRAP: FLEXIBLE FLAT CONDUCTOR, 480 STRANDS OF 30-GAGE BARE COPPER WIRE; 3/4-INCH WIDE, 9-1/2-INCHES LONG; 48,250CM. PROTECT BRAID WITH COPPER BOLT HOLE ENDS WITH HOLES SIZED FOR 3/8-INCH DIA. BOLTS.
- (E) BONDING PLATES, CONNECTORS, TERMINALS AND CLAMPS: PROVIDE ELECTRICAL BONDING PLATES, CONNECTORS, TERMINALS, LUGS AND CLAMPS AS RECOMMENDED BY BONDING PLATE, CONNECTOR, TERMINAL AND CLAMP MANUFACTURERS FOR INDICATED APPLICATIONS.

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(F) GROUND RODS AND PLATES:

1. GROUND RODS: STEEL WITH COPPER WELDED EXTERIOR, 5/8-INCH DIA. X 8-FEET (UNLESS OTHERWISE NOTED).
2. GROUND PLATES: SHEET COPPER PLATE, 20-GAGE X 36-INCH X 36-INCH, WITH TWO (2) CABLE ATTACHMENTS FOR 1/0 OR 2/0 CABLES.

(G) ELECTRICAL GROUNDING CONNECTION ACCESSORIES: PROVIDE ELECTRICAL INSULATING TAPE, HEAT-SHRINKABLE INSULATING TUBING, WELDING MATERIALS, BONDING STRAPS, AS RECOMMENDED BY ACCESSORIES MANUFACTURERS FOR TYPE SERVICES INDICATED.

(H) EXOTHERMIC WELDED CONNECTIONS: COMPLY WITH AWS CODE FOR PROCEDURES, APPEARANCE, AND QUALITY OF WELDS; AND METHODS USED IN CORRECTING WELDING WORK. PROVIDE WELDED CONNECTIONS WHERE GROUNDING CONDUCTORS CONNECT TO UNDERGROUND GROUNDING RODS/ELECTRODES.

PART 3 - EXECUTION

3.01 INSPECTION

- (A)** INSTALLER MUST EXAMINE AREAS AND CONDITIONS UNDER WHICH ELECTRICAL GROUNDING CONNECTIONS ARE TO BE MADE AND NOTIFY CONTRACTOR IN WRITING OF CONDITIONS DETRIMENTAL TO PROPER COMPLETION OF WORK. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN A MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF ELECTRICAL GROUNDING

- (A)** GENERAL: INSTALL ELECTRICAL GROUNDING SYSTEMS WHERE SHOWN, IN ACCORDANCE WITH APPLICABLE PORTIONS OF NEC, WITH NECA'S "STANDARD OF INSTALLATION" AND IN ACCORDANCE WITH RECOGNIZED INDUSTRY PRACTICES TO ENSURE THAT PRODUCTS COMPLY WITH REQUIREMENTS AND SERVE INTENDED FUNCTIONS.
- (B)** THE EQUIPMENT GROUNDING CONDUCTOR SHALL BE CONNECTED DIRECTLY TO THE EQUIPMENT GROUNDING SCREW PROVIDED ON RECEPTACLES.
- (C)** AT SWITCH OUTLETS, WHERE SELF-GROUNDING TYPE SWITCHES ARE INSTALLED IN METAL BOXES, THE EQUIPMENT GROUNDING CONDUCTOR SHALL BE CONNECTED DIRECTLY TO THE METAL BOX.
- (D)** WHERE SWITCHES INSTALLED IN NON-METALLIC BOXES HAVE METALLIC COVER PLATES OR SCREWS, PROVIDE SWITCHES WITH GREEN HEXAGONAL EQUIPMENT GROUND SCREW AND CONNECT TO THE EQUIPMENT GROUNDING CONDUCTOR.
- (E)** COORDINATE WITH OTHER ELECTRICAL WORK AS NECESSARY TO INTERFACE INSTALLATION OF ELECTRICAL GROUNDING SYSTEM WITH OTHER WORK.
- (F)** WELD GROUNDING CONDUCTORS TO UNDERGROUND GROUNDING RODS/ELECTRODES. (WELDS THAT ARE PUFFED UP OR THAT SHOW CONVEX SURFACES INDICATING IMPROPER CLEANING ARE NOT ACCEPTABLE).
- (G)** INSTALL BONDING JUMPERS WITH GROUND CLAMPS ON WATER METER PIPING TO ELECTRICALLY BYPASS WATER METERS.
- (H)** INSTALL CLAMP-ON CONNECTORS ONLY ON THOROUGHLY CLEANED METAL CONTACT SURFACES, TO ENSURE ELECTRICAL CONDUCTIVITY AND CIRCUIT INTEGRITY.

3.03 FIELD QUALITY CONTROL

- (A) UPON COMPLETION OF INSTALLATION OF ELECTRICAL GROUNDING SYSTEMS, TEST GROUND RESISTANCE WITH GROUND RESISTANCE TESTER. WHERE TESTS SHOW RESISTANCE TO GROUND IS OVER 5 OHMS, TAKE APPROPRIATE ACTION TO REDUCE RESISTANCE TO 5 OHMS OR LESS, BY DRIVING ADDITIONAL GROUND RODS AND/OR BY CHEMICALLY TREATING SOIL ENCIRCLING GROUND ROD; THEN RETEST TO DEMONSTRATE COMPLIANCE.

END OF SECTION 26 05 26 - GROUNDING

SECTION 26 05 29 - SUPPORTING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) THIS SECTION INCLUDES SECURE SUPPORT FROM THE BUILDING STRUCTURE FOR ELECTRICAL ITEMS BY MEANS OF HANGERS, SUPPORTS, ANCHORS, SLEEVES, INSERTS, SEALS AND ASSOCIATED FASTENINGS.

1. REFER TO OTHER DIVISION 26 SECTIONS FOR ADDITIONAL SPECIFIC SUPPORT REQUIREMENTS THAT MAY BE APPLICABLE TO SPECIFIC ITEMS.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY THE FOLLOWING:

1. SLOTTED METAL ANGLE AND U-CHANNEL SYSTEMS:

- A. ALLIED TUBE & CONDUIT.
- B. AMERICAN ELECTRIC.
- C. B-LINE SYSTEMS, INC.
- D. CINCH CLAMP CO., INC.
- E. GS METALS CORP.
- F. HAYDON CORP.
- G. KIN-LINE, INC.
- H. UNISTRUT DIVERSIFIED PRODUCTS.

2. CONDUIT SEALING BUSHINGS:

- A. BRIDGEPORT FITTINGS, INC.
- B. COOPER INDUSTRIES, INC.
- C. ELLIOTT ELECTRIC MFG. CORP.
- D. GS METALS CORP.
- E. KILLARK ELECTRIC MFG. CO.

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- F. MADISON EQUIPMENT CO.
- G. L.E. MASON CO.
- H. O-Z/GEDNEY.
- I. PRODUCTO ELECTRIC CORP.
- J. RACO, INC.
- K. RED SEAL ELECTRIC CORP.
- L. SPRING CITY ELECTRICAL MFG. CO.
- M. THOMAS & BETTS CORP.

2.02 COATINGS

- (A) COATING: SUPPORTS, SUPPORT HARDWARE, AND FASTENERS SHALL BE PROTECTED WITH ZINC COATING OR WITH TREATMENT OF EQUIVALENT CORROSION RESISTANCE USING APPROVED ALTERNATIVE TREATMENT, FINISH OR INHERENT MATERIAL CHARACTERISTIC. PRODUCTS FOR USE OUTDOORS SHALL BE HOT-DIP GALVANIZED.

2.03 MANUFACTURED SUPPORTING DEVICES

- (A) RACEWAY SUPPORTS: CLEVIS HANGERS, RISER CLAMPS, CONDUIT STRAPS, THREADED C-CLAMPS WITH RETAINERS, CEILING TRAPEZE HANGERS, WALL BRACKETS AND SPRING STEEL CLAMPS.
- (B) FASTENERS: TYPES, MATERIALS AND CONSTRUCTION FEATURES AS FOLLOWS:
- 1. EXPANSION ANCHORS: CARBON STEEL WEDGE OR SLEEVE TYPE. PLASTIC EXPANSION ANCHORS (FOR CONDUIT 1-INCH AND SMALLER ONLY).
 - 2. TOGGLE BOLTS: ALL STEEL SPRINGHEAD TYPE.
 - 3. POWDER-DRIVEN THREADED STUDS: HEAT-TREATED STEEL, DESIGNED SPECIFICALLY FOR THE INTENDED SERVICE.
- (C) CONDUIT SEALING BUSHINGS: FACTORY-FABRICATED WATERTIGHT CONDUIT SEALING BUSHING ASSEMBLIES SUITABLE FOR SEALING AROUND CONDUIT OR TUBING PASSING THROUGH CONCRETE FLOORS AND WALLS. CONSTRUCT SEALS WITH STEEL SLEEVE, MALLEABLE IRON BODY, NEOPRENE SEALING GROMMETS OR RINGS, METAL PRESSURE RINGS, PRESSURE CLAMPS AND CAP SCREWS.
- (D) CABLE SUPPORTS FOR VERTICAL CONDUIT: FACTORY-FABRICATED ASSEMBLY CONSISTING OF THREADED BODY AND INSULATING WEDGING PLUG FOR NONARMORED ELECTRICAL CABLES IN RISER CONDUITS. PROVIDE PLUGS WITH NUMBER AND SIZE OF CONDUCTOR GRIPPING HOLES AS REQUIRED TO SUIT INDIVIDUAL RISERS. CONSTRUCT BODY OF MALLEABLE-IRON CASTING WITH HOT-DIP GALVANIZED FINISH.
- (E) U-CHANNEL SYSTEMS: 16-GAGE STEEL CHANNELS, WITH 9/16-INCH DIAMETER HOLES, AT A MINIMUM OF 8-INCHES ON CENTER, IN TOP SURFACE. PROVIDE FITTINGS AND ACCESSORIES THAT MATE AND MATCH THE U-CHANNEL AND ARE OF THE SAME MANUFACTURER.

2.04 FABRICATED SUPPORTING DEVICES

- (A) GENERAL: SHOP- OR FIELD-FABRICATED SUPPORTS OR MANUFACTURED SUPPORTS ASSEMBLED FROM U-CHANNEL COMPONENTS.
- (B) STEEL BRACKETS: FABRICATED OF ANGLES, CHANNELS AND OTHER STANDARD STRUCTURAL SHAPES. CONNECT WITH WELDS AND MACHINE BOLTS TO FORM RIGID SUPPORTS.
- (C) PIPE SLEEVES: PROVIDE PIPE SLEEVES OF ONE (1) OF THE FOLLOWING:
1. SHEET METAL: FABRICATE FROM GALVANIZED SHEET METAL; ROUND TUBE CLOSED WITH SNAPLOCK JOINT, WELDED SPIRAL SEAMS OR WELDED LONGITUDINAL JOINT. FABRICATE SLEEVES FROM THE FOLLOWING GAGE METAL FOR SLEEVE DIAMETER NOTED:
 - A. 3-INCHES AND SMALLER: 20-GAGE.
 - B. 4-INCH TO 6-INCHES: 16-GAGE.
 - C. OVER 6-INCHES: 14-GAGE.
 2. STEEL PIPE: FABRICATE FROM SCHEDULE 40 GALVANIZED STEEL PIPE.
 3. PLASTIC PIPE: FABRICATE FROM SCHEDULE 80 PVC PLASTIC PIPE.

PART 3 - EXECUTION

3.01 INSTALLATION

- (A) INSTALL SUPPORTING DEVICES TO FASTEN ELECTRICAL COMPONENTS SECURELY AND PERMANENTLY IN ACCORDANCE WITH NEC REQUIREMENTS.
- (B) COORDINATE WITH THE BUILDING STRUCTURAL SYSTEM AND WITH OTHER ELECTRICAL INSTALLATION.
- (C) RACEWAY SUPPORTS: COMPLY WITH THE NEC AND THE FOLLOWING REQUIREMENTS:
1. CONFORM TO MANUFACTURER'S RECOMMENDATIONS FOR SELECTION AND INSTALLATION OF SUPPORTS.
 2. STRENGTH OF EACH SUPPORT SHALL BE ADEQUATE TO CARRY PRESENT AND FUTURE LOAD MULTIPLIED BY A SAFETY FACTOR OF AT LEAST FOUR (4). WHERE THIS DETERMINATION RESULTS IN A SAFETY ALLOWANCE OF LESS THAN 200 LBS, PROVIDE ADDITIONAL STRENGTH UNTIL THERE IS A MINIMUM OF 200 LBS SAFETY ALLOWANCE IN THE STRENGTH OF EACH SUPPORT.
 3. INSTALL INDIVIDUAL AND MULTIPLE (TRAPEZE) RACEWAY HANGERS AND RISER CLAMPS AS NECESSARY TO SUPPORT RACEWAYS. PROVIDE U-BOLTS, CLAMPS, ATTACHMENTS, AND OTHER HARDWARE NECESSARY FOR HANGER ASSEMBLY AND FOR SECURING HANGER RODS AND CONDUITS.
 4. SUPPORT PARALLEL RUNS OF HORIZONTAL RACEWAYS TOGETHER ON TRAPEZE-TYPE HANGERS.
 5. SUPPORT INDIVIDUAL HORIZONTAL RACEWAYS BY SEPARATE PIPE HANGERS. SPRING STEEL FASTENERS MAY BE USED IN LIEU OF HANGERS ONLY FOR 1-INCH AND SMALLER RACEWAYS SERVING LIGHTING AND RECEPTACLE BRANCH CIRCUITS ABOVE SUSPENDED CEILINGS ONLY. FOR HANGER RODS WITH SPRING STEEL FASTENERS, USE 1/4-INCH DIAMETER OR LARGER THREADED STEEL. USE SPRING STEEL FASTENERS THAT ARE SPECIFICALLY DESIGNED FOR SUPPORTING SINGLE CONDUITS OR TUBING.

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6. SUPPORT EXPOSED AND CONCEALED RACEWAY WITHIN 1-FOOT OF AN UNSUPPORTED BOX AND ACCESS FITTINGS. IN HORIZONTAL RUNS, SUPPORT AT THE BOX AND ACCESS FITTINGS MAY BE OMITTED WHERE BOX OR ACCESS FITTINGS ARE INDEPENDENTLY SUPPORTED AND RACEWAY TERMINALS ARE NOT MADE WITH CHASE NIPPLES OR THREADLESS BOX CONNECTORS.
 7. IN VERTICAL RUNS, ARRANGE SUPPORT SO THAT LOAD PRODUCED BY THE WEIGHT OF THE RACEWAY AND THE ENCLOSED CONDUCTORS IS CARRIED ENTIRELY BY THE CONDUIT SUPPORTS WITH NO WEIGHT LOAD ON RACEWAY TERMINALS.
- (D) VERTICAL CONDUCTOR SUPPORTS: INSTALL SIMULTANEOUSLY WITH INSTALLATION OF CONDUCTORS.
- (E) MISCELLANEOUS SUPPORTS: SUPPORT MISCELLANEOUS ELECTRICAL COMPONENTS AS REQUIRED TO PRODUCE THE SAME STRUCTURAL SAFETY FACTORS AS SPECIFIED FOR RACEWAY SUPPORTS. INSTALL METAL CHANNEL RACKS FOR MOUNTING CABINETS, PANELBOARDS, DISCONNECTS, CONTROL ENCLOSURES, PULL BOXES, JUNCTION BOXES, TRANSFORMERS AND OTHER DEVICES.
- (F) SUPPORT SHEET METAL BOXES DIRECTLY FROM THE BUILDING STRUCTURE OR BY BAR HANGERS.
- (G) SLEEVES: INSTALL IN CONCRETE SLABS AND WALLS AND ALL OTHER FIRERATED FLOORS AND WALLS FOR RACEWAYS AND CABLE INSTALLATIONS. FOR SLEEVES THROUGH FIRE RATED-WALL OR FLOOR CONSTRUCTION, APPLY UL LISTED FIRESTOPPING SEALANT IN GAPS BETWEEN SLEEVES AND ENCLOSED CONDUITS AND CABLES.
- (H) CONDUIT SEALS: INSTALL SEALS FOR CONDUIT PENETRATIONS OF SLABS ON GRADE AND EXTERIOR WALLS BELOW GRADE AND WHERE INDICATED. TIGHTEN SLEEVE SEAL SCREWS UNTIL SEALING GROMMETS HAVE EXPANDED TO FORM WATERTIGHT SEAL.
- (I) FASTENING: UNLESS OTHERWISE INDICATED, FASTEN ELECTRICAL ITEMS AND THEIR SUPPORTING HARDWARE SECURELY TO THE BUILDING STRUCTURE, INCLUDING BUT NOT LIMITED TO CONDUITS, RACEWAYS, CABLES, CABLE TRAYS, BUSWAYS, CABINETS, PANELBOARDS, TRANSFORMERS, BOXES, DISCONNECT SWITCHES AND CONTROL COMPONENTS IN ACCORDANCE WITH THE FOLLOWING:
1. FASTEN BY MEANS OF WOOD SCREWS OR SCREW-TYPE NAILS ON WOOD, TOGGLE BOLTS ON HOLLOW MASONRY UNITS, CONCRETE INSERTS OR EXPANSION BOLTS ON CONCRETE OR SOLID MASONRY, AND MACHINE SCREWS, WELDED THREADED STUDS, OR SPRING-TENSION CLAMPS ON STEEL. THREADED STUDS DRIVEN BY A POWDER CHARGE AND PROVIDED WITH LOCK WASHERS AND NUTS MAY BE USED INSTEAD OF EXPANSION BOLTS AND MACHINE OR WOOD SCREWS. DO NOT WELD CONDUIT, PIPE STRAPS OR ITEMS OTHER THAN THREADED STUDS TO STEEL STRUCTURES. IN PARTITIONS OF LIGHT STEEL CONSTRUCTION, USE SHEET METAL SCREWS.
 2. HOLES CUT TO DEPTH OF MORE THAN 1-1/2-INCH IN REINFORCED CONCRETE BEAMS OR TO DEPTH OF MORE THAN 3/4-INCH IN CONCRETE SHALL NOT CUT THE MAIN REINFORCING BARS. FILL HOLES THAT ARE NOT USED.
 3. ENSURE THAT THE LOAD APPLIED TO ANY FASTENER DOES NOT EXCEED 25% OF THE PROOF TEST LOAD. USE VIBRATION- AND SHOCK-RESISTANT FASTENERS FOR ATTACHMENTS TO CONCRETE SLABS.

END OF SECTION 26 05 29 – SUPPORTING DEVICES

SECTION 26 05 33 - RACEWAYS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) ALL WIRING SHALL BE INSTALLED IN CONTINUOUS RACEWAYS AS SPECIFIED HEREIN EXCEPT WHERE SPECIFICALLY NOTED OTHERWISE.

1. WHEN IN CONFORMANCE WITH THE NATIONAL ELECTRICAL CODE AND OTHER APPLICABLE CODES AND LISTED FOR USE IN RETURN AIR PLENUMS, LOW VOLTAGE WIRING (30-VOLT OR LESS) MAY BE INSTALLED WITHOUT CONDUIT ABOVE ACCESSIBLE CEILINGS UNLESS NOTED OTHERWISE. ALL LOW VOLTAGE WIRING AT OTHER LOCATIONS (CONCEALED IN WALLS, ABOVE NON-ACCESSIBLE CEILINGS, EXPOSED AREAS WITHOUT CEILINGS, ETC.) SHALL BE INSTALLED IN CONDUIT. ALL FIRE ALARM SYSTEM WIRING SHALL BE INSTALLED IN CONDUIT. ALL CABLE INSTALLED WITHOUT CONDUIT SHALL BE NEATLY PLACED WITHIN JOIST SPACE ABOVE CEILINGS AND PROPERLY SUPPORTED. CABLE SHALL NOT BE PLACED ON OR SUPPORTED BY CEILING SYSTEM.

- (B) TYPES OF RACEWAYS IN THIS SECTION INCLUDE THE FOLLOWING:

1. ELECTRICAL METALLIC TUBING.
2. FLEXIBLE METAL CONDUIT.
3. LIQUID-TIGHT FLEXIBLE METAL CONDUIT.
4. RIGID METAL CONDUIT.
5. RIGID NONMETALLIC CONDUIT.

PART 2 - PRODUCTS

2.01 METAL CONDUIT AND TUBING

- (A) GENERAL: PROVIDE METAL CONDUIT, TUBING AND FITTINGS OF TYPES, GRADES, SIZES AND WEIGHTS (WALL THICKNESSES) FOR EACH SERVICE INDICATED. WHERE TYPES AND GRADES ARE NOT INDICATED, PROVIDE PROPER SELECTION DETERMINED BY INSTALLER TO FULFILL WIRING REQUIREMENTS AND COMPLY WITH APPLICABLE PORTIONS OF NEC FOR RACEWAYS.

- (B) RIGID STEEL CONDUIT: PROVIDE RIGID STEEL, ZINC-COATED, THREADED TYPE CONFORMING TO ANSI C80.1 AND UL 6. PROVIDE ZINC COATING FUSED TO INSIDE AND OUTSIDE WALLS.

1. RIGID METAL CONDUIT FITTINGS: RIGID METAL CONDUITS SHALL HAVE THREADED COUPLINGS WHEN INSTALLED IN CONCRETE OR DIRECT BURIAL IN THE GROUND. OTHER INSTALLATIONS IN DRY LOCATIONS MAY BE THREADLESS RIGID FITTINGS.
2. PVC EXTERNALLY COATED RIGID STEEL CONDUIT: PROVIDE RIGID STEEL ZINC-COATED WITH ADDITIONAL EXTERNAL COATING OF PVC CONFORMING TO ANSI C80.1 AND NEMA RN 1.

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- (C) FLEXIBLE METAL CONDUIT: PROVIDE FLEXIBLE METAL CONDUIT CONFORMING TO UL 1. FORMED FROM CONTINUOUS LENGTH OF SPIRALLY WOUND, INTERLOCKED ZINC-COATED STRIP STEEL.
1. FLEXIBLE METAL CONDUIT FITTINGS: PROVIDE CONDUIT FITTINGS FOR USE WITH FLEXIBLE STEEL CONDUIT OF THREADLESS HINGED CLAMP TYPE.
- A. STRAIGHT TERMINAL CONNECTORS: ONE-PIECE BODY, FEMALE END WITH CLAMP AND DEEP SLOTTED MACHINE SCREW FOR SECURING CONDUIT AND MALE THREADED END PROVIDED WITH LOCKNUT.
- B. 45° OR 90° TERMINAL ANGLE CONNECTORS: TWO-PIECE BODY CONSTRUCTION WITH REMOVABLE UPPER SECTION, FEMALE END WITH CLAMP AND DEEP SLOTTED MACHINE SCREW FOR SECURING CONDUIT AND MALE THREADED END PROVIDED WITH LOCKNUT.
- (D) LIQUID-TIGHT FLEXIBLE METAL CONDUIT: PROVIDE LIQUID-TIGHT FLEXIBLE METAL CONDUIT CONFORMING TO UL 360; CONSTRUCT OF SINGLE STRIP, FLEXIBLE, CONTINUOUS, INTERLOCKED AND DOUBLE-WRAPPED STEEL; GALVANIZED INSIDE AND OUTSIDE; COAT WITH LIQUID-TIGHT JACKET OF FLEXIBLE POLYVINYL CHLORIDE (PVC).
1. LIQUID-TIGHT FLEXIBLE METAL CONDUIT FITTINGS: PROVIDE CADMIUM PLATED, MALLEABLE IRON FITTINGS WITH COMPRESSION TYPE STEEL FERRULE AND NEOPRENE GASKET SEALING RINGS, WITH INSULATED THROAT.
- (E) ELECTRICAL METALLIC TUBING (EMT): PROVIDE ELECTRICAL METALLIC TUBING CONFORMING TO ANSI C80.3 AND UL 797.
1. EMT FITTINGS: FITTINGS FOR EMT SHALL BE STEEL AND MAY BE OF THE SCREW OR COMPRESSION TYPE EXCEPT THAT IN POURED CONCRETE THE SCREW TYPE IS NOT ACCEPTABLE. ALL EMT CONNECTORS SHALL BE OF THE INSULATED THROAT TYPE. CAST OR INDENTER FITTINGS ARE NOT ACCEPTABLE. EMT CONNECTORS SHALL BE FASTENED TO BOX OR ENCLOSURE WITH LOCKNUTS. SNAP-IN FITTINGS ARE NOT ACCEPTABLE.
2. STEEL EMT CONNECTORS WITH MALE THREADS ON THE LOCKNUT AND FEMALE THREADS ON THE CONNECTOR EQUAL TO COOPER CROUSE-HINDS SPACE-SAVER CONNECTORS MAY BE USED IN LIEU OF INSULATED THROAT TYPE CONNECTORS.
- (F) CONDUIT BODIES: PROVIDE GALVANIZED CAST-METAL CONDUIT BODIES OF TYPES, SHAPES AND SIZES AS REQUIRED TO FULFILL JOB REQUIREMENTS AND NEC REQUIREMENTS. CONSTRUCT CONDUIT BODIES WITH THREADED-CONDUIT-ENTRANCE ENDS, REMOVABLE COVERS, EITHER CAST OR OF GALVANIZED STEEL AND CORROSION-RESISTANT SCREWS.

2.02 NONMETALLIC CONDUIT

- (A) GENERAL: PROVIDE NONMETALLIC CONDUIT AND FITTINGS OF TYPES, SIZES AND WEIGHTS AS SPECIFIED.
- (B) RIGID NONMETALLIC CONDUIT:
1. HEAVY WALL CONDUIT: SCHEDULE 40, 90 C, UL RATED, CONSTRUCT OF POLYVINYL CHLORIDE AND CONFORMING TO NEMA TC-2, FOR DIRECT BURIAL, OR NORMAL ABOVE GROUND USE, UL LISTED.
2. EXTRA HEAVY WALL CONDUIT: SCHEDULE 80, UL RATED, CONSTRUCT OF POLYVINYL CHLORIDE COMPOUND C-200 PVC AND UL LISTED FOR DIRECT BURIAL OR ABOVE GROUND USE.
- (C) CONDUIT AND TUBING ACCESSORIES: PROVIDE CONDUIT AND TUBING DUCT ACCESSORIES OF TYPES, SIZES, AND MATERIALS, COMPLYING WITH MANUFACTURERS PUBLISHED PRODUCT INFORMATION, WHICH MATE AND MATCH CONDUIT AND TUBING.

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PART 3 - EXECUTION

3.01 INSTALLATION OF RACEWAYS

- (A) GENERAL: INSTALL RACEWAYS AS INDICATED; IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTALLATION INSTRUCTIONS, AND IN COMPLIANCE WITH NEC AND NECA'S "STANDARDS OF INSTALLATION". INSTALL UNITS PLUMB AND LEVEL AND MAINTAIN MANUFACTURER'S RECOMMENDED CLEARANCES.
- (B) COORDINATE WITH OTHER WORK INCLUDING WIRES/CABLES, BOXES AND PANEL WORK, AS NECESSARY TO INTERFACE INSTALLATION OF ELECTRICAL RACEWAYS AND COMPONENTS WITH OTHER WORK.

3.02 INSTALLATION OF CONDUITS

- (A) GENERAL: ALL CONDUITS SHALL BE CONCEALED UNLESS NOTED OTHERWISE. INSTALL CONCEALED CONDUITS EITHER IN WALLS, SLABS OR ABOVE HUNG CEILINGS.
1. MECHANICALLY FASTEN TOGETHER METAL CONDUITS, ENCLOSURES, AND RACEWAYS FOR CONDUCTORS TO FORM CONTINUOUS ELECTRICAL CONDUCTOR. CONNECT TO ELECTRICAL BOXES, FITTINGS AND CABINETS TO PROVIDE ELECTRICAL CONTINUITY AND FIRM MECHANICAL ASSEMBLY.
 2. AVOID USE OF DISSIMILAR METALS THROUGHOUT SYSTEM TO ELIMINATE POSSIBILITY OF ELECTROLYSIS. WHERE DISSIMILAR METALS ARE IN CONTACT, COAT SURFACES WITH CORROSION INHIBITING COMPOUND BEFORE ASSEMBLING.
 3. INSTALL MISCELLANEOUS FITTINGS SUCH AS REDUCERS, CHASE NIPPLES, 3-PIECE UNIONS, SPLIT COUPLINGS, AND PLUGS THAT HAVE BEEN SPECIFICALLY DESIGNED AND MANUFACTURED FOR THEIR PARTICULAR APPLICATION. INSTALL EXPANSION FITTINGS IN RACEWAYS EVERY 200-FEET LINEAR RUN OR WHEREVER STRUCTURAL EXPANSION JOINTS ARE CROSSED.
 4. USE ROUGHING-IN DIMENSIONS OF ELECTRICALLY OPERATED UNIT FURNISHED BY SUPPLIER. SET CONDUIT AND BOXES FOR CONNECTION TO UNITS ONLY AFTER RECEIVING REVIEW OF DIMENSIONS AND AFTER CHECKING LOCATION WITH OTHER TRADES.
- (B) CONDUIT INSTALLATION: PROVIDE RIGID CONDUIT WHERE EMBEDDED IN CONCRETE ON OR BELOW GRADE, IN DIRECT CONTACT WITH EARTH OR FILL BELOW SLAB, WET LOCATIONS, IN SIZES LARGER THAN 2-INCHES OR INSTALLED OUTDOORS. FOLLOW MINIMUM REQUIREMENTS IN OTHER AREAS AS FOLLOWS:
1. USE RIGID STEEL ZINC-COATED CONDUIT IN SPACES WHERE EXPOSED BELOW 4-FEET-0-INCH HEIGHT IN MECHANICAL EQUIPMENT ROOMS, ELECTRICAL EQUIPMENT ROOMS, PENTHOUSES AND IN SERVICE SPLINES. OTHER AREAS INCLUDE WAREHOUSE SPACES WHERE EXPOSED BELOW 18-FEET-0-INCH HEIGHT, ON FLOORS OF CRAWL SPACES AND LOCATIONS SUBJECT TO MECHANICAL INJURY.
 2. WHERE ACCEPTABLE TO ALL AUTHORITIES HAVING JURISDICTION, INTERMEDIATE METAL CONDUIT MAY BE USED IN LIEU OF RIGID STEEL CONDUIT IN NON-HAZARDOUS LOCATIONS WHEN IN COMPLIANCE WITH NEC.
 3. USE PVC COATED RIGID STEEL CONDUIT AND FITTINGS WHERE INSTALLED IN CORROSIVE ATMOSPHERE. PATCH ALL NICKS AND SCRAPES IN PVC COATING AFTER INSTALLING CONDUIT.
 4. USE STEEL ZINC-COATED EMT FOR RACEWAY SYSTEMS EXCEPT AS SPECIFICALLY SPECIFIED PREVIOUSLY, WHERE NOT ALLOWED BY NEC OR NOTED ON DRAWINGS. ADDITIONALLY EMT SHALL NOT BE ACCEPTABLE BELOW GRADE, IN OR UNDER SLABS ON GRADE, IN WET LOCATIONS OR IN SIZES LARGER THAN 2-INCHES.

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5. USE FLEXIBLE CONDUIT IN MOVABLE PARTITIONS AND FROM OUTLET BOXES TO RECESSED LIGHTING FIXTURES IN ACCESSIBLE CEILINGS, AND FINAL 24-INCHES OF CONNECTION TO MOTORS, OR CONTROL ITEMS SUBJECT TO MOVEMENT OR VIBRATION, AND IN CELLS OF PRECAST CONCRETE PANELS. THE MAXIMUM LENGTH FOR FLEXIBLE CONDUIT SHALL NOT EXCEED 6-FEET.
6. USE LIQUID-TIGHT FLEXIBLE CONDUIT WHERE SUBJECTED TO ONE (1) OR MORE OF THE FOLLOWING CONDITIONS:
 - A. EXTERIOR LOCATION.
 - B. MOIST OR HUMID ATMOSPHERE WHERE CONDENSATE CAN BE EXPECTED TO ACCUMULATE.
 - C. PUMP MOTORS.
 - D. CORROSIVE ATMOSPHERE.
 - E. SUBJECTED TO WATER SPRAY OR DRIPPING OIL, WATER OR GREASE.
7. RIGID NON-METALLIC CONDUITS:
 - A. RIGID NON-METALLIC CONDUITS MAY BE USED BELOW GRADE OR EMBEDDED IN CONCRETE ON OR BELOW GRADE ONLY.
 - B. RIGID NON-METALLIC CONDUITS SHALL NOT BE USED FOR EXPOSED STUB-UPS ABOVE FLOOR. WHERE ACCEPTABLE TO AUTHORITY HAVING JURISDICTION, RIGID NON-METALLIC CONDUITS MAY BE STUBBED-UP 6-INCHES ABOVE FLOOR WHERE CONCEALED WITHIN WALLS. IN MASONRY WALLS, NON-METALLIC CONDUITS MAY BE EXTENDED TO A MAXIMUM OF 48-INCHES ABOVE FLOOR.
 - C. MAKE SOLVENT CEMENTED JOINTS IN ACCORDANCE WITH RECOMMENDATIONS OF MANUFACTURER.
 - D. INSTALL RIGID NON-METALLIC CONDUITS IN COMPLIANCE WITH NEC, LOCAL UTILITY PRACTICES, AND ALL OTHER AUTHORITIES HAVING JURISDICTION.
- (C) STUB-UP CONNECTIONS: EXTEND CONDUITS THROUGH CONCRETE FLOOR FOR CONNECTION TO FREESTANDING EQUIPMENT WITH AN ADJUSTABLE TOP OR COUPLING THREAD INSIDE THE PLUGS AND SET FLUSH WITH THE FINISHED FLOOR. EXTEND CONDUCTORS TO EQUIPMENT WITH RIGID STEEL CONDUIT; FLEXIBLE METAL CONDUIT MAY BE USED 6-INCHES ABOVE THE FLOOR. WHERE EQUIPMENT CONNECTIONS ARE NOT MADE UNDER THIS CONTRACT, INSTALL SCREWDRIVER-OPERATED THREADED FLUSH PLUGS FLUSH WITH FLOOR.
- (D) PROTECT STUB-UPS FROM DAMAGE WHERE CONDUITS RISE FROM FLOOR SLABS. ARRANGE SO CURVED PORTION OF BENDS IS NOT VISIBLE ABOVE THE FINISHED SLAB.
- (E) INSTALL PULL WIRES IN EMPTY RACEWAYS. USE NO. 14 AWG ZINC-COATED STEEL OR MONOFILAMENT PLASTIC LINE HAVING NOT LESS THAN 200 LB TENSILE STRENGTH. LEAVE NOT LESS THAN 12-INCHES OF SLACK AT EACH END OF THE PULL WIRE.
- (F) CUT CONDUITS STRAIGHT, PROPERLY REAM, AND CUT THREADS FOR HEAVY WALL CONDUIT DEEP AND CLEAN. USE TEMPORARY CLOSURES TO PREVENT FOREIGN MATTER FROM ENTERING RACEWAYS.
- (G) FIELD-BEND CONDUIT WITH BENDERS DESIGNED FOR PURPOSE SO AS NOT TO DISTORT NOR VARY INTERNAL DIAMETER.

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- (H) SIZE CONDUITS TO MEET NEC REQUIREMENTS AND AS SHOWN ON DRAWINGS OR SPECIFIED HEREIN. ALL CONDUITS SHALL BE 3/4-INCH MINIMUM TRADE SIZE.
- (I) FASTEN RIGID CONDUIT TERMINATIONS IN SHEET METAL ENCLOSURES WITH LOCKNUTS INSIDE AND OUTSIDE ENCLOSURE OR WITH THREADLESS RIGID BOX CONNECTORS AND TERMINATE WITH BUSHING.
- (J) CONDUIT TERMINATIONS IN WET LOCATIONS SHALL BE OF THE THREADED HUB TYPE OR OTHER SEALING TYPE FITTINGS UL LISTED FOR USE IN WET LOCATIONS.
- (K) CONDUITS ARE NOT TO CROSS VERTICAL OR HORIZONTAL OPENINGS SUCH AS PIPE SHAFTS, ELEVATOR SHAFTS, VENTILATING DUCT OPENINGS, ETC.
- (L) KEEP CONDUITS A MINIMUM DISTANCE OF 6-INCHES FROM PARALLEL RUNS OF FLUES, HOT WATER PIPES OR OTHER SOURCES OF HEAT. WHEREVER POSSIBLE, INSTALL HORIZONTAL RACEWAY RUNS ABOVE WATER AND STEAM PIPING.
- (M) CONDUIT SHALL BE PROPERLY SUPPORTED AS SPECIFIED HEREIN AND AS REQUIRED BY NEC.
- (N) SUPPORT RISER CONDUIT AT EACH FLOOR LEVEL WITH CLAMP HANGERS.
- (O) USE OF RUNNING THREADS AT CONDUIT JOINTS AND TERMINATIONS IS PROHIBITED. WHERE REQUIRED, USE 3-PIECE UNION OR SPLIT COUPLING.
- (P) COMPLETE INSTALLATION OF ELECTRICAL RACEWAYS BEFORE STARTING INSTALLATION OF CABLES/WIRES WITHIN RACEWAYS.
- (Q) INSTALL RACEWAY SEALING FITTINGS IN ACCORDANCE WITH THE MANUFACTURER'S WRITTEN INSTRUCTIONS. LOCATE FITTINGS AT SUITABLE, APPROVED, ACCESSIBLE LOCATIONS AND FILL THEM WITH UL LISTED SEALING COMPOUND. FOR CONCEALED RACEWAYS, INSTALL EACH FITTING IN A FLUSH STEEL BOX WITH A BLANK COVER PLATE HAVING A FINISH SIMILAR TO THAT OF ADJACENT PLATES OR SURFACES. INSTALL RACEWAY SEALING FITTINGS AT THE FOLLOWING POINTS AND ELSEWHERE AS INDICATED:
 - 1. WHERE CONDUITS ENTER OR LEAVE HAZARDOUS LOCATIONS.
 - 2. WHERE CONDUITS PASS FROM WARM LOCATIONS TO COLD LOCATIONS, SUCH AS THE BOUNDARIES OF REFRIGERATED SPACES AND AIR-CONDITIONED SPACES.
 - 3. WHERE REQUIRED BY THE NEC.
- (R) OPENINGS AROUND ELECTRICAL PENETRATIONS THROUGH FIRE-RESISTANT-RATED WALLS, PARTITIONS, FLOORS OR CEILINGS SHALL BE FIRESTOPPED USING APPROVED METHODS TO MAINTAIN THE FIRE RESISTANCE RATING.
- (S) PROVIDE SLEEVES FOR CONDUITS PASSING THROUGH FOUNDATION OR OTHER LOAD BEARING WALLS.
- (T) CONDUITS INSTALLED UNDERGROUND WHICH EXTEND THROUGH THE FOUNDATION WALLS SHALL BE SEALED TO PREVENT THE ENTRANCE OF MOISTURE THROUGH THE FOUNDATION WALLS. ALL CONDUITS EXTENDING THROUGH THE EXTERIOR WALLS OF A BUILDING IN AREAS BELOW GRADE SHALL BE PROVIDED WITH A HYDROSTATIC SEAL SUCH AS LINK SEAL OR EQUAL.
- (U) CONCEALED CONDUITS:
 - 1. CONDUITS IN FINISHED AREAS SHALL BE INSTALLED CONCEALED.

2. METALLIC RACEWAYS INSTALLED UNDERGROUND OR IN FLOORS BELOW GRADE, OR OUTSIDE ARE TO HAVE CONDUIT THREADS PAINTED WITH CORROSION INHIBITING COMPOUND BEFORE COUPLINGS ARE ASSEMBLED. DRAW UP COUPLING AND CONDUIT SUFFICIENTLY TIGHT TO ENSURE WATERTIGHTNESS.
3. FOR FLOORS-ON-GRADE, INSTALL CONDUITS UNDER CONCRETE SLABS.
4. INSTALL UNDERGROUND CONDUITS MINIMUM OF 24-INCHES BELOW FINISHED GRADE.
5. RIGID STEEL CONDUIT BURIED IN DIRECT CONTACT WITH THE EARTH SHALL BE COATED WITH AN ASPHALTUM BASE PAINT PRIOR TO INSTALLATION AND ALL SCRATCHES SHALL BE REPAINTED AFTER INSTALLATION BEFORE BACKFILLING.

(V) CONDUITS IN CONCRETE SLABS:

1. CONDUITS SHALL NOT BE INSTALLED IN CONCRETE SLABS WITHOUT PRIOR APPROVAL/DIRECTION FROM THE STRUCTURAL ENGINEER REGARDING MAXIMUM CONDUIT SIZES, MINIMUM COVER, LOCATIONS, ETC.

(W) INSTALL CONDUITS AS NOT TO DAMAGE OR RUN THROUGH STRUCTURAL MEMBERS. AVOID HORIZONTAL OR CROSS RUNS IN BUILDING PARTITIONS OR SIDE WALLS.

(X) EXPOSED CONDUITS:

1. IN UNFINISHED AREAS SUCH AS JANITOR CLOSETS, STORAGE, MECHANICAL EQUIPMENT ROOMS, ETC., CONDUIT MAY BE RUN EXPOSED. PRIOR PERMISSION SHALL BE FIRST OBTAINED FROM THE ARCHITECT. ALL EXPOSED CONDUIT SHALL BE INSTALLED IN A NEAT MANNER FOLLOWING THE BUILDING LINES. HORIZONTAL RUNS SHALL BE CLOSE TO THE CEILING AND SHALL BE INSTALLED ABOVE MECHANICAL PIPING AS MUCH AS POSSIBLE. SINGLE HUNG CONDUITS SHALL BE SUPPORTED WITH STRAP OR ROD HANGERS, WIRE IS NOT AN ACCEPTABLE HANGER. MULTIPLE HUNG CONDUITS SHALL BE STRAPPED TO THE CHANNEL TO HOLD IT IN PLACE.
2. INSTALL EXPOSED CONDUITS AND EXTENSIONS FROM CONCEALED CONDUIT SYSTEMS NEATLY, PARALLEL WITH OR AT RIGHT ANGLES TO WALLS OF BUILDING.
3. INSTALL EXPOSED CONDUIT WORK AS NOT TO INTERFERE WITH CEILING INSERTS, LIGHTS OR VENTILATION DUCTS OR OUTLETS.
4. SUPPORT EXPOSED CONDUITS BY USE OF HANGERS, CLAMPS OR CLIPS. SUPPORT CONDUITS ON EACH SIDE OF BENDS AND ON SPACING NOT TO EXCEED FOLLOWING: UP TO 1-INCH: 6-FEET-0-INCH; 1-1/4-INCH AND OVER: 8-FEET-0-INCH.
5. RUN CONDUITS FOR OUTLETS ON WATERPROOF WALLS EXPOSED. SET ANCHORS FOR SUPPORTING CONDUIT ON WATERPROOF WALL IN WATERPROOF CEMENT.
6. ABOVE REQUIREMENTS FOR EXPOSED CONDUITS ALSO APPLY TO CONDUITS INSTALLED IN SPACE ABOVE HUNG CEILINGS, AND IN CRAWL SPACES EXCEPT THAT SPACING OF SUPPORTS FOR CONDUITS UP TO 1-INCH SHALL NOT EXCEED 8-FEET-0-INCH.

(Y) CONDUIT FITTINGS:

1. CONSTRUCT LOCKNUTS FOR SECURING CONDUIT TO METAL ENCLOSURE WITH SHARP EDGE FOR DIGGING INTO METAL, AND RIDGED OUTSIDE CIRCUMFERENCE FOR PROPER FASTENING.

2. PLASTIC INSULATING BUSHINGS FOR TERMINATING RIGID CONDUITS SMALLER THAN 1-1/4-INCH ARE TO HAVE RIBBED SIDES, WITH SMOOTH UPPER EDGES TO PREVENT INJURY TO CABLE INSULATION.
3. INSTALL METALLIC INSULATED TYPE BUSHINGS FOR TERMINATING RIGID CONDUITS 1-1/4-INCH AND LARGER. BUSHINGS ARE TO HAVE FLARED BOTTOM AND RIBBED SIDES. UPPER EDGE TO HAVE PHENOLIC INSULATING RING MOLDED INTO BUSHING.
4. MISCELLANEOUS FITTINGS SUCH AS REDUCERS, CHASE NIPPLES, 3-PIECE UNIONS, SPLIT COUPLINGS AND PLUGS TO BE SPECIFICALLY DESIGNED FOR THEIR PARTICULAR APPLICATION.

END OF SECTION 26 05 33 - RACEWAYS

SECTION 26 05 34 - ELECTRICAL BOXES AND FITTINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF ELECTRICAL BOX AND ASSOCIATED FITTING WORK IS INDICATED BY DRAWINGS AND SCHEDULES.

- (B) TYPES OF ELECTRICAL BOXES AND FITTINGS IN THIS SECTION INCLUDE THE FOLLOWING:

1. OUTLET BOXES.
2. JUNCTION BOXES.
3. PULL BOXES.
4. BUSHINGS.
5. LOCKNUTS.
6. KNOCKOUT CLOSURES.

PART 2 - PRODUCTS

2.01 FABRICATED MATERIALS

- (A) OUTLET BOXES: CONFORM TO UL 514A, "METALLIC OUTLET BOXES, ELECTRICAL," AND UL 514B, "FITTINGS FOR CONDUIT AND OUTLET BOXES." BOXES SHALL BE OF TYPE, SHAPE, SIZE AND DEPTH TO SUIT EACH LOCATION AND APPLICATION.

1. CONFORM TO NEMA OS 1, "SHEET STEEL OUTLET BOXES, DEVICE BOXES, COVERS AND BOX SUPPORTS." BOXES SHALL BE SHEET STEEL WITH STAMPED KNOCKOUTS, THREADED SCREW HOLES AND ACCESSORIES SUITABLE FOR EACH LOCATION INCLUDING MOUNTING BRACKETS AND STRAPS, CABLE CLAMPS, EXTERIOR RINGS AND FIXTURE STUDS.

- (B) RAIN-TIGHT OUTLET BOXES: PROVIDE CORROSION-RESISTANT CAST-METAL RAIN-TIGHT OUTLET WIRING BOXES, OF TYPES, SHAPES AND SIZES, INCLUDING DEPTH OF BOXES, WITH THREADED CONDUIT HOLES FOR FASTENING ELECTRICAL CONDUIT, CAST-METAL FACE PLATES WITH SPRING-HINGED WATERTIGHT CAPS SUITABLY CONFIGURED FOR EACH APPLICATION, INCLUDING FACE PLATE GASKETS AND CORROSION-RESISTANT PLUGS AND FASTENERS.

- (C) JUNCTION AND PULL BOXES: PROVIDE GALVANIZED CODE-GAGE SHEET STEEL JUNCTION AND PULL BOXES, WITH SCREW-ON COVERS; OF TYPES, SHAPES AND SIZES, TO SUIT EACH RESPECTIVE LOCATION AND INSTALLATION; WITH WELDED SEAMS AND EQUIPPED WITH STEEL NUTS, BOLTS, SCREWS AND WASHERS.

- (D) BUSHINGS, KNOCKOUT CLOSURES AND LOCKNUTS: PROVIDE CORROSION-RESISTANT BOX KNOCKOUT CLOSURES, CONDUIT LOCKNUTS AND CONDUIT BUSHINGS, OFFSET CONNECTORS, OF TYPES AND SIZES, TO SUIT RESPECTIVE INSTALLATION REQUIREMENTS AND APPLICATIONS.

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ELECTRICAL BOXES AND FITTINGS

PART 3 - EXECUTION

3.01 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

- (A) GENERAL: INSTALL ELECTRICAL BOXES AND FITTINGS AS INDICATED, IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS, APPLICABLE REQUIREMENTS OF NEC AND NECA'S "STANDARD OF INSTALLATION" AND IN ACCORDANCE WITH RECOGNIZED INDUSTRY PRACTICES TO FULFILL PROJECT REQUIREMENTS.
- (B) SURFACE-MOUNTED DEVICE BOXES IN UNFINISHED AREAS SHALL BE A MINIMUM OF 4-INCH SQUARE KNOCKOUT TYPE. SURFACE-MOUNTED BOXES IN FINISHED AND EXTERIOR AREAS, SHALL BE CAST METAL, THREADED HUB SIMILAR TO CROUSE HINDS "FS" OR "FD" CONDULET BOX.
- (C) COORDINATE INSTALLATION OF ELECTRICAL BOXES AND FITTINGS WITH WIRE/CABLE, WIRING DEVICES AND RACEWAY INSTALLATION WORK.
- (D) PROVIDE WEATHERTIGHT OUTLETS FOR INTERIOR AND EXTERIOR LOCATIONS EXPOSED TO WEATHER OR MOISTURE.
- (E) PROVIDE KNOCKOUT CLOSURES TO CAP UNUSED KNOCKOUT HOLES WHERE BLANKS HAVE BEEN REMOVED.
- (F) INSTALL ELECTRICAL BOXES IN THOSE LOCATIONS, WHICH ENSURE READY ACCESSIBILITY TO ENCLOSED ELECTRICAL WIRING. JUNCTION BOXES SHALL NOT BE INSTALLED ABOVE NON-ACCESSIBLE CEILINGS.
- (G) AVOID INSTALLING BOXES BACK-TO-BACK IN WALLS. PROVIDE NOT LESS THAN 24-INCH SEPARATION.
- (H) AVOID INSTALLING ALUMINUM PRODUCTS IN CONCRETE.
- (I) POSITION RECESSED OUTLET BOXES ACCURATELY TO ALLOW FOR SURFACE FINISH THICKNESS.
- (J) AVOID USING ROUND BOXES WHERE CONDUIT MUST ENTER BOX THROUGH SIDE OF BOX, WHICH WOULD RESULT IN DIFFICULT AND INSECURE CONNECTIONS WHEN FASTENED WITH LOCKNUT OR BUSHING ON ROUNDED SURFACES.
- (K) FASTEN ELECTRICAL BOXES FIRMLY AND RIGIDLY TO SUBSTRATES OR STRUCTURAL SURFACES TO WHICH ATTACHED OR SOLIDLY EMBED ELECTRICAL BOXES IN CONCRETE OR MASONRY. BOX SUPPORT SHALL BE INDEPENDENT OF CONDUIT.
- (L) PROVIDE ELECTRICAL CONNECTIONS FOR INSTALLED BOXES.
- (M) SUBSEQUENT TO INSTALLATION OF BOXES, PROTECT BOXES FROM CONSTRUCTION DEBRIS AND DAMAGE.

3.02 POSITION OF OUTLETS

- (A) THE ELECTRICAL CONTRACTOR SHALL CONSULT WITH MECHANICAL AND GENERAL CONTRACTOR PRIOR TO ROUGH-IN OUTLETS AND SHALL SET BOXES TO AVOID INTERFERENCE WITH EQUIPMENT INSTALLATION IN WALLS OR CEILINGS.
- (B) OUTLETS SHALL BE CENTERED WITH RESPECT TO PANELING, TRIM, FURRING, ETC. OUTLETS IMPROPERLY LOCATED SHALL BE CORRECTED AT CONTRACTOR'S EXPENSES. OUTLETS SHALL BE SET PLUMB, SECURED FIRMLY IN PLACE WITH FACE OF BOX OR PLASTER RING EXTENDING TO FINISHED SURFACE OR WALL, CEILING OR FLOOR AS THE CASE MAY BE.
- (C) WASHERS OR BUSHINGS SHALL BE INSTALLED BETWEEN RECESSED BOX AND DEVICE STRAP TO MAKE A FLUSH RIGID INSTALLATION OF THE DEVICE INSTALLED.

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**ELECTRICAL BOXES AND
FITTINGS**

- (D) THE FOLLOWING MOUNTING HEIGHT SCHEDULE IS INCLUDED TO ASSIST THE CONTRACTOR IN ESTIMATING. ALL DEVICE LOCATIONS SHALL BE COORDINATED WITH ARCHITECTURAL DETAILS AND ELEVATIONS. EXACT HEIGHTS SHALL BE OBTAINED FROM THE PROJECT SUPERINTENDENT AT THE TIME OF INSTALLATION OR TAKEN FROM DRAWINGS AS SHOWN THEREON. HEIGHTS OF DEVICE OUTLETS ARE NOTED IN INCHES FROM THE FINISHED FLOOR.

SWITCHES	48-INCH TOP
RECEPTACLES IN JANITOR CLOSET EQUIPMENT ROOM, STORAGE ROOM, SHOP TOILETS AND UNFINISHED AREAS	48-INCH TOP
WEATHERPROOF (EXTERIOR)	24-INCH BOTTOM
OTHERS	16-INCH BOTTOM
AT COUNTERS AND DESK (UNLESS OTHERWISE INDICATED)	BOTTOM 2-INCHES ABOVE BACKSPLASH
FIRE ALARM VISUAL NOTIFICATION UNITS OR COMBINATION AUDIBLE/VISIBLE	BOTTOM OF UNIT 80-INCHES ABOVE FINISHED FLOOR
FIRE ALARM AUDIBLE NOTIFICATION UNITS, CLOCKS, SPEAKERS, ETC. (UNLESS OTHERWISE INDICATED)	TOP OF UNIT 6-INCHES BELOW CEILING OR 96- INCHES (WHICHEVER IS LOWER)
THERMOSTATS, STARTERS, SPEAKER CONTROLS, FIRE ALARM MANUAL STATIONS, WALL PHONES, ETC.	48-INCH TOP

3.03 GROUNDING

- (A) UPON COMPLETION OF INSTALLATION WORK, GROUND ELECTRICAL BOXES AS REQUIRED BY NEC AND OTHER DIVISION 26 SECTIONS.

END OF SECTION 26 05 34 – ELECTRICAL BOXES AND FITTINGS

SECTION 26 05 53 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF ELECTRICAL IDENTIFICATION IS INDICATED BY DRAWINGS AND SCHEDULES.
- (B) TYPES OF ELECTRICAL IDENTIFICATION SPECIFIED IN THIS SECTION INCLUDE THE FOLLOWING:
1. BURIED CABLE WARNINGS.
 2. ELECTRICAL POWER, CONTROL AND COMMUNICATION CONDUCTORS.
 3. OPERATIONAL INSTRUCTIONS AND WARNINGS.
 4. DANGER SIGNS.
 5. EQUIPMENT/SYSTEM IDENTIFICATION SIGNS.
- (C) REFER TO DIVISION 01 GENERAL REQUIREMENTS SECTION, IDENTIFICATION SYSTEMS, FOR EQUIPMENT AND SYSTEM NAMEPLATES AND PERFORMANCE DATA; NOT WORK OF THIS SECTION.

PART 2 - PRODUCTS

2.01 ELECTRICAL IDENTIFICATION MATERIALS

- (A) GENERAL: EXCEPT AS OTHERWISE INDICATED, PROVIDE MANUFACTURER'S STANDARD PRODUCTS OF CATEGORIES AND TYPES REQUIRED FOR EACH APPLICATION. WHERE MORE THAN ONE (1) SINGLE TYPE IS SPECIFIED FOR AN APPLICATION, SELECTION IS INSTALLER'S OPTION, BUT PROVIDE SINGLE SELECTION FOR EACH APPLICATION.
- (B) PLASTICIZED TAGS:
1. GENERAL: MANUFACTURER'S STANDARD PRE-PRINTED OR PARTIALLY PRE- PRINTED ACCIDENT-PREVENTION AND OPERATIONAL TAGS, OF PLASTICIZED CARD STOCK WITH MATTE FINISH SUITABLE FOR WRITING, APPROXIMATELY 3-1/4-INCH X 5-5/8-INCH, WITH BRASS GROMMETS AND WIRE FASTENERS, AND WITH APPROPRIATE PRE-PRINTED WORDING INCLUDING LARGE-SIZE PRIMARY WORKING, E.G., DANGER, CAUTION, DO NOT OPERATE.
- (C) SELF-ADHESIVE PLASTIC SIGNS:
1. GENERAL: PROVIDE MANUFACTURER'S STANDARD, SELF-ADHESIVE OR PRESSURE-SENSITIVE, PRE-PRINTED, FLEXIBLE VINYL SIGNS FOR OPERATIONAL INSTRUCTIONS OR WARNINGS; OF SIZES SUITABLE FOR APPLICATION AREAS AND ADEQUATE FOR VISIBILITY, WITH PROPER WORDING FOR EACH APPLICATION, E.G., 208V, EXHAUST FAN, RECTIFIER.
 - A. COLORS: UNLESS OTHERWISE INDICATED OR REQUIRED BY GOVERNING REGULATIONS, PROVIDE ORANGE SIGNS WITH BLACK LETTERING.

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ELECTRICAL IDENTIFICATION

(D) BAKED ENAMEL DANGER SIGNS:

1. GENERAL: PROVIDE MANUFACTURER'S STANDARD "DANGER" SIGNS OF BAKED ENAMEL FINISH ON 20-GAGE STEEL; OF STANDARD RED, BLACK AND WHITE GRAPHICS; 14-INCH X 10-INCH SIZE EXCEPT WHERE 10-INCHES X 7-INCHES IS THE LARGEST SIZE WHICH CAN BE APPLIED WHERE NEEDED, AND EXCEPT WHERE LARGER SIZE IS NEEDED FOR ADEQUATE VISION; WITH RECOGNIZED STANDARD EXPLANATION WORDING, E.G., HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH.

(E) ENGRAVED PLASTIC-LAMINATE SIGNS:

1. GENERAL: PROVIDE ENGRAVING STOCK MELAMINE PLASTIC LAMINATE, COMPLYING WITH FS L-P-387, IN SIZES AND THICKNESSES INDICATED, ENGRAVED WITH ENGRAVER'S STANDARD LETTER STYLE OF SIZES AND WORDING INDICATED, BLACK FACE AND WHITE CORE (LETTER COLOR) EXCEPT AS OTHERWISE INDICATED, PUNCHED FOR MECHANICAL FASTENING EXCEPT WHERE ADHESIVE MOUNTING IS NECESSARY BECAUSE OF SUBSTRATE.
 - A. THICKNESS: 1/16-INCH, FOR UNITS UP TO 20 SQ. IN. OR 8-INCH LENGTH; 1/8-INCH FOR LARGER UNITS.
 - B. FASTENERS: SELF-TAPPING STAINLESS STEEL SCREWS, EXCEPT CONTACT-TYPE PERMANENT ADHESIVE WHERE SCREWS CANNOT OR SHOULD NOT PENETRATE SUBSTRATE.

(F) UNDERGROUND-TYPE PLASTIC LINE MARKER: [DIRECT-BURIAL CABLE]

1. GENERAL: MANUFACTURER'S STANDARD PERMANENT, BRIGHT-COLORED, CONTINUOUS-PRINTED PLASTIC TAPE, INTENDED FOR DIRECT-BURIAL SERVICE; NOT LESS THAN 6-INCH WIDE X 4 MILS THICK. PROVIDE TAPE WITH PRINTING WHICH MOST ACCURATELY INDICATES TYPE OF SERVICE OR BURIED CABLE.

(G) MARKER TAPES:

1. VINYL OR VINYL-CLOTH, SELF-ADHESIVE WRAPAROUND TYPE, WITH CIRCUIT IDENTIFICATION LEGEND MACHINE PRINTED BY THERMAL TRANSFER OR EQUIVALENT PROCESS.

2.02 LETTERING AND GRAPHICS

- (A) GENERAL: COORDINATE NAMES, ABBREVIATIONS AND OTHER DESIGNATIONS USED IN ELECTRICAL IDENTIFICATION WORK, WITH CORRESPONDING DESIGNATIONS SHOWN, SPECIFIED OR SCHEDULED. PROVIDE NUMBERS, LETTERING AND WORDING AS INDICATED OR, IF NOT OTHERWISE INDICATED, AS RECOMMENDED BY MANUFACTURERS OR AS REQUIRED FOR PROPER IDENTIFICATION AND OPERATION/MAINTENANCE OF ELECTRICAL SYSTEMS AND EQUIPMENT. COMPLY WITH ANSI A13.1 PERTAINING TO MINIMUM SIZES FOR LETTERS AND NUMBERS.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION

(A) GENERAL INSTALLATION REQUIREMENTS:

1. INSTALL ELECTRICAL IDENTIFICATION PRODUCTS AS INDICATED, IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS AND REQUIREMENTS OF NEC.
2. COORDINATION: WHERE IDENTIFICATION IS TO BE APPLIED TO SURFACES, WHICH REQUIRE FINISH, INSTALL IDENTIFICATION AFTER COMPLETION OF PAINTING.

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ELECTRICAL IDENTIFICATION

3. REGULATIONS: COMPLY WITH GOVERNING REGULATIONS AND REQUESTS OF GOVERNING AUTHORITIES FOR IDENTIFICATION OF ELECTRICAL WORK.

(B) OPERATIONAL IDENTIFICATION AND WARNINGS:

1. GENERAL: WHEREVER REASONABLY REQUIRED TO ENSURE SAFE AND EFFICIENT OPERATION AND MAINTENANCE OF ELECTRICAL SYSTEMS, AND ELECTRICALLY CONNECTED MECHANICAL SYSTEMS AND GENERAL SYSTEMS AND EQUIPMENT, INCLUDING PREVENTION OF MISUSE OF ELECTRICAL FACILITIES BY UNAUTHORIZED PERSONNEL, INSTALL SELF-ADHESIVE PLASTIC SIGNS OR SIMILAR EQUIVALENT IDENTIFICATION, INSTRUCTION OR WARNINGS ON SWITCHES, OUTLETS AND OTHER CONTROLS, DEVICES AND COVERS OF ELECTRICAL ENCLOSURES. WHERE DETAILED INSTRUCTIONS OR EXPLANATIONS ARE NEEDED, PROVIDE PLASTICIZED TAGS WITH CLEARLY WRITTEN MESSAGES ADEQUATE FOR INTENDED PURPOSES.

(C) DANGER SIGNS:

1. GENERAL: IN ADDITION TO INSTALLATION OF DANGER SIGNS REQUIRED BY GOVERNING REGULATIONS AND AUTHORITIES, INSTALL APPROPRIATE DANGER SIGNS AT LOCATIONS INDICATED AND AT LOCATIONS SUBSEQUENTLY IDENTIFIED BY INSTALLER OF ELECTRICAL WORK AS CONSTITUTING SIMILAR DANGERS FOR PERSONS IN OR ABOUT PROJECT.
 - A. HIGH VOLTAGE: INSTALL DANGER SIGNS WHEREVER IT IS POSSIBLE, UNDER ANY CIRCUMSTANCES, FOR PERSONS TO COME INTO CONTACT WITH ELECTRICAL POWER OF VOLTAGES HIGHER THAN 250-VOLTS.
 - B. CRITICAL SWITCHES/CONTROLS: INSTALL DANGER SIGNS ON SWITCHES AND SIMILAR CONTROLS, REGARDLESS OF WHETHER CONCEALED OR LOCKED UP, WHERE UNTIMELY OR INADVERTENT OPERATION (BY ANYONE) COULD RESULT IN SIGNIFICANT DANGER TO PERSONS, OR DAMAGE TO OR LOSS OF PROPERTY WHERE INSTRUCTED BY ARCHITECT.

(D) EQUIPMENT/SYSTEM IDENTIFICATION:

1. GENERAL: INSTALL ENGRAVED PLASTIC-LAMINATE SIGN ON EACH MAJOR UNIT OF ELECTRICAL EQUIPMENT IN BUILDING; INCLUDING CENTRAL OR MASTER UNIT OF EACH ELECTRICAL SYSTEM INCLUDING COMMUNICATION/CONTROL/SIGNAL SYSTEMS, UNLESS UNIT IS SPECIFIED WITH ITS OWN SELF-EXPLANATORY IDENTIFICATION OR SIGNAL SYSTEM. SIGNS FOR DISCONNECT SWITCHES, MOTOR STARTERS, CONTACTORS AND SIMILAR EQUIPMENT SHALL INDICATE THE LOAD SERVED. EXCEPT AS OTHERWISE INDICATED, PROVIDE SINGLE LINE OF TEXT, 1/2-INCH HIGH LETTERING ON 1-1/2-INCH HIGH SIGN (2-INCH HIGH WHERE TWO (2) LINES ARE REQUIRED), WHITE LETTERING IN BLACK FIELD. LETTERING FOR EMERGENCY POWER SYSTEM COMPONENTS SHALL BE WHITE LETTERING IN RED FIELD. PROVIDE TEXT MATCHING TERMINOLOGY AND NUMBERING OF THE CONTRACT DOCUMENTS AND SHOP DRAWINGS. PROVIDE SIGNS FOR EACH UNIT OF THE FOLLOWING CATEGORIES OF ELECTRICAL WORK.
 - A. PANELBOARDS, ELECTRICAL CABINETS AND ENCLOSURES.
 - B. MAJOR ELECTRICAL SWITCHGEAR.
 - C. DISCONNECT SWITCHES.
 - D. POWER TRANSFER EQUIPMENT.
 - E. FIRE ALARM MASTER STATION.
 - F. SECURITY MONITORING MASTER STATION.

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ELECTRICAL IDENTIFICATION

PROJECT NO. H IH BLAC 19100

2. PROVIDE ENGRAVED SIGN INDICATING LOCATION OF TRANSFORMER DISCONNECTING MEANS.
3. SERVICE EQUIPMENT SHALL BE LEGIBLY MARKED WITH ENGRAVED SIGN STATING THE FOLLOWING:

A. AVAILABLE FAULT CURRENT.

B. _____ AMPERES.

C. DATE CALCULATED.

D. MONTH/DAY/YEAR.

E. EXAMPLE:

AVAILABLE FAULT CURRENT

49,058 AMPERES

DATED CALCULATED

08/01/08

F. FAULT CURRENT VALUES SHALL BE CALCULATED BY THE CONTRACTOR PER SPECIFICATION SECTION 26 05 73.

4. ALL PANELBOARDS, SWITCHBOARDS, FUSED AND UNFUSED SAFETY SWITCHES, TRANSFER SWITCHES, COMBINATION STARTERS AND TRANSFORMERS SHALL BE PROVIDED WITH AN ENGRAVED SIGN STATING THE FOLLOWING:

A. NAME OF EQUIPMENT.

B. VOLTAGE.

C. POWER SOURCE.

D. EXAMPLE:

PANEL A

480Y/277 VOLT

FED FROM MSB1

CIRCUIT 3

5. INSTALL SIGNS AT LOCATIONS INDICATED OR, WHERE NOT OTHERWISE INDICATED, AT LOCATION FOR BEST CONVENIENCE OF VIEWING WITHOUT INTERFERENCE WITH OPERATION AND MAINTENANCE OF EQUIPMENT. SECURE TO SUBSTRATE WITH FASTENERS, EXCEPT USE ADHESIVE WHERE FASTENERS SHOULD NOT OR CANNOT PENETRATE SUBSTRATE.

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ELECTRICAL IDENTIFICATION
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(E) UNDERGROUND CABLE IDENTIFICATION:

1. GENERAL: DURING BACK-FILLING/TOP-SOILING OF EACH EXTERIOR UNDERGROUND ELECTRICAL, SIGNAL OR COMMUNICATION CABLE, INSTALL CONTINUOUS UNDERGROUND-TYPE PLASTIC LINE MARKER, LOCATED DIRECTLY OVER BURIED LINE AT 6-INCH TO 8-INCH BELOW FINISHED GRADE. WHERE MULTIPLE SMALL LINES ARE BURIED IN A COMMON TRENCH AND DO NOT EXCEED AN OVERALL WIDTH OF 16-INCH, INSTALL A SINGLE LINE MARKER.
2. INSTALL LINE MARKER FOR EVERY BURIED CABLE, REGARDLESS OF WHETHER DIRECT BURIED OR PROTECTED IN CONDUIT.

(F) CONTROL WIRING AND CABLE IDENTIFICATION:

1. ALL WIRING AND CABLING, INCLUDING THAT WITHIN FACTORY-FABRICATED PANELS AND FIELD INSTALLED SHALL BE LABELED AT EACH END WITHIN 2-INCHES OF TERMINATION WITH A CABLE IDENTIFIER AND OTHER DESCRIPTIVE INFORMATION. ALL WIRING AND CABLES SHALL HAVE ADDITIONAL IDENTIFIERS WITHIN 2-INCHES OF EXIT FROM THE ASSOCIATED RACEWAY.
2. PERMANENTLY LABEL OR CODE EACH POINT OF FIELD TERMINAL STRIPS TO SHOW THE INSTRUMENT OR ITEM SERVED.
3. IDENTIFY ALL OTHER CONTROL COMPONENTS WITH PERMANENT LABELS. IDENTIFIERS SHALL MATCH RECORD DOCUMENTS. ALL PLUG-IN COMPONENTS SHALL BE LABELED SUCH THAT REMOVAL OF COMPONENTS DOES NOT REMOVE LABEL.

(G) CABLE/CONDUCTOR IDENTIFICATION:

1. GENERAL: APPLY CABLE/CONDUCTOR IDENTIFICATION IN EACH BOX/ENCLOSURE/CABINET, EXCEPT WHERE ANOTHER FORM OF IDENTIFICATION (SUCH AS COLOR-CODED CONDUCTORS) IS PROVIDED. MATCH IDENTIFICATION WITH MARKING SYSTEM USED IN PANELBOARDS, SHOP DRAWINGS, CONTRACT DOCUMENTS, AND SIMILAR PREVIOUSLY ESTABLISHED IDENTIFICATION FOR PROJECT ELECTRICAL WORK.

END OF SECTION 26 05 53 – ELECTRICAL IDENTIFICATION

SECTION 26 09 23 - OCCUPANCY SENSORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 INCLUDED

- (A) CONTRACTOR'S WORK TO INCLUDE ALL LABOR, MATERIALS, TOOLS, APPLIANCES, CONTROL HARDWARE, POWER PACKS, SENSOR, WIRE, JUNCTION BOXES AND EQUIPMENT NECESSARY FOR AND INCIDENTAL TO THE DELIVERY, INSTALLATION AND FURNISHING OF A COMPLETELY OPERATIONAL OCCUPANCY SENSOR LIGHTING CONTROL SYSTEM, AS DESCRIBED HEREIN.
- (B) CONTRACTOR/SUPPLIER SHALL EXAMINE ALL GENERAL SPECIFICATION PROVISIONS AND DRAWINGS FOR RELATED ELECTRICAL WORK REQUIRED AS WORK UNDER DIVISION 26.
- (C) CONTRACTOR SHALL COORDINATE ALL WORK DESCRIBED IN THIS SECTION WITH ALL OTHER APPLICABLE PLANS AND SPECIFICATIONS, INCLUDING BUT NOT LIMITED TO WIRING, CONDUIT, FIXTURES, HVAC SYSTEMS AND BUILDING MANAGEMENT SYSTEMS.

1.03 EQUIPMENT QUALIFICATION

- (A) PRODUCTS SUPPLIED SHALL BE FROM A SINGLE MANUFACTURER THAT HAS BEEN CONTINUOUSLY INVOLVED IN THE MANUFACTURING OF OCCUPANCY SENSORS FOR A MINIMUM OF FIVE (5) YEARS. MIXING OF MANUFACTURERS SHALL NOT BE ALLOWED.
- (B) ALL COMPONENTS SHALL BE UL LISTED, OFFER A FIVE (5) YEAR WARRANTY AND MEET ALL STATE AND LOCAL APPLICABLE CODE REQUIREMENTS.
- (C) WALL SWITCH PRODUCTS MUST BE CAPABLE OF WITHSTANDING THE EFFECTS OF INRUSH CURRENT. SUBMITTALS SHALL CLEARLY INDICATE THE METHOD USED.

1.04 SYSTEM DESCRIPTION

- (A) THE OBJECTIVE OF THIS SECTION IS TO ENSURE THE PROPER INSTALLATION OF THE OCCUPANCY SENSOR BASED LIGHTING CONTROL SYSTEM SO THAT LIGHTING IS TURNED OFF AUTOMATICALLY AFTER REASONABLE TIME DELAY WHEN A ROOM OR AREA IS VACATED BY THE LAST PERSON TO OCCUPY SAID ROOM OR AREA.
- (B) THE OCCUPANCY SENSOR BASED LIGHTING CONTROL SHALL ACCOMMODATE ALL CONDITIONS OF SPACE UTILIZATION AND ALL IRREGULAR WORK HOURS AND HABITS.
- (C) CONTRACTOR SHALL WARRANT ALL EQUIPMENT FURNISHED IN ACCORDANCE TO THIS SPECIFICATION TO BE UNDAMAGED, FREE OF DEFECTS IN MATERIALS AND WORKMANSHIP AND IN CONFORMANCE WITH THE SPECIFICATIONS. THE SUPPLIER'S OBLIGATION SHALL INCLUDE REPAIR OR REPLACEMENT, AND TESTING WITHOUT CHARGE TO THE OWNER, ALL OR ANY PARTS OF EQUIPMENT WHICH ARE FOUND TO BE DAMAGED, DEFECTIVE OR NON-CONFORMING AND RETURNED TO THE SUPPLIER. THE WARRANTY SHALL COMMENCE UPON THE OWNER'S ACCEPTANCE OF THE PROJECT. WARRANTY ON LABOR SHALL BE FOR A MINIMUM PERIOD OF ONE (1) YEAR.

1.05 SUBMITTALS

- (A) MANUFACTURER SHALL SUBSTANTIATE CONFORMANCE TO THIS SPECIFICATION BY SUPPLYING THE NECESSARY DOCUMENTS, PERFORMANCE DATA AND WIRING DIAGRAMS. ANY DEVIATIONS TO THIS SPECIFICATION MUST BE CLEARLY STATED BY LETTER AND SUBMITTED.
- (B) SUBMIT PAPER PRINTS OF CAD-GENERATED LIGHTING PLANS PREPARED BY MANUFACTURER SHOWING PROPER PRODUCT, LOCATION, AND ORIENTATION OF EACH SENSOR AND LOCATION AND QUANTITY OF POWER PACKS. ELECTRONIC FILES ARE NOT ACCEPTABLE.
- (C) SUBMIT ANY INTERCONNECTION DIAGRAMS PER MAJOR SUBSYSTEM SHOWING PROPER WIRING.
- (D) SUBMIT STANDARD CATALOG LITERATURE, WHICH INCLUDES PERFORMANCE SPECIFICATIONS INDICATING COMPLIANCE TO THE SPECIFICATION.
- (E) SUBMIT ANY TIMING AND SENSITIVITY SETTINGS LITERATURE FOR EACH TYPE OF PROPOSED DEVICE.
- (F) CATALOG SHEETS MUST CLEARLY STATE ANY LOAD RESTRICTIONS WHEN USED WITH ELECTRONIC BALLASTS.

1.06 SYSTEM OPERATION

- (A) IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO MAKE ALL PROPER ADJUSTMENTS TO ENSURE OWNER'S SATISFACTION WITH THE OCCUPANCY SYSTEM.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE OCCUPANCY SENSOR PRODUCTS OF ONE (1) OF THE FOLLOWING:
 - 1. HUBBELL
 - 2. SENSORSWITCH
 - 3. LEVITON
 - 4. WATT-STOPPER

2.02 PRODUCTS

- (A) PROVIDE THE FOLLOWING TYPE OF SENSOR PER AREA UNLESS OTHERWISE NOTED ON THE DRAWINGS:
 - 1. DUAL TECHNOLOGY.
- (B) WALL SWITCH SENSORS SHALL HAVE MANUAL ON/OFF CAPABILITY.
- (C) WALL SWITCH SENSORS SHOWN TO CONTROL TWO (2) LIGHTING ZONES IN THE SAME SPACE SHALL BE PROVIDED WITH TWO (2) MANUAL ON/OFF SWITCHES.
- (D) ULTRASONIC SENSORS SHALL UTILIZE ADVANCED SIGNAL PROCESSING TO ADJUST THE DETECTION THRESHOLD DYNAMICALLY TO COMPENSATE FOR CONSTANTLY CHANGING LEVELS OF ACTIVITY AND AIRFLOW THROUGHOUT CONTROLLED SPACE.

- (E) ALL SENSORS SHALL BE CAPABLE OF OPERATING NORMALLY WITH DRIVER/BALLASTS/LAMP SYSTEMS AS SHOWN ON THE DRAWINGS.
- (F) ALL SENSORS SHALL HAVE READILY ACCESSIBLE, USER ADJUSTABLE SETTINGS FOR TIME DELAY AND SENSITIVITY. SETTINGS SHALL BE LOCATED ON THE SENSOR.
- (G) ALL SENSORS SHALL PROVIDE AN LED AS A VISUAL MEANS OF INDICATION AT ALL TIMES TO VERIFY THAT MOTION IS BEING DETECTED DURING BOTH TESTING AND NORMAL OPERATION.
- (H) ALL SENSORS SHALL BE UL RATED.
- (I) PROVIDE POWER PACKS AND REMOTE POWER PACKS WHERE REQUIRED FOR PROPER OPERATION OF SENSOR.
- (J) FACEPLATE MATERIAL/FINISH AND WALL-MOUNTED SENSOR COLOR SHALL MATCH FINISH/COLORS OF OTHER WIRING DEVICES IN THE SAME ROOM OR SPACE. (SEE DIVISION 26 SECTION WIRING DEVICES FOR MATERIAL AND FINISH).

2.03 CIRCUIT CONTROL HARDWARE - CU

- (A) CONTROL UNITS - FOR EASE OF MOUNTING, INSTALLATION AND FUTURE SERVICE, CONTROL UNIT(S) SHALL BE ABLE TO EXTERNALLY MOUNT THROUGH A 1/2-INCH KNOCK-OUT ON A STANDARD ELECTRICAL ENCLOSURE AND BE AN INTEGRATED, SELF-CONTAINED UNIT CONSISTING INTERNALLY OF AN ISOLATED LOAD SWITCHING CONTROL RELAY AND A TRANSFORMER TO PROVIDE LOW-VOLTAGE POWER.
- (B) RELAY CONTACTS SHALL HAVE RATINGS OF:
 - 1. 13 A - 120 VAC TUNGSTEN
 - 2. 20 A - 120 VAC BALLAST
 - 3. 20 A - 277 VAC BALLAST
- (C) REFER TO SPECIFICATION SECTION 26 05 33 REGARDING ROUTING OF POWER AND CONTROL WIRING.
- (D) PROVIDE CONTACTS, ISOLATED RELAYS AND/OR ADDITIONAL POWER PACKS AS REQUIRED TO CONNECT OCCUPANCY SENSORS TO HVAC SYSTEM. COORDINATE HVAC CONTROL REQUIREMENTS WITH DIVISION 23.

PART 3 - EXECUTION

3.01 INSTALLATION

- (A) THE LOCATIONS AND QUANTITIES OF SENSORS SHOWN ON THE DRAWINGS ARE DIAGRAMMATIC AND INDICATE ONLY THE AREA PROVIDED WITH DETECTION.
- (B) IT SHALL BE THE MANUFACTURER AND CONTRACTOR'S RESPONSIBILITY TO LOCATE AND AIM SENSORS IN THE CORRECT LOCATION REQUIRED FOR COMPLETE AND PROPER VOLUMETRIC COVERAGE WITHIN THE RANGE OF COVERAGE(S) OF CONTROLLED AREAS PER THE MANUFACTURER'S RECOMMENDATIONS. ROOMS SHALL HAVE 90% TO 100% COVERAGE TO COMPLETELY COVER THE CONTROLLED AREA. SENSORS SHALL BE LOCATED SUCH THAT DETECTION DOES NOT EXTEND BEYOND CORRESPONDING ROOM OR AREA.
- (C) THE MANUFACTURER AND CONTRACTOR SHALL PROVIDE ADDITIONAL SENSORS, POWER PACKS AND MISCELLANEOUS EQUIPMENT AS REQUIRED TO PROPERLY AND COMPLETELY COVER THE RESPECTIVE CONTROLLED AREA.

1. WHERE THE CONTRACTOR PROVIDES A CEILING-MOUNTED SENSOR IN LIEU OF A WALL-MOUNTED SENSOR AS SHOWN ON THE DRAWINGS, THE CONTRACTOR SHALL PROVIDE A WALL SWITCH FOR MANUAL ON/OFF CONTROL OF THE SPACE. THE SWITCH SHALL BE LOCATED WHERE THE WALL-MOUNTED OCCUPANCY SENSOR IS SHOWN ON THE DRAWINGS.
 - (D) PROPER JUDGMENT MUST BE EXERCISED IN EXECUTING THE INSTALLATION SO AS TO ENSURE THE BEST POSSIBLE INSTALLATION IN THE AVAILABLE SPACE AND TO OVERCOME LOCATION DIFFICULTIES DUE TO SPACE LIMITATIONS OR INTERFERENCE OF STRUCTURAL COMPONENTS. THE MANUFACTURER AND CONTRACTOR SHALL ALSO, PROVIDE, AT THE OWNER'S FACILITY, THE TRAINING NECESSARY TO FAMILIARIZE THE OWNER'S PERSONNEL WITH THE OPERATION, USE, ADJUSTMENT AND PROBLEM SOLVING DIAGNOSIS OF THE OCCUPANCY SENSING DEVICES AND SYSTEMS.
 - (E) COORDINATE LOCATIONS OF REMOTE POWER PACKS WITH ACCESSIBLE CEILING LOCATIONS. WHERE NO ACCESSIBLE CEILING SPACE IS AVAILABLE, PROVIDE SENSORS WITH INTEGRAL POWER PACKS OR LINE-VOLTAGE TYPE SENSORS.
- 3.02 FACTORY COMMISSIONING
- (A) UPON COMPLETION OF THE INSTALLATION, THE SYSTEM SHALL BE COMPLETELY COMMISSIONED BY THE MANUFACTURER'S FACTORY AUTHORIZED TECHNICIAN WHO WILL VERIFY ALL ADJUSTMENTS AND SENSOR PLACEMENT TO ENSURE A TROUBLE-FREE OCCUPANCY-BASED LIGHTING CONTROL SYSTEM.
 - (B) THE ELECTRICAL CONTRACTOR SHALL PROVIDE BOTH THE MANUFACTURER AND THE ELECTRICAL ENGINEER WITH 10 WORKING DAYS WRITTEN NOTICE OF THE SCHEDULED COMMISSIONING DATE. UPON COMPLETION OF THE SYSTEMS FINE TUNING THE FACTORY-AUTHORIZED TECHNICIAN SHALL PROVIDE THE PROPER TRAINING TO THE OWNER'S PERSONNEL IN THE ADJUSTMENT AND MAINTENANCE OF THE SENSORS.

END OF SECTION 26 09 23 – OCCUPANCY SENSORS

SECTION 26 20 10 - SERVICE ENTRANCE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) THE POWER COMPANY WILL PROVIDE ELECTRICAL SERVICE FROM A PAD MOUNTED TRANSFORMER, FURNISHED BY THE POWER COMPANY, LOCATED WHERE SHOWN ON THE PROJECT DRAWINGS. THE PAD SHALL BE FURNISHED BY DIVISION 26 IN ACCORDANCE WITH POWER COMPANY REQUIREMENTS.
- (B) THE ELECTRICAL SERVICE TO THE SERVICE ENTRANCE EQUIPMENT FROM THE TRANSFORMER SHALL BE BY DIVISION 26 IN ACCORDANCE WITH THE ONE-LINE POWER RISER DIAGRAMS.
- (C) ADDITIONAL REQUIREMENTS FOR SERVICE-ENTRANCE WORK ARE INDICATED BY DRAWINGS AND SCHEDULES.
- (D) WIRES/CABLES, RACEWAYS, AND ELECTRICAL BOXES AND FITTINGS ARE SPECIFIED IN DIVISION 26 BASIC ELECTRICAL MATERIALS AND METHODS SECTIONS, WIRES AND CABLES, RACEWAYS AND ELECTRICAL BOXES AND FITTINGS AND ARE WORK OF THIS SECTION.

PART 2 - PRODUCTS

2.01 SERVICE-ENTRANCE EQUIPMENT

- (A) GENERAL: PROVIDE SERVICE-ENTRANCE EQUIPMENT AND ACCESSORIES; OF TYPES, SIZES, RATINGS AND ELECTRICAL CHARACTERISTICS INDICATED, WHICH COMPLY WITH MANUFACTURER'S STANDARD MATERIALS, DESIGN AND CONSTRUCTION IN ACCORDANCE WITH PUBLISHED PRODUCT INFORMATION AND AS REQUIRED FOR COMPLETE INSTALLATION AND AS HEREIN SPECIFIED.

PART 3 - EXECUTION

3.01 INSTALLATION OF SERVICE-ENTRANCE EQUIPMENT

- (A) INSTALL SERVICE-ENTRANCE EQUIPMENT AS INDICATED, IN ACCORDANCE WITH EQUIPMENT MANUFACTURER'S WRITTEN INSTRUCTIONS AND WITH RECOGNIZED INDUSTRY PRACTICES, TO ENSURE THAT SERVICE-ENTRANCE EQUIPMENT FULFILLS REQUIREMENTS. COMPLY WITH APPLICABLE INSTALLATION REQUIREMENTS OF NEC AND NEMA STANDARDS.
- (B) COORDINATE WITH OTHER ELECTRICAL WORK, INCLUDING UTILITY COMPANY WIRING, AS NECESSARY TO INTERFACE INSTALLATION OF SERVICE-ENTRANCE EQUIPMENT WORK WITH OTHER WORK.
- (C) INSTALL FUSES, IF ANY, IN SERVICE-ENTRANCE EQUIPMENT.
- (D) INSTALL GROUND-FAULT PROTECTION DEVICES COMPLYING WITH MANUFACTURER'S SPECIFICATIONS.
- (E) SET FIELD-ADJUSTABLE GFP DEVICES AND CIRCUIT BREAKERS FOR PICKUP AND TIME-CURRENT SENSITIVITY RANGES IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS, SUBSEQUENT TO INSTALLATION OF DEVICES AND CB'S.

3.02 GROUNDING

- (A) PROVIDE EQUIPMENT BONDING AND GROUNDING CONNECTIONS, SUFFICIENTLY TIGHT TO ASSURE A PERMANENT AND EFFECTIVE GROUND, FOR SERVICE-ENTRANCE EQUIPMENT AS REQUIRED BY NEC, THE GROUNDING SECTION OF DIVISION 26 AND AS INDICATED ON DRAWINGS.

3.03 ADJUST AND CLEAN

- (A) ADJUST OPERATING MECHANISMS FOR FREE MECHANICAL MOVEMENT.
- (B) TOUCH-UP SCRATCHED OR MARRED ENCLOSURE SURFACES TO MATCH ORIGINAL FINISHES.

3.04 FIELD QUALITY CONTROL

- (A) UPON COMPLETION OF INSTALLATION OF SERVICE-ENTRANCE EQUIPMENT AND ELECTRICAL CIRCUITRY, ENERGIZED CIRCUITRY AND DEMONSTRATE CAPABILITY AND COMPLIANCE WITH REQUIREMENTS. WHERE POSSIBLE, CORRECT MALFUNCTIONING UNITS AT SITE, THEN RETEST TO DEMONSTRATE COMPLIANCE; OTHERWISE, REMOVE AND REPLACE WITH NEW UNITS AND RETEST.

END OF SECTION 26 20 10 – SERVICE ENTRANCE

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF PANELBOARD AND ENCLOSURE WORK, INCLUDING CABINETS AND CUTOUT BOXES IS INDICATED BY DRAWINGS AND SCHEDULES.
- (B) TYPES OF PANELBOARDS AND ENCLOSURES IN THIS SECTION INCLUDE THE FOLLOWING:
1. POWER-DISTRIBUTION PANELBOARDS.
 2. LIGHTING AND APPLIANCE PANELBOARDS.
 3. LOAD CENTERS
- (C) REFER TO OTHER DIVISION 26 SECTIONS FOR CABLE/WIRE, CONNECTORS AND ELECTRICAL RACEWAY WORK REQUIRED IN CONJUNCTION WITH PANELBOARDS AND ENCLOSURES; NOT WORK OF THIS SECTION.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PANELBOARD PRODUCTS OF ONE (1) OF THE FOLLOWING:
1. GENERAL ELECTRIC COMPANY.
 2. SIEMENS.
 3. SQUARE D COMPANY.
 4. CUTLER-HAMMER.

2.02 PANELBOARDS

- (A) GENERAL: EXCEPT AS OTHERWISE INDICATED, PROVIDE PANELBOARDS, ENCLOSURES AND AUXILIARY COMPONENTS, OF TYPES, SIZES AND RATINGS INDICATED, WHICH COMPLY WITH MANUFACTURER'S STANDARD MATERIALS; DESIGN AND CONSTRUCTION IN ACCORDANCE WITH PUBLISHED PRODUCT INFORMATION; EQUIP WITH PROPER NUMBER OF UNIT PANELBOARD DEVICES AS REQUIRED FOR COMPLETE INSTALLATION. WHERE TYPES, SIZES OR RATINGS ARE NOT INDICATED, COMPLY WITH NEC, UL AND ESTABLISHED INDUSTRY STANDARDS FOR THOSE APPLICATIONS INDICATED.
- (B) POWER DISTRIBUTION PANELBOARDS: PROVIDE CIRCUIT BREAKER TYPE DEAD-FRONT SAFETY CONSTRUCTED POWER DISTRIBUTION PANELBOARDS AS INDICATED, WITH PANELBOARD SWITCHING AND PROTECTIVE DEVICES IN QUANTITIES, RATINGS, TYPES AND WITH ARRANGEMENT SHOWN; WITH ANTI-TURN (SOLDERLESS PRESSURE) TYPE MAIN LUG CONNECTORS APPROVED FOR COPPER OR ALUMINUM CONDUCTORS. EQUIP WITH COPPER BUS BARS WITH NOT LESS THAN 98% CONDUCTIVITY AND WITH FULL-SIZED NEUTRAL BUS; PROVIDE SUITABLE LUGS ON

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NEUTRAL BUS FOR OUTGOING FEEDERS REQUIRING NEUTRAL CONNECTIONS. PROVIDE MOLDED-CASE CIRCUIT-BREAKERS FOR EACH BRANCH CIRCUIT, WITH TOGGLE HANDLES THAT INDICATE WHEN TRIPPED. WHERE MULTIPOLE BREAKERS ARE INDICATED, PROVIDE WITH COMMON TRIP SO OVERLOAD ON ONE-POLE WILL TRIP ALL POLES SIMULTANEOUSLY. PROVIDE PANELBOARDS WITH BARE UNINSULATED GROUNDING BARS SUITABLE FOR BOLTING TO ENCLOSURES. PANELBOARD ENCLOSURES SHALL BE NOT LESS THAN 8-INCHES DEEP. PROVIDE PANELBOARDS WITH UL MARKINGS INDICATING "SUITABLE FOR USE AS SERVICE-ENTRANCE EQUIPMENT".

1. BREAKERS IN 240-VOLT PANELBOARDS SHALL BE FULLY RATED AND SHALL HAVE AN INTERRUPTING CAPACITY OF NOT LESS THAN AS INDICATED ON THE DRAWINGS.

2. CIRCUIT BREAKER DISTRIBUTION PANELBOARDS SHALL BE:

GENERAL ELECTRIC	SPECTRA SERIES
SIEMENS	S4, S5
SQUARE D	I-LINE
CUTLER-HAMMER	POW-R-LINE 4B

(C) LIGHTING AND APPLIANCE PANELBOARDS: PROVIDE DEAD-FRONT SAFETY TYPE LIGHTING AND APPLIANCE PANELBOARDS AS INDICATED, WITH SWITCHING AND PROTECTIVE DEVICES IN QUANTITIES, RATINGS, TYPES AND ARRANGEMENTS SHOWN; WITH ANTI-TURN SOLDERLESS PRESSURE TYPE LUG CONNECTORS APPROVED FOR COPPER OR ALUMINUM CONDUCTORS; EQUIP WITH COPPER BUS BARS, FULL-SIZED NEUTRAL BAR, WITH BOLT-ON TYPE HEAVY-DUTY, QUICK-MAKE, QUICK-BREAK, SINGLE-POLE OR MULTI-POLE CIRCUIT- BREAKERS, AS INDICATED, WITH TOGGLE HANDLES THAT INDICATE WHEN TRIPPED. MULTIPOLE BREAKERS SHALL BE PROVIDED WITH A COMMON TRIP. PROVIDE SUITABLE LUGS ON NEUTRAL BUS FOR EACH OUTGOING FEEDER REQUIRED; PROVIDE BARE UNINSULATED GROUNDING BARS SUITABLE FOR BOLTING TO ENCLOSURES.

1. LIGHTING AND APPLIANCE PANELBOARDS SHALL BE TYPE:

	240V
	BOLT-ON
GENERAL ELECTRIC	AQ
SIEMENS	S1
SQUARE D	NQOD
CUTLER-HAMMER	PRL1, PRL2

2. BREAKERS IN 240-VOLT PANELBOARDS SHALL BE FULLY RATED AND SHALL HAVE AN INTERRUPTING CAPACITY OF NOT LESS THAN AS INDICATED ON THE DRAWINGS.

(D) LIGHTING AND APPLIANCE PANELBOARD ENCLOSURES: PROVIDE GALVANIZED SHEET STEEL CABINET TYPE ENCLOSURES, MINIMUM 20-INCHES WIDE AND 5-3/4-INCHES DEEP, CODE-GAGE, MINIMUM 16-GAGE THICKNESS. CONSTRUCT WITH MULTIPLE KNOCKOUTS AND WIRING GUTTERS. PROVIDE FRONTS WITH ADJUSTABLE TRIM CLAMPS, AND DOORS WITH FLUSH METAL LOCKS AND KEYS, ALL PANELBOARD ENCLOSURES KEYED ALIKE. EQUIP WITH INTERIOR CIRCUIT-DIRECTORY FRAME, AND CARD WITH CLEAR PLASTIC COVERING. PROVIDE BAKED GRAY ENAMEL FINISH OVER A RUST INHIBITOR COATING. DESIGN ENCLOSURES FOR RECESSED OR SURFACE-MOUNTING AS INDICATED. PROVIDE ENCLOSURES WHICH ARE FABRICATED BY SAME MANUFACTURER AS PANELBOARDS, WHICH MATE PROPERLY WITH PANELBOARDS TO BE ENCLOSED AND ARE NEMA RATED TO SUIT THE ATMOSPHERIC CONDITIONS OF THE EQUIPMENT SURROUNDINGS.

1. FURNISH SIX (6) SPARE KEYS FOR EACH TYPE OF PANELBOARD CABINET LOCK.

(E) LOAD CENTERS: PROVIDE APARTMENT LOAD CENTERS AS INDICATED, WITH SWITCHING AND PROTECTIVE DEVICES IN QUANTITIES, RATINGS, TYPES AND ARRANGEMENTS SHOWN; WITH SOLDERLESS PRESSURE TYPE LUG CONNECTORS APPROVED FOR COPPER OR ALUMINUM CONDUCTORS; ALUMINUM BUS BARS, FULL SIZED NEUTRAL BAR, WITH PLUG-IN TYPE QUICK-MAKE, QUICK BREAK, SINGLE POLE OR MULTI-POLE CIRCUIT-BREAKERS, AS INDICATED, WITH TOGGLE HANDLES THAT INDICATE WHEN TRIPPED. MULTIPOLE BREAKERS SHALL BE PROVIDED

WITH A COMMON TRIP. PROVIDE SUITABLE LUGS ON NEUTRAL BUS FOR EACH OUTGOING CIRCUIT REQUIRED; PROVIDE BARE UNINSULATED GROUNDING BARS SUITABLE FOR BOLTING TO ENCLOSURES.

1. BREAKERS IN LOAD CENTERS SHALL BE FULL SIZE (3/4-INCH MINIMUM) AND SHALL HAVE AN INTERRUPTING CAPACITY OF NOT LESS THAN AS INDICATED ON THE DRAWINGS. HALF-SIZE OR TANDEM BREAKERS ARE NOT ACCEPTABLE.
- (F) LOAD CENTER ENCLOSURES: THE LOAD CENTER BUS ASSEMBLY SHALL BE ENCLOSED IN A STEEL CABINET. THE MINIMUM SIZE OF THE WIRING GUTTERS AND GAUGE STEEL SHALL BE IN ACCORDANCE WITH NEC AND UL REQUIREMENTS. PROVIDE FRONTS WITH AND A DIRECTORY FOR CIRCUIT IDENTIFICATION. PROVIDE BAKED GRAY ENAMEL FINISH OVER A RUST INHIBITOR COATING. ENCLOSURES AND FRONTS SHALL BE DESIGNED FOR THE TYPE OF MOUNTING INDICATED. PROVIDE ENCLOSURES WHICH ARE FABRICATED BY SAME MANUFACTURER AS LOAD CENTER, WHICH MATE PROPERLY WITH LOAD CENTER TO BE ENCLOSED, AND ARE NEMA RATED TO SUIT THE ATMOSPHERIC CONDITIONS OF THE EQUIPMENT SURROUNDINGS.
- (G) PANELBOARD ACCESSORIES: PROVIDE PANELBOARD ACCESSORIES AND DEVICES INCLUDING, BUT NOT NECESSARILY LIMITED TO, CARTRIDGE AND PLUG TIME-DELAY TYPE FUSES, CIRCUIT-BREAKERS, GROUND-FAULT PROTECTION UNITS, ETC., AS RECOMMENDED BY MANUFACTURER FOR RATINGS AND APPLICATIONS INDICATED.

PART 3 - EXECUTION

3.01 INSPECTION

- (A) INSTALLER MUST EXAMINE AREAS AND CONDITIONS UNDER WHICH PANELBOARDS AND ENCLOSURES ARE TO BE INSTALLED AND NOTIFY CONTRACTOR IN WRITING OF CONDITIONS DETRIMENTAL TO PROPER COMPLETION OF WORK. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN A MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF PANELBOARDS

- (A) GENERAL: INSTALL PANELBOARDS AND ENCLOSURES AS INDICATED, IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS, APPLICABLE REQUIREMENTS OF NEC STANDARDS AND NECA'S "STANDARD OF INSTALLATION", AND IN COMPLIANCE WITH RECOGNIZED INDUSTRY PRACTICES TO ENSURE THAT PRODUCTS FULFILL REQUIREMENTS.
- (B) COORDINATE INSTALLATION OF PANELBOARDS AND ENCLOSURES WITH CABLE AND RACEWAY INSTALLATION WORK.
- (C) TIGHTEN CONNECTORS AND TERMINALS, INCLUDING SCREWS AND BOLTS, IN ACCORDANCE WITH EQUIPMENT MANUFACTURER'S PUBLISHED TORQUE TIGHTENING VALUES FOR EQUIPMENT CONNECTORS. WHERE MANUFACTURER'S TORQUING REQUIREMENTS ARE NOT INDICATED, TIGHTEN CONNECTORS AND TERMINALS TO COMPLY WITH TIGHTENING TORQUES SPECIFIED IN UL STANDARDS 486A AND B OR MANUFACTURER'S TORQUE REQUIREMENTS WHEN MORE STRINGENT.
- (D) ANCHOR ENCLOSURES FIRMLY TO WALLS AND STRUCTURAL SURFACES, ENSURING THAT THEY ARE PERMANENTLY AND MECHANICALLY SECURE.
- (E) PROVIDE PROPERLY WIRED ELECTRICAL CONNECTIONS WITHIN ENCLOSURES.
- (F) PROVIDE FACTORY PANELBOARD CIRCUIT DIRECTORY CARDS UPON COMPLETION OF INSTALLATION WORK. CIRCUIT DIRECTORY CARDS SHALL BE ARRANGED WITH EVEN NUMBERED CIRCUITS SEPARATED BY GROUP OR CARD FROM ODD NUMBERED CIRCUITS. ALL CIRCUITS, INCLUDING SPARES AND SPACES, SHALL BE LABELED. ALL IDENTIFICATION SHALL BE AT A MINIMUM TYPEWRITTEN. HAND LETTERING IS NOT ACCEPTABLE.

(G) PROVIDE FOUR (4) 3/4-INCH EMPTY CONDUITS FOR FUTURE FROM EACH FLUSH-MOUNTED PANELBOARD TO AN ACCESSIBLE SPACE ABOVE THE CEILING IN FINISHED ROOMS OR IN JOIST SPACE OF UNFINISHED ROOMS.

(H) ALL WIRING WITHIN PANELBOARDS SHALL BE ARRANGED IN A NEAT AND ORGANIZED MANNER.

3.03 GROUNDING

(A) PROVIDE EQUIPMENT GROUNDING CONNECTIONS FOR PANELBOARDS AS REQUIRED BY NEC AND OTHER DIVISION 26 SECTIONS. TIGHTEN CONNECTIONS TO COMPLY WITH TIGHTENING TORQUES SPECIFIED IN UL STANDARDS 486A AND B TO ASSURE PERMANENT AND EFFECTIVE GROUNDS.

3.04 FIELD QUALITY CONTROL

(A) PRIOR TO ENERGIZATION OF CIRCUITRY, CHECK ALL ACCESSIBLE CONNECTIONS TO MANUFACTURER'S TIGHTENING TORQUE SPECIFICATIONS.

(B) PRIOR TO ENERGIZATION OF PANELBOARDS, CHECK WITH GROUND RESISTANCE TESTER PHASE-TO-PHASE AND PHASE-TO-GROUND INSULATION RESISTANCE LEVELS TO ENSURE REQUIREMENTS ARE FULFILLED.

(C) PRIOR TO ENERGIZATION, CHECK PANELBOARDS FOR ELECTRICAL CONTINUITY OF CIRCUITS AND FOR SHORT-CIRCUITS.

(D) SUBSEQUENT TO WIRE AND CABLE HOOK-UPS, ENERGIZE PANELBOARDS AND DEMONSTRATE FUNCTIONING IN ACCORDANCE WITH REQUIREMENTS. WHERE NECESSARY, CORRECT MALFUNCTIONING UNITS AND THEN RETEST TO DEMONSTRATE COMPLIANCE.

END OF SECTION 26 24 16 - PANELBOARDS

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) THE EXTENT OF WIRING DEVICE WORK IS INDICATED BY DRAWINGS AND SCHEDULES. WIRING DEVICES ARE DEFINED AS SINGLE DISCRETE UNITS OF ELECTRICAL DISTRIBUTION SYSTEMS, WHICH ARE INTENDED TO CARRY BUT NOT UTILIZE ELECTRIC ENERGY.

- (B) TYPES OF ELECTRICAL WIRING DEVICES IN THIS SECTION INCLUDE THE FOLLOWING:

1. RECEPTACLES.
2. GROUND-FAULT CIRCUIT INTERRUPTERS.
3. SWITCHES.
4. WALLPLATES.
5. DIMMERS.
6. PLUGS AND CONNECTORS.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE WIRING DEVICES OF ONE (1) OF THE FOLLOWING (FOR EACH TYPE AND RATING OF WIRING DEVICE):

1. ARROW HART
2. BRYANT ELECTRIC CO.
3. COOPER WIRING DEVICES
4. DANIEL WOODHEAD CO.
5. EAGLE ELECTRIC MFG. CO.
6. GENERAL ELECTRIC CO.
7. HUBBELL INC.
8. LEVITON MFG CO.
9. PASS AND SEYMOUR INC.

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WIRING DEVICES
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2.02 FABRICATED WIRING DEVICES

(A) GENERAL: PROVIDE FACTORY-FABRICATED WIRING DEVICES, IN TYPES, COLORS AND ELECTRICAL RATINGS FOR APPLICATIONS INDICATED AND WHICH COMPLY WITH NEMA STANDARDS PUB/NO. WD 1. PROVIDE WHITE COLOR DEVICES EXCEPT AS OTHERWISE INDICATED; COLOR SELECTION TO BE VERIFIED BY CONTRACTOR WITH ARCHITECT/ENGINEER. ALL DEVICES SHALL BE SPECIFICATION GRADE.

1. DEVICES ON EMERGENCY CIRCUITS SHALL BE RED.

A. WALLPLATES FOR EMERGENCY DEVICES SHALL BE RED.

(B) RECEPTACLES:

1. ALL NON-LOCKING TYPE 15 AND 20 AMP SIMPLEX AND DUPLEX RECEPTACLES SHALL BE LISTED TAMPER-RESISTANT RECEPTACLES.

2. HEAVY-DUTY SIMPLEX: PROVIDE SINGLE HEAVY-DUTY SELF-GROUNDING TYPE RECEPTACLES, 2-POLE, 3-WIRE, WITH GREEN HEXAGONAL EQUIPMENT GROUND SCREW, 20-AMPERES, 125-VOLTS, WITH METAL PLASTER EARS; DESIGN FOR SIDE AND BACK WIRING WITH SPRING LOADED, SCREW ACTIVATED PRESSURE PLATE, WITH NEMA CONFIGURATION 5-20R UNLESS OTHERWISE INDICATED.

3. HEAVY-DUTY DUPLEX: PROVIDE HEAVY-DUTY SELF-GROUNDING TYPE DUPLEX RECEPTACLES, 2-POLE, 3-WIRE, 20-AMPERES, 125-VOLTS, WITH GREEN HEXAGONAL EQUIPMENT GROUND SCREW, METAL PLASTER EARS, FINDER GROOVE, DESIGN FOR SIDE AND BACK WIRING WITH SPRING LOADED, SCREW ACTIVATED PRESSURE PLATE, WITH NEMA CONFIGURATION 5-20R UNLESS OTHERWISE INDICATED.

A. P & S PLUG TAIL RECEPTACLES WITH CONNECTOR BUILT INTO BACK OF DEVICE AND SEPARATE POLYCARBONATE CONNECTOR HOUSING WITH CONNECTOR LEADS ARE ACCEPTABLE.

4. GROUND-FAULT INTERRUPTERS: PROVIDE "FEED-THRU" TYPE GROUND-FAULT CIRCUIT INTERRUPTERS, WITH HEAVY-DUTY DUPLEX RECEPTACLES, CAPABLE OF PROTECTING CONNECTED DOWNSTREAM RECEPTACLES ON SINGLE CIRCUIT, AND OF BEING INSTALLED IN A 2-3/4-INCH DEEP OUTLET BOX WITHOUT ADAPTER, GROUNDING TYPE UL RATED CLASS A, GROUP 1, RATED 20-AMPERES, 120-VOLTS, 60 HZ; WITH SOLID-STATE GROUND-FAULT SENSING AND SIGNALING; WITH 5-MILLIAMPERES GROUND-FAULT TRIP LEVEL; EQUIP WITH NEMA CONFIGURATION 5-20R.

(C) PLUGS AND CONNECTORS:

1. PLUGS AND CONNECTORS: PROVIDE PLUGS AND CONNECTORS WITH REQUIRED AMPERAGE RATINGS, VOLTAGE RATINGS AND NEMA CONFIGURATIONS, WHICH ARE DESIGNED TO SUIT THE ATMOSPHERIC CONDITIONS OF THE EQUIPMENT SURROUNDINGS. ALL PLUGS AND CONNECTORS SHALL BE MANUFACTURED BY DANIEL WOODHEAD COMPANY OR APPROVED EQUAL BY ONE (1) OF THE FOLLOWING MANUFACTURERS:

A. HUBBELL INC.

B. PASS AND SEYMOUR INC.

(D) SWITCHES:

1. GENERAL: SWITCHES SHALL BE PROVIDED AS SPECIFIED IN THIS SECTION. ADDITIONAL FEATURES SUCH, AS KEY OPERATOR, ROCKER AND LIGHTED TOGGLE SHALL BE PROVIDED WHERE INDICATED ON THE DRAWINGS.

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2. SINGLE-POLE: PROVIDE HEAVY-DUTY FLUSH SINGLE-POLE AC QUIET, SELF-GROUNDING TYPE SWITCHES, 20-AMPERES, 120/277-VOLTS, WITH MOUNTING YOKE INSULATED FROM MECHANISM, EQUIP WITH PLASTER EARS, TOGGLE SWITCH HANDLE, AND SIDE-WIRED SCREW TERMINALS.
3. DOUBLE POLE: PROVIDE HEAVY-DUTY FLUSH DOUBLE-POLE AC QUIET, SELF-GROUNDING TYPE SWITCHES, 20-AMPERES, 120/277-VOLTS, WITH MOUNTING YOKE INSULATED FROM MECHANISM, EQUIP WITH PLASTER EARS, TOGGLE SWITCH HANDLES AND SIDE-WIRED SCREW TERMINALS.
4. THREE-WAY: PROVIDE HEAVY-DUTY FLUSH 3-WAY AC QUIET, SELF-GROUNDING TYPE SWITCHES, 20-AMPERES, 120/277-VOLTS, WITH MOUNTING YOKE INSULATED FROM MECHANISM, EQUIP WITH PLASTER EARS, TOGGLE SWITCH HANDLES AND SIDE-WIRED SCREW TERMINALS.
5. FOUR-WAY: PROVIDE HEAVY-DUTY FLUSH 4-WAY AC QUIET, SELF-GROUNDING TYPE SWITCHES, 20-AMPERES, 120/277-VOLTS, WITH MOUNTING YOKE INSULATED FROM MECHANISM, EQUIP WITH PLASTER EARS, TOGGLE SWITCH HANDLES AND SIDE-WIRED SCREW TERMINALS.

2.03 WIRING DEVICE ACCESSORIES

- (A) WALLPLATES: PROVIDE WALLPLATES FOR SINGLE AND COMBINATION WIRING DEVICES, OF TYPES, SIZES AND WITH GANGING AND CUTOUPS AS INDICATED. SELECT PLATES WHICH MATE AND MATCH WIRING DEVICES TO WHICH ATTACHED. CONSTRUCT WITH METAL SCREWS FOR SECURING PLATES TO DEVICES; SCREW HEADS COLORED TO MATCH FINISH OF PLATES; WALLPLATES COLORED TO MATCH WIRING DEVICES EXCEPT AS NOTED BELOW. PROVIDE PLATES POSSESSING THE FOLLOWING ADDITIONAL CONSTRUCTION FEATURES:

1. FINISHED AREAS:

MATERIAL AND FINISH:	PLASTIC, SMOOTH.
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2. UNFINISHED AREAS:

MATERIAL AND FINISH:	STEEL PLATE, GALVANIZED.
----------------------	--------------------------
3. SURFACE-MOUNTED BOXES IN UNFINISHED AREAS SHALL BE FURNISHED WITH 4-INCH SQUARE RAISED COVERS, WITH OPENINGS TO FIT DEVICE OR DEVICES TO BE INSTALLED.

- (B) FURNISH NON-METALLIC WEATHERPROOF COVERS FOR RECEPTACLE INSTALLED OUTDOORS, IN WET LOCATIONS OR SHOWN AS WEATHERPROOF. PROVIDE IN-USE WEATHERPROOF COVERS WHERE REQUIRED PER NEC.

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRING DEVICES

- (A) INSTALL WIRING DEVICES AS INDICATED, IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS, APPLICABLE REQUIREMENTS OF NEC AND NECA'S "STANDARD OF INSTALLATION" AND IN ACCORDANCE WITH RECOGNIZED INDUSTRY PRACTICES TO FULFILL PROJECT REQUIREMENTS.
- (B) COORDINATE WITH OTHER WORK, INCLUDING PAINTING, ELECTRICAL BOXES AND WIRING WORK, AS NECESSARY TO INTERFACE INSTALLATION OF WIRING DEVICES WITH OTHER WORK.
- (C) INSTALL WIRING DEVICES ONLY IN ELECTRICAL BOXES, WHICH ARE CLEAN; FREE FROM EXCESS BUILDING MATERIALS, DIRT AND DEBRIS.
- (D) INSTALL WALLPLATES AFTER PAINTING WORK IS COMPLETED.

- (E) THE CONTINUITY OF BRANCH CIRCUIT CONDUCTORS SHALL NOT DEPEND ON DEVICE CONNECTIONS SUCH AS LAMP HOLDERS, RECEPTACLES, ETC. WHERE THE REMOVAL OF THE DEVICE WOULD INTERRUPT THE CONTINUITY. BRANCH CIRCUIT CONDUCTORS SHALL BE SPLICED WITH JUMPERS TO CONNECT THE DEVICE.
- (F) CONNECTIONS OF WIRE TO DEVICES SHALL BE SCREW TIGHTENED (EXCEPT DEVICES WITH BUILT-IN CONNECTOR/LEADS). CONNECTIONS USING ONLY SPRING PRESSURE ARE NOT ACCEPTABLE.
- (G) TIGHTEN CONNECTORS AND TERMINALS, INCLUDING SCREWS AND BOLTS, IN ACCORDANCE WITH EQUIPMENT MANUFACTURER'S PUBLISHED TORQUE TIGHTENING VALUES FOR WIRING DEVICES. WHERE MANUFACTURER'S TORQUING REQUIREMENTS ARE NOT INDICATED, TIGHTEN CONNECTORS AND TERMINALS TO COMPLY WITH TIGHTENING TORQUES SPECIFIED IN UL STANDARDS 486A AND B. USE PROPERLY SCALED TORQUE INDICATING HAND TOOL.
- (H) ALL SWITCHES AND RECEPTACLES WITH EXPOSED TERMINALS SHALL BE WRAPPED WITH INSULATING TAPE EQUAL TO SCOTCH NO. 33 SUCH THAT NO LIVE PARTS ARE LEFT EXPOSED.

3.02 PROTECTION OF WALLPLATES AND RECEPTACLES

- (A) UPON INSTALLATION OF WALLPLATES AND RECEPTACLES, ADVISE CONTRACTOR REGARDING PROPER AND CAUTIOUS USE OF CONVENIENCE OUTLETS. AT TIME OF SUBSTANTIAL COMPLETION, REPLACE THOSE ITEMS, WHICH HAVE BEEN DAMAGED, INCLUDING THOSE BURNED AND SCORED BY FAULTY PLUGS AND THOSE, WHICH ARE NOT CLEAN AND FREE FROM PAINT, DIRT AND DEBRIS.

3.03 GROUNDING

- (A) PROVIDE EQUIPMENT GROUNDING CONNECTIONS FOR WIRING DEVICES, UNLESS OTHERWISE INDICATED. TIGHTEN CONNECTIONS TO COMPLY WITH TIGHTENING TORQUES SPECIFIED IN UL STANDARD 486A TO ASSURE PERMANENT AND EFFECTIVE GROUNDS.

3.04 TESTING

- (A) PRIOR TO ENERGIZING CIRCUITRY, TEST WIRING FOR ELECTRICAL CONTINUITY, AND FOR SHORT-CIRCUITS. ENSURE PROPER POLARITY OF CONNECTIONS IS MAINTAINED. SUBSEQUENT TO ENERGIZATION, TEST WIRING DEVICES TO DEMONSTRATE COMPLIANCE WITH REQUIREMENTS.

END OF SECTION 26 27 26 – WIRING DEVICES

SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF FUSE WORK IS INDICATED BY DRAWINGS AND SCHEDULES.
- (B) TYPES OF FUSES SPECIFIED IN THIS SECTION INCLUDE THE FOLLOWING:
1. CLASS L TIME-DELAY.
 2. CLASS RK1 TIME-DELAY.
 3. CLASS RK5 TIME-DELAY.
 4. PLUG FUSES.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURER: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS OF ONE (1) OF THE FOLLOWING:
1. BUSSMAN DIV; MCGRAW-EDISON CO.
 2. LITTELFUSE CO.
 3. GOULD SHAWMUT.
- (B) FUSE TYPES LISTED BELOW ARE FOR BUSSMAN CO. FUSES BY LITTELFUSE CO. OR GOULD SHAWMUT SHALL BE EQUAL TO TYPES INDICATED.

2.02 FUSES

- (A) GENERAL: EXCEPT AS OTHERWISE INDICATED, PROVIDE FUSES OF TYPES, SIZES, RATINGS, AND AVERAGE TIME/CURRENT AND PEAK LET-THROUGH CURRENT CHARACTERISTICS INDICATED, WHICH COMPLY WITH MANUFACTURER'S STANDARD DESIGN, MATERIALS AND CONSTRUCTION IN ACCORDANCE WITH PUBLISHED PRODUCT INFORMATION, AND WITH INDUSTRY STANDARDS AND CONFIGURATIONS.
- (B) CLASS L TIME-DELAY FUSES: PROVIDE UL CLASS L TIME-DELAY FUSES RATED 600V (TYPE KRP-C), 60 HZ, WITH 200,000 RMS SYMMETRICAL INTERRUPTING CURRENT RATING FOR SIZES 601-AMPERES AND LARGER.
- (C) CLASS RK1 TIME-DELAY FUSES: PROVIDE UL CLASS RK1 TIME-DELAY FUSES RATED 250V (TYPE LPN-RK) FOR VOLTAGES UNDER 250V AND 600V (TYPE LPS-RK) FOR VOLTAGES 250-600V, 60 HZ, WITH 200,000 RMS SYMMETRICAL INTERRUPTING CURRENT RATING FOR SIZES 100- THROUGH 600-AMPERES.

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- (D) CLASS RK5 TIME-DELAY FUSES: PROVIDE UL CLASS RK5 TIME-DELAY FUSES RATED 250V (TYPE FRN-R) FOR VOLTAGES UNDER 250V AND 600V (TYPE FRS-R) FOR VOLTAGES 250-600V, 60 HZ, WITH 200,000 RMS SYMMETRICAL INTERRUPTING CURRENT RATING FOR SIZES .1- THROUGH 90-AMPERES.
- (E) PLUG FUSES SHALL BE PERMITTED ONLY FOR SINGLE-POLE FUSEHOLDER WITH SWITCH UNITS. PLUG FUSES SHALL BE DUAL-ELEMENT TYPE S FUSES.

PART 3 - EXECUTION

3.01 INSTALLATION OF FUSES

- (A) INSTALL FUSES AS INDICATED, IN ACCORDANCE WITH THE MANUFACTURER'S WRITTEN INSTRUCTIONS AND WITH RECOGNIZED INDUSTRY PRACTICES TO ENSURE THAT PROTECTIVE DEVICES COMPLY WITH REQUIREMENTS. COMPLY WITH NEC AND NEMA STANDARDS FOR INSTALLATION OF FUSES.
- (B) COORDINATE WITH OTHER WORK, INCLUDING ELECTRICAL WIRING WORK, AS NECESSARY TO INTERFACE INSTALLATION OF FUSES WITH OTHER WORK.
- (C) INSTALL FUSES IN FUSED SWITCHES, IF ANY.
- (D) SHORT-CIRCUIT PROTECTION DUAL-ELEMENT FUSES INSTALLED IN INDIVIDUAL MOTOR CIRCUITS WITH SEPARATE OVERLOAD PROTECTION SHALL BE SIZED AT 150% OF MOTOR NAMEPLATE CURRENT RATING OR THE NEXT STANDARD FUSE SIZE. WHERE EXCESSIVE AMBIENT TEMPERATURE, HIGH INERTIA MOTOR LOADS OR FREQUENT "ON-OFF" CYCLING REQUIRES LARGER FUSES, CONSULT THE ELECTRICAL ENGINEER. USE FUSE REDUCERS WHERE FUSE GAPS ARE LARGER THAN FUSE DIMENSION.
- (E) ALL FUSE SIZES SHALL BE COORDINATED WITH MANUFACTURER'S REQUIREMENTS FOR EACH UNIT OF EQUIPMENT TO BE CONNECTED.

3.02 FIELD QUALITY CONTROL

- (A) PRIOR TO ENERGIZATION OF FUSIBLE DEVICES, TEST DEVICES FOR CONTINUITY OF CIRCUITRY AND FOR SHORT-CIRCUITS. CORRECT MALFUNCTIONING UNITS AND THEN DEMONSTRATE COMPLIANCE WITH REQUIREMENTS.

END OF SECTION 26 28 13 - FUSES

SECTION 26 28 16 - CIRCUIT AND MOTOR DISCONNECTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF CIRCUIT AND MOTOR DISCONNECT SWITCH WORK IS INDICATED ON DRAWINGS AND SCHEDULES.

- (B) TYPES OF CIRCUIT AND MOTOR DISCONNECT SWITCHES IN THIS SECTION INCLUDE THE FOLLOWING:

1. EQUIPMENT DISCONNECTS.
2. APPLIANCE DISCONNECTS.
3. MOTOR-CIRCUIT DISCONNECTS.

- (C) WIRES/CABLES, RACEWAYS AND ELECTRICAL BOXES AND FITTINGS REQUIRED IN CONNECTION WITH CIRCUIT AND MOTOR DISCONNECT WORK ARE SPECIFIED IN OTHER DIVISION 26 SECTIONS.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURER: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE CIRCUIT AND MOTOR DISCONNECTS OF ONE (1) OF THE FOLLOWING:

1. GENERAL ELECTRIC CO.
2. SIEMENS.
3. SQUARE D COMPANY.
4. CUTLER-HAMMER.

2.02 DISCONNECT SWITCHES

- (A) GENERAL-DUTY DISCONNECT SWITCHES: FOR SWITCHES RATED LESS THAN 100-AMPS PROVIDE SURFACE-MOUNTED, GENERAL-DUTY TYPE, SHEET-STEEL ENCLOSED SWITCHES, OF TYPES, SIZES AND ELECTRICAL CHARACTERISTICS INDICATED; RATED FOR SYSTEM VOLTAGE, 60 HZ, WITH REQUIRED NUMBER OF POLES AND SOLID NEUTRAL INCORPORATING SPRING ASSISTED, QUICK-MAKE, QUICK-BREAK SWITCHES. EQUIP WITH OPERATING HANDLE WHICH IS INTEGRAL PART OF ENCLOSURE BASE AND WHOSE OPERATING POSITION IS EASILY RECOGNIZABLE AND IS CAPABLE OF BEING PADLOCKED IN OFF POSITION. CONSTRUCT CURRENT CARRYING PARTS OF HIGH-CONDUCTIVITY COPPER, WITH SILVER-TUNGSTEN TYPE SWITCH CONTACTS AND POSITIVE PRESSURE TYPE REINFORCED FUSE CLIPS WHERE FUSING IS REQUIRED. THE ENCLOSURE SHALL BE NEMA RATED TO SUIT THE ATMOSPHERIC CONDITIONS OF THE EQUIPMENT SURROUNDINGS AND OF THE MANUFACTURER'S STANDARD FINISH. WHEN USED AS SERVICE DISCONNECT, PROVIDE WITH UL MARKINGS INDICATING "SUITABLE FOR USE AS SERVICE EQUIPMENT".

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- (B) HEAVY-DUTY DISCONNECT SWITCHES: FOR SWITCHES RATED 100-AMPS OR GREATER PROVIDE SURFACE-MOUNTED, HEAVY-DUTY TYPE, SHEET-STEEL ENCLOSED SWITCHES, OF TYPES, SIZES AND ELECTRICAL CHARACTERISTICS INDICATED; RATED FOR SYSTEM VOLTAGE 60 HZ, WITH REQUIRED NUMBER OF POLES AND SOLID NEUTRAL INCORPORATING QUICK-MAKE, QUICK-BREAK TYPE SWITCHES. EQUIP WITH OPERATING HANDLE WHICH IS INTEGRAL PART OF ENCLOSURE BASE AND WHOSE POSITION IS EASILY RECOGNIZABLE AND IS PADLOCKABLE IN OFF POSITION; CONSTRUCT CURRENT CARRYING PARTS OF HIGH-CONDUCTIVITY COPPER, WITH SILVER-TUNGSTEN TYPE SWITCH CONTACTS, AND POSITIVE PRESSURE TYPE REINFORCED FUSE CLIPS WHERE FUSING IS REQUIRED. THE ENCLOSURE SHALL BE NEMA RATED TO SUIT THE ATMOSPHERIC CONDITIONS OF THE EQUIPMENT SURROUNDINGS AND OF THE MANUFACTURER'S STANDARD FINISH. WHEN USED AS SERVICE DISCONNECT, PROVIDE WITH UL MARKINGS INDICATING "SUITABLE FOR USE AS SERVICE EQUIPMENT".
- (C) MOTOR-CIRCUIT DISCONNECT SWITCHES MUST BE HP RATED.
- (D) FUSES: PROVIDE FUSES FOR DISCONNECT SWITCHES, AS RECOMMENDED BY SWITCH MANUFACTURER, OF CLASSES, TYPES AND RATINGS NEEDED TO FULFILL ELECTRICAL REQUIREMENTS FOR SERVICE INDICATED.
- (E) AUXILIARY CONTACTS: PROVIDE AUXILIARY CONTACTS (SPDT) INSTALLED ON DISCONNECT SWITCH OR CIRCUIT BREAKER OPERATING MECHANISM FOR ALL CONTROLLER DISCONNECTS. AUXILIARY CONTACTS TO PROVIDE NEC REQUIRED DISCONNECTING MEANS FOR EXTERNAL CONTROL POWER FOR ASSOCIATED CONTROLLER.

PART 3 - EXECUTION

3.01 INSTALLATION OF MOTOR AND CIRCUIT DISCONNECT SWITCHES

- (A) INSTALL CIRCUIT AND MOTOR DISCONNECT SWITCHES WHERE INDICATED, COMPLYING WITH MANUFACTURER'S WRITTEN INSTRUCTIONS, APPLICABLE REQUIREMENTS OF NEC, NEMA AND NECA'S "STANDARD OF INSTALLATION" AND IN ACCORDANCE WITH RECOGNIZED INDUSTRY PRACTICES.
- (B) COORDINATE MOTOR AND CIRCUIT DISCONNECT SWITCH INSTALLATION WORK WITH ELECTRICAL RACEWAY WORK, LOCATION OF EQUIPMENT AND AS NECESSARY FOR PROPER INTERFACE. PROVIDE U-CHANNEL SUPPORTS FROM FLOOR AND/OR STRUCTURE WHERE REQUIRED TO MOUNT DISCONNECTS AT FREE-STANDING EQUIPMENT.
- (C) INSTALL DISCONNECT SWITCHES USED WITH MOTOR-DRIVEN APPLIANCES, AND MOTORS AND CONTROLLERS WITHIN SIGHT OF CONTROLLER POSITION FOR MOTORS GREATER THAN 1/8 HP.

3.02 GROUNDING

- (A) PROVIDE EQUIPMENT GROUNDING CONNECTIONS, SUFFICIENTLY TIGHT TO ASSURE A PERMANENT AND EFFECTIVE GROUND AS REQUIRED BY NEC AND IN GROUNDING SECTION OF DIVISION 26.

3.03 FIELD QUALITY CONTROL

- (A) SUBSEQUENT TO COMPLETION OF INSTALLATION OF ELECTRICAL DISCONNECT SWITCHES, ENERGIZE CIRCUITRY AND DEMONSTRATE CAPABILITY AND COMPLIANCE WITH REQUIREMENTS. WHERE POSSIBLE, CORRECT MALFUNCTIONING UNITS AT PROJECT SITE, THEN RETEST TO DEMONSTRATE COMPLIANCE; OTHERWISE REMOVE AND REPLACE WITH NEW UNITS AND RETEST.

END OF SECTION 26 28 16 – CIRCUIT AND MOTOR DISCONNECTS

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SECTION 26 32 13 - PACKAGED ENGINE GENERATOR SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) THIS SECTION INCLUDES PACKAGED ENGINE GENERATOR SET WITH THE FOLLOWING SYSTEM COMPONENTS:

1. NATURAL GAS ENGINE GENERATOR.
2. UNIT-MOUNTED RADIATOR SYSTEM.
3. EXHAUST SYSTEM.
4. GENERATOR ACCESSORIES (BATTERY SYSTEM, ETC.).
5. CONTROL AND MONITORING.
6. SKIN-TIGHT WALK-IN ENCLOSURE.

- (B) REFER TO 26 36 00 TRANSFER SWITCHES FOR TRANSFER SWITCH REQUIREMENTS.

1.03 REFERENCES

- (A) COMPLY WITH THE FOLLOWING CODES/STANDARDS:

1. NFPA 30 – FLAMMABLE AND COMBUSTIBLE LIQUIDS CODE.
2. NFPA 70 – NATIONAL ELECTRICAL CODE.
3. NFPA 37 – INSTALLATION AND USE OF STATIONARY COMBUSTION ENGINES AND GAS TURBINES.
4. NFPA 110 – STANDARD FOR EMERGENCY AND STANDBY POWER SYSTEMS.
5. UL 2200 – STATIONARY ENGINE GENERATOR ASSEMBLIES.
6. NEMA MG 1 – MOTORS AND GENERATORS.
7. ISO 8528 FAMILY OF STANDARDS.
8. ISO 3046 FAMILY OF STANDARDS.
9. SAE J1349: SPARK IGNITION AND COMPRESSION IGNITION ENGINE NET POWER RATING.
10. SAE J1995: SPARK IGNITION AND COMPRESSION IGNITION ENGINE GROSS POWER RATING.

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1.04 DEFINITIONS

- (A) EMERGENCY STANDBY RATED ENGINE GENERATOR SYSTEM: OUTPUT SERVES VARYING LOAD DURING UNEXPECTED NORMAL POWER SOURCE OUTAGE(S). TYPICALLY, RUN-TIME LESS THAN 100 HOURS PER YEAR WITH A MAXIMUM EXPECTED RUN-TIME OF 200 HOURS PER YEAR. TO REMAIN CLASSIFIED AS AN EMERGENCY STANDBY SYSTEM PER EPA REQUIREMENTS, THE RUN-TIME FOR MAINTENANCE AND TESTING (WITH UTILITY SOURCE AVAILABLE) SHALL NOT EXCEED 100 HOURS PER YEAR. UP TO 50 HOURS OF THE 100 HOUR NON-EMERGENCY ALLOWANCE MAY BE USED FOR STORM AVOIDANCE AND FACILITY MAINTENANCE. USE OF SYSTEM AS PART OF A UTILITY INTERRUPT PROGRAM IS **NOT** ALLOWED. NO OVERLOAD CAPACITY.

1.05 SUBMITTALS

- (A) SUBMIT A COMPREHENSIVE, PROJECT-SPECIFIC BILL OF MATERIAL INDICATING THE SELECTED GENERATOR OPTIONS AND ALL INCLUDED ACCESSORIES.
- (B) SUBMIT DETAILED TECHNICAL CUT SHEETS FOR ALL SYSTEM COMPONENTS INCLUDING, BUT NOT LIMITED TO, ENGINE GENERATOR, BATTERY SYSTEM, FUEL SUPPLY AND FUEL STORAGE SYSTEM, EXHAUST SYSTEM (INCLUDING AFTER-TREATMENT SYSTEM COMPONENTS, IF NEEDED), COOLING SYSTEM AND REMOTE ANNUNCIATOR. CLEARLY IDENTIFY INCLUDED OPTIONS FOR EACH PIECE OF EQUIPMENT WHEN OPTIONAL ACCESSORIES ARE LISTED.
- (C) SUBMIT PROJECT SPECIFIC CAD-STYLE DRAWINGS SHOWING ELEVATION VIEWS OF THE GENERATOR AND GENERATOR ENCLOSURE WITH EQUIPMENT WEIGHTS AND DIMENSIONS, PLUS ALL APPLICABLE WIRING AND INTERCONNECTION DIAGRAMS.
- (D) SUBMIT LETTER FROM GENERATOR MANUFACTURER INDICATING COMPLIANCE WITH SPECIFIED SOUND LEVELS AND INCLUDE SUPPORTING CALCULATIONS WHICH USES A REPRESENTATIVE SYSTEM SIMILAR TO THE EQUIPMENT BEING SUPPLIED FOR THIS PROJECT.
- (E) SUBMIT LETTER OF CERTIFICATION THAT THE SUPPLIED SYSTEM MEETS THE EPA TIER EMISSIONS REQUIREMENTS BASED ON ENGINE HP RATING AND USAGE TYPE SPECIFIED.
- (F) SUBMIT WARRANTY INFORMATION MEETING THE REQUIREMENTS OF THIS SPECIFICATION SECTION.
- (G) SUBMIT PROPOSED GENERATOR FOUNDATION DESIGN.

1.06 OPERATIONAL AND MAINTENANCE DATA

- (A) SUBMIT COPIES OF OPERATIONAL & MAINTENANCE DOCUMENTS UNDER THE PROVISIONS OF SECTION 01 77 00 WITH THE FOLLOWING ADDITIONAL REQUIREMENTS:
1. INCLUDE COPY OF ALL APPROVED ENGINE GENERATOR SYSTEM SHOP DRAWING MATERIALS.
 2. INCLUDE TYPED INSTRUCTIONS FOR NORMAL AND EMERGENCY SYSTEM OPERATION, ALL COMPONENT MANUFACTURER SERVICE MANUALS AND REQUIRED YEARLY MAINTENANCE SCHEDULES (OIL CHANGES, AIR FILTER REPLACEMENT, ETC.).
 3. INCLUDE TYPED COPY OF ENGINE GENERATOR SYSTEM PROTOTYPE FACTORY TEST RESULTS.
 4. INCLUDE TYPED COPY OF ALL SITE ACCEPTANCE TEST RESULTS.

1.07 WARRANTY

- (A) ALL PRODUCTS SHALL BE WARRANTED BY MANUFACTURER AGAINST DEFECTS IN MATERIAL AND WORKMANSHIP FOR A PERIOD OF FIVE (5) YEARS FROM THE DATE OF START UP IN ACCORDANCE WITH MANUFACTURER'S STANDARD PUBLISHED LIMITED WARRANTY. WARRANTY COVERAGE SHALL INCLUDE PARTS, LABOR, TRAVEL EXPENSES AND LABOR TO REMOVE/RE-INSTALL MANUFACTURER'S PRODUCTS. WARRANTY SHALL BE FOR THE FULL SPECIFIED PERIOD WITHOUT ANY DEDUCTIBLE OR REDUCTION OF COVERAGE WITH TIME.
- (B) A WARRANTY BY A GENERATOR SET MANUFACTURER WHICH PLACES RESPONSIBILITY ON THE ENGINE OR GENERATOR MANUFACTURER SHALL NOT BE ACCEPTABLE.

1.08 QUALITY ASSURANCE

(A) ENGINE GENERATOR MANUFACTURER:

1. THE GENERATOR SYSTEM SHALL BE THE STANDARD OF A SINGLE MANUFACTURER WITH NO LESS THAN 5 YEARS OF GENERATOR MANUFACTURING EXPERIENCE. THE ENGINE GENERATOR SYSTEM SHALL BE FACTORY BUILT, TESTED AND SHIPPED BY THIS SINGLE MANUFACTURER. THE USE OF A THIRD-PARTY FABRICATOR FOR A WALK-IN ENCLOSURE IS ACCEPTABLE.

(B) ENGINE GENERATOR SUPPLIER:

1. THE SUPPLIER SHALL BE THE SYSTEM MANUFACTURER'S AUTHORIZED LOCAL REPRESENTATIVE, WHO SHALL PROVIDE INITIAL START-UP SERVICES, FUTURE REPAIR SERVICES AND BE RESPONSIBLE FOR CONDUCTING FIELD ACCEPTANCE TESTING.
2. THE SUPPLIER SHALL HAVE A SERVICE FACILITY LOCATED WITHIN 100 MILES OF THE PROJECT SITE.

1.9 PROJECT CONDITIONS

(A) ENVIRONMENTAL CONDITIONS: ENGINE GENERATOR SYSTEM, INCLUDING ENCLOSURE, SHALL BE SUITABLE FOR OPERATION WITHIN THE FOLLOWING PARAMETERS:

1. AMBIENT TEMPERATURE: -25 DEG F TO 110 DEG F.
2. RELATIVE HUMIDITY: 0 TO 95%, NON-CONDENSING.
3. ALTITUDE: SEA LEVEL TO 2,000 FEET WITHOUT DE-RATING.

1.10 COORDINATE SIZE AND LOCATION OF GENERATOR FOUNDATION AND ALL ANCHOR BOLTS WITH GENERATOR MANUFACTURER. ALL CONCRETE, REINFORCEMENT AND FORMWORK REQUIREMENTS ARE SPECIFIED IN DIVISION 03. GENERATOR FOUNDATION SHALL BE APPROVED BY PROJECT STRUCTURAL ENGINEER.

1.11 SPARE COMPONENTS

- (A) PROVIDE TWO SETS OF SPARE FILTERS FOR EACH OF THE FOLLOWING: OIL, AIR AND FUEL.
- (B) PROVIDE ONE SET OF SPARE FUSES FOR EACH FUSE SIZE USED.

1.12 MAINTENANCE SERVICE

- (A) INCLUDE THE SERVICES OF THE FACTORY AUTHORIZED GENERATOR SERVICE COMPANY FOR ONE (1) YEAR AFTER INITIAL, SUCCESSFUL ACCEPTANCE TESTING TO PROVIDE GENERATOR MANUFACTURER RECOMMENDED ROUTINE MAINTENANCE, TESTING, INCLUSIVE OF PARTS, LABOR AND TRAVEL EXPENSES.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING MANUFACTURERS:

1. CATERPILLAR.
2. CUMMINS.
3. KOHLER.
4. MTU.
5. GENERAC.

2.02 ENGINE-GENERATOR SET

- (A) FACTORY ASSEMBLED AND TESTED ENGINE GENERATOR SET.

- (B) MOUNTING FRAME: ENGINE AND ELECTRICAL GENERATOR SHALL BE FACTORY MOUNTED TO SUITABLY-SIZED STEEL RAIL SYSTEM WITH CRANE LIFTING POINTS AND CAPABLE OF SUPPORTING THE EQUIPMENT WITHOUT REQUIRING A CONCRETE FOUNDATION FOR SUPPORT. PROVIDE SPRING-TYPE VIBRATION ISOLATORS [OR EQUIVALENT VIBRATION REDUCING PADS] AT BOLTED CONNECTIONS TO THE ENGINE AND GENERATOR.

- (C) CAPACITIES AND CHARACTERISTICS:

1. NAMEPLATE POWER RATING: REFER TO RISER DIAGRAM FOR KW/KVA RATING AT 0.8 POWER FACTOR.
2. USAGE RATING: EMERGENCY STANDBY
3. LOAD FACTOR (MINIMUM): 70%
4. OUTPUT VOLTAGE: 208Y/120 VOLT.
5. OUTPUT CONNECTIONS: 3-PHASE, 4-WIRE.
6. SYSTEM CLASSIFICATION PER NFPA 110: LEVEL 1.
7. OVERLOAD CAPACITY: NONE

- (D) GENERATOR SET PERFORMANCE:

1. STEADY-STATE VOLTAGE OPERATIONAL BANDWIDTH: 3 PERCENT OF RATED OUTPUT VOLTAGE FROM NO LOAD TO FULL LOAD.

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2. TRANSIENT VOLTAGE PERFORMANCE: NOT MORE THAN 20 PERCENT VARIATION FOR 50 PERCENT STEP-LOAD INCREASE OR DECREASE. VOLTAGE SHALL RECOVER AND REMAIN WITHIN THE STEADY-STATE OPERATING BAND WITHIN THREE SECONDS.
3. STEADY-STATE FREQUENCY OPERATIONAL BANDWIDTH: 0.5 PERCENT OF RATED FREQUENCY FROM NO LOAD TO FULL LOAD.
4. STEADY-STATE FREQUENCY STABILITY: WHEN SYSTEM IS OPERATING AT ANY CONSTANT LOAD WITHIN THE RATED LOAD, THERE SHALL BE NO RANDOM SPEED VARIATIONS OUTSIDE THE STEADY-STATE OPERATIONAL BAND AND NO HUNTING OR SURGING OF SPEED.
5. TRANSIENT FREQUENCY PERFORMANCE: LESS THAN 5 PERCENT VARIATION FOR 50 PERCENT STEP-LOAD INCREASE OR DECREASE. FREQUENCY SHALL RECOVER AND REMAIN WITHIN THE STEADY-STATE OPERATING BAND WITHIN FIVE SECONDS.
6. OUTPUT WAVEFORM: AT NO LOAD, HARMONIC CONTENT MEASURED LINE TO LINE OR LINE TO NEUTRAL SHALL NOT EXCEED 5 PERCENT TOTAL AND 3 PERCENT FOR SINGLE HARMONICS.
7. SUSTAINED SHORT-CIRCUIT CURRENT: FOR A 3-PHASE, BOLTED SHORT CIRCUIT AT SYSTEM OUTPUT TERMINALS, SYSTEM SHALL SUPPLY A MINIMUM OF 300 PERCENT OF RATED FULL-LOAD CURRENT FOR NOT LESS THAN 10 SECONDS AND THEN CLEAR THE FAULT AUTOMATICALLY, WITHOUT DAMAGE TO GENERATOR SYSTEM COMPONENTS.
8. TELEPHONE INFLUENCE FACTOR (TIF): < 50 PER NEMA MG1-22.43.
9. TELEPHONE HARMONIC FACTOR: < 3.
10. START TIME: COMPLY WITH NFPA 110 SYSTEM REQUIREMENTS.

2.03 ENGINE

(A) RATED ENGINE SPEED: 1800 RPM.

(B) GOVERNOR: DIGITAL ELECTRONIC, ISOCHRONOUS.

(C) LUBRICATION SYSTEM: (THE FOLLOWING ITEMS ARE MOUNTED ON ENGINE OR SKID)

1. FILTER AND STRAINER: RATED TO REMOVE 90 PERCENT OF PARTICLES 5 MICROMETERS AND SMALLER WHILE PASSING FULL FLOW.
2. THERMOSTATIC CONTROL VALVE: CONTROL FLOW IN SYSTEM TO MAINTAIN OPTIMUM OIL TEMPERATURE. UNIT SHALL BE CAPABLE OF FULL FLOW AND IS DESIGNED TO BE FAIL-SAFE.
3. CRANKCASE DRAIN: ARRANGED FOR COMPLETE GRAVITY DRAINAGE TO AN EASILY REMOVABLE CONTAINER WITH NO DISASSEMBLY AND WITHOUT USE OF PUMPS, SIPHONS, SPECIAL TOOLS, OR APPLIANCES.
4. PROVIDE LUBE OIL COOLER.
5. PROVIDE DIGITAL OR ANALOG LUBE OIL PRESSURE GAUGE ON GENERATOR CONTROL PANEL.

- (D) COOLING SYSTEM: CLOSED LOOP, LIQUID COOLED, WITH RADIATOR FACTORY MOUNTED ON ENGINE-GENERATOR-SET MOUNTING FRAME AND INTEGRAL ENGINE-DRIVEN COOLANT PUMP.
1. COOLANT: SOLUTION OF 50 PERCENT ETHYLENE-GLYCOL-BASED ANTIFREEZE AND 50 PERCENT WATER, WITH ANTICORROSION ADDITIVES AS RECOMMENDED BY ENGINE MANUFACTURER.
 2. SIZE OF RADIATOR: ADEQUATE TO CONTAIN EXPANSION OF TOTAL SYSTEM COOLANT FROM COLD START TO FULL LOAD CONDITION.
 3. EXPANSION TANK: CONSTRUCTED OF WELDED STEEL PLATE AND RATED TO WITHSTAND MAXIMUM CLOSED-LOOP COOLANT SYSTEM PRESSURE FOR ENGINE USED. EQUIP WITH GAGE GLASS AND PETCOCK.
 4. TEMPERATURE CONTROL: SELF-CONTAINED, THERMOSTATIC-CONTROL VALVE MODULATES COOLANT FLOW AUTOMATICALLY TO MAINTAIN OPTIMUM CONSTANT COOLANT TEMPERATURE AS RECOMMENDED BY ENGINE MANUFACTURER.
 5. COOLANT HOSE: FLEXIBLE ASSEMBLY WITH INSIDE SURFACE OF NONPOROUS RUBBER AND OUTER COVERING OF AGING-, ULTRAVIOLET-, AND ABRASION-RESISTANT FABRIC.
 - A. RATING: 15-PSIG MAXIMUM WORKING PRESSURE WITH COOLANT AT 180 DEG F AND NON-COLLAPSIBLE UNDER VACUUM.
 - B. END FITTINGS: FLANGES OR STEEL PIPE NIPPLES WITH CLAMPS TO SUIT PIPING AND EQUIPMENT CONNECTIONS.
- (E) JACKET HEATER: THERMAL CIRCULATION TYPE WATER HEATER WITH INTEGRAL THERMOSTATIC CONTROL, SIZED BY GENERATOR MANUFACTURER TO MAINTAIN ENGINE JACKET WATER AT 90°F, AND SUITABLE FOR OPERATION AT 120/208 VOLTS AC, 1-PHASE. INCLUDE DIGITAL OR ANALOG WATER TEMPERATURE GAUGE ON GENERATOR CONTROL PANEL.
- (F) ALTERNATOR HEATER: ANTI-CONDENSATION TYPE STRIP HEATER, SIZED BY MANUFACTURER, AND SUITABLE FOR OPERATION AT 120 VOLTS.
- (G) FUEL SUPPLY SYSTEM:
1. FUEL TYPE: NO. 2 ULTRA LOW SULFUR FUEL OIL NATURAL GAS.
 2. NATURAL GAS SYSTEM CARBURETOR, SECONDARY GAS REGULATOR, FUEL-SHUTOFF SOLENOID VALVE, AND FLEXIBLE FUEL CONNECTORS.
 3. RELIEF-BYPASS VALVE: AUTOMATICALLY REGULATES PRESSURE IN FUEL LINE AND RETURN EXCESS FUEL TO SOURCE.
- (H) EXHAUST SYSTEM:
1. REFER TO ENGINE GENERATOR ENCLOSURE FOR TOTAL SYSTEM SOUND LEVEL REQUIREMENTS.
 2. PROVIDE CRITICAL TYPE MUFFLER WITH FLEXIBLE, STAINLESS STEEL EXHAUST FITTINGS AND SIZED PER MANUFACTURER RECOMMENDATIONS. UTILIZE IN-CYLINDER ENGINE TECHNOLOGY ONLY TO ATTAIN EPA TIER RATING. EXTERNAL AFTER-TREATMENT SYSTEMS ARE NOT ACCEPTABLE.
- (I) AIR INTAKE FILTER: HEAVY DUTY, ENGINE MOUNTED AIR CLEANER WITH REPLACEABLE DRY-FILTER ELEMENT AND BLOCKED FILTER INDICATOR.

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(J) DC STARTING SYSTEM:

1. COMPONENTS: SIZED BY GENERATOR MANUFACTURER TO MEET STARTING REQUIREMENT OF ENGINE.
2. CRANKING MOTOR: HEAVY-DUTY UNIT THAT AUTOMATICALLY ENGAGES AND RELEASES FROM ENGINE FLYWHEEL WITHOUT BINDING.
3. CRANKING CYCLE: AS REQUIRED BY NFPA 110 FOR SYSTEM LEVEL SPECIFIED.
4. BATTERY: ADEQUATE CAPACITY TO PROVIDE SPECIFIED CRANKING CYCLE AT LEAST TWICE WITHOUT RECHARGING.
5. BATTERY CABLE: SIZE AS RECOMMENDED BY ENGINE MANUFACTURER. INCLUDE REQUIRED INTERCONNECTING CONDUCTORS AND CONNECTION ACCESSORIES.
6. BATTERY COMPARTMENT: FACTORY FABRICATED OF METAL OR FIBERGLASS WITH ACID-RESISTANT FINISH AND THERMAL INSULATION. INCLUDE ACCESSORIES REQUIRED TO SUPPORT AND FASTEN BATTERIES IN PLACE.
7. BATTERY-CHARGING ALTERNATOR: FACTORY MOUNTED ON ENGINE WITH SOLID-STATE VOLTAGE REGULATION.
8. BATTERY CHARGER: CURRENT-LIMITING, AUTOMATIC-EQUALIZING AND FLOAT-CHARGING TYPE. UNIT SHALL COMPLY WITH UL 1236. ENCLOSURE SHALL BE NEMA 250, TYPE 1, WALL OR FLOOR MOUNTED CABINET.

2.04 GENERATOR

- (A) TYPE: BRUSHLESS SYNCHRONOUS GENERATOR WITH BRUSHLESS EXCITER AND PMG ALTERNATOR EXCITATION.
- (B) DRIVE: GENERATOR SHAFT SHALL BE DIRECTLY CONNECTED TO ENGINE SHAFT. EXCITER SHALL BE ROTATED INTEGRALLY WITH GENERATOR ROTOR.
- (C) ELECTRICAL INSULATION: CLASS H.
- (D) CONSTRUCTION SHALL PREVENT MECHANICAL, ELECTRICAL, AND THERMAL DAMAGE DUE TO VIBRATION, OVERSPEED UP TO 125 PERCENT OF RATING AND HEAT DURING OPERATION AT RATED CAPACITY.
- (E) ENCLOSURE: OPEN, DRIP-PROOF.
- (F) INSTRUMENT TRANSFORMERS: MOUNTED WITHIN GENERATOR ENCLOSURE.
- (G) VOLTAGE REGULATOR: SOLID-STATE TYPE, SEPARATE FROM EXCITER. ADJUSTING RHEOSTAT SHALL PROVIDE PLUS OR MINUS 5 PERCENT ADJUSTMENT OF OUTPUT-VOLTAGE OPERATING BAND.
- (H) STRIP HEATER: THERMOSTATICALLY CONTROLLED UNIT SIZED BY MANUFACTURER TO MAINTAIN STATOR WINDINGS ABOVE DEW POINT, TAKING INTO ACCOUNT THE PROJECT SITE CONDITIONS. HEATER SHALL OPERATE AT 120 VAC.
- (I) WINDINGS: TWO-THIRDS PITCH STATOR WINDING AND FULLY LINKED AMORTISSEUR WINDING.
- (J) SUB-TRANSIENT REACTANCE: 15 PERCENT, MAXIMUM.

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2.05 CONTROL AND MONITORING

- (A) MANUAL STARTING SYSTEM SEQUENCE OF OPERATION: PLACING THE ON-OFF SWITCH ON THE GENERATOR CONTROL PANEL TO THE 'ON' POSITION STARTS GENERATOR SET. THE 'OFF' POSITION OF SAME SWITCH INITIATES GENERATOR-SET SHUTDOWN. WHEN GENERATOR SET IS RUNNING, SPECIFIED SYSTEM OR EQUIPMENT FAILURES OR DERANGEMENTS AUTOMATICALLY SHUT DOWN GENERATOR SET AND INITIATE ALARMS. OPERATION OF A REMOTE EMERGENCY-STOP SWITCH ALSO SHUTS DOWN GENERATOR SET.
- (B) AUTOMATIC STARTING SYSTEM SEQUENCE OF OPERATION: WHEN MODE-SELECTOR SWITCH ON THE CONTROL AND MONITORING PANEL IS IN THE 'AUTO' POSITION, REMOTE-CONTROL CONTACTS IN ONE OR MORE SEPARATE AUTOMATIC TRANSFER SWITCHES INITIATE STARTING AND STOPPING OF GENERATOR SET. WHEN MODE-SELECTOR SWITCH IS SWITCHED TO THE ON POSITION, GENERATOR SET STARTS. THE OFF POSITION OF SAME SWITCH INITIATES GENERATOR-SET SHUTDOWN. WHEN GENERATOR SET IS RUNNING, SPECIFIED SYSTEM OR EQUIPMENT FAILURES OR DERANGEMENTS AUTOMATICALLY SHUT DOWN GENERATOR SET AND INITIATE ALARMS. OPERATION OF A REMOTE EMERGENCY-STOP SWITCH ALSO SHUTS DOWN GENERATOR SET.
- (C) CONFIGURATION: OPERATING AND SAFETY INDICATIONS, PROTECTIVE DEVICES, BASIC SYSTEM CONTROLS, ENGINE GAGES, LOCAL EMERGENCY SHUTOFF SHALL BE GROUPED IN A COMMON PANEL MOUNTED ON THE GENERATOR SET. THE GENERATOR OUTPUT BREAKER(S) SHALL BE CONTAINED IN A SEPARATE ENCLOSURE MOUNTED ON THE GENERATOR. MOUNTING METHOD SHALL ISOLATE THE CONTROL PANEL FROM GENERATOR-SET VIBRATION.
- (D) INDICATING AND PROTECTIVE DEVICES AND CONTROLS (ACCESS VIA LCD INTERFACE AT GENERATOR IS ALLOWED IN LIEU OF ANALOG GAUGES):
1. ALARM INDICATION AS REQUIRED BY NFPA 110 FOR LEVEL 1 SYSTEM.
 2. AC VOLTMETER.
 3. AC AMMETER.
 4. AC FREQUENCY METER.
 5. DC VOLTMETER (ALTERNATOR BATTERY CHARGING).
 6. ENGINE-COOLANT TEMPERATURE GAGE.
 7. ENGINE LUBRICATING-OIL PRESSURE GAGE.
 8. RUNNING-TIME METER.
 9. AMMETER-VOLTMETER, PHASE-SELECTOR SWITCH(ES).
 10. GENERATOR-VOLTAGE ADJUSTING RHEOSTAT.
 11. START-STOP SWITCH.
 12. OVERSPEED SHUTDOWN DEVICE.
 13. COOLANT HIGH-TEMPERATURE SHUTDOWN DEVICE.
 14. COOLANT LOW-LEVEL SHUTDOWN DEVICE.

15. OIL LOW-PRESSURE SHUTDOWN DEVICE.
 16. FUEL TANK DERANGEMENT ALARM.
 17. FUEL TANK HIGH-LEVEL SHUTDOWN OF FUEL SUPPLY ALARM.
 18. GENERATOR OVERLOAD.
 19. PROVISIONS FOR REMOTE LEVEL 1 GENERATOR ANNUNCIATOR CONNECTIONS.
- (E) SUPPORTING ITEMS: INCLUDE SENSORS, TRANSDUCERS, TERMINALS, RELAYS, AND OTHER DEVICES AND INCLUDE WIRING REQUIRED TO SUPPORT SPECIFIED ITEMS. LOCATE SENSORS AND OTHER SUPPORTING ITEMS ON ENGINE OR GENERATOR, UNLESS OTHERWISE INDICATED.
- (F) BUILDING AUTOMATION SYSTEM (BAS) INTEGRATION: A SEPARATE TERMINAL BLOCK, FACTORY WIRED TO FORM C DRY CONTACTS, FOR EACH ALARM AND STATUS INDICATION RESERVED FOR CONNECTIONS TO BUILDING AUTOMATION SYSTEM. COORDINATE BAS PROTOCOL WITH MECHANICAL CONTRACTOR.
- (G) REMOTE ANNUNCIATOR PANEL: PROVIDE FLUSH SURFACE MOUNTED UNIT WITH LED INDICATOR LIGHTS AND AUDIBLE ALARMS AS REQUIRED BY NFPA 110 FOR A LEVEL 1 SYSTEM FOR THE ITEMS LISTED BELOW. YELLOW LIGHTS SHALL INDICATE WARNINGS AND RED LIGHTS SHALL INDICATE SHUTDOWNS. COORDINATE EXACT LOCATION OF REMOTE ANNUNCIATOR WITH OWNER. CONTRACTOR SHALL PROVIDE ALL REQUIRED CABLING IN CONDUIT.
1. GENERATOR FAULTS AND ALARMS:
 - A. OVERCRANK SHUTDOWN.
 - B. HIGH ENGINE TEMPERATURE WARNING.
 - C. HIGH ENGINE TEMPERATURE SHUTDOWN.
 - D. LOW OIL PRESSURE WARNING.
 - E. LOW OIL PRESSURE SHUTDOWN.
 - F. OVERSPEED SHUTDOWN.
 - G. LOW COOLANT LEVEL SHUTDOWN.
 - H. LOW COOLANT TEMPERATURE.
 - I. LOW CRANKING VOLTAGE.
 - J. LOW FUEL LEVEL.
 - K. RUPTURE BASIN ALARM (BASE TANK).
 - L. HIGH BATTERY VOLTAGE.
 - M. LOW BATTERY VOLTAGE.
 - N. BATTERY CHARGER FAILURE.

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- O. EMERGENCY STOP BUTTON ACTIVATED.
- P. COMMON FAULT.
- Q. LAMP TEST BUTTON.
- 2. GENERATOR STATUS INDICATORS:
 - A. GENERATOR SUPPLYING LOAD.
 - B. GENERATOR NOT-IN-AUTO.
 - C. SYSTEM READY.
 - D. GENERATOR RUNNING.
 - E. COMMUNICATION STATUS.
- (H) COMPUTER-BASED ANNUNCIATOR AND CONTROL SYSTEM: PROVIDE ALL REQUIRED COMMUNICATION INTERFACES FOR INTEGRATION INTO THE COMPREHENSIVE ENGINE GENERATOR AND AUTOMATIC TRANSFER SWITCH CONTROL AND MONITORING SOFTWARE PROGRAM. REFER TO TRANSFER SWITCH SPECIFICATION SECTION 26 36 00 FOR SYSTEM DESCRIPTION.
- (I) REMOTE EMERGENCY STOP MUSHROOM-STYLE PUSHBUTTON WITH EXTERIOR RATED WEATHERPROOF COVER, SHIPPED LOOSE AND FIELD INSTALLED BY CONTRACTOR ON EXTERIOR WALL OF BUILDING VISIBLE FROM GENERATOR LOCATION. PROVIDE ALL WIRING REQUIRED FOR OPERATION, IN CONDUIT, INCLUDING SHUNT TRIP OF GENERATOR MAIN CIRCUIT BREAKER. ACTIVATION OF REMOTE STOP SHALL SIGNAL THE PRIME MOVER TO STOP, SHUNT TRIP THE GENERATOR MAIN CIRCUIT BREAKER AND ANNUNCIATE AT THE LOCAL AND REMOTE GENERATOR ANNUNCIATOR(S). CONTRACTOR SHALL INSTALL ENGRAVED PLASTIC SIGN OVER DEVICE THAT READS: "GENERATOR EMERGENCY SHUTOFF". EXACT REMOTE STOP PUSHBUTTON LOCATION SHALL BE CLEARED WITH THE AUTHORITY HAVING JURISDICTION PRIOR TO ROUGH-IN.
- 2.06 GENERATOR OVERCURRENT PROTECTION
 - (A) GENERATOR OUTPUT CIRCUIT BREAKER: MOLDED-CASE, ELECTRONIC-TRIP TYPE; 100 PERCENT RATED; COMPLYING WITH UL 489.
 - 1. TRIPPING CHARACTERISTICS: ADJUSTABLE LONG-TIME AND SHORT-TIME DELAY, INSTANTANEOUS.
 - 2. TRIP SETTINGS: SELECTED TO COORDINATE WITH GENERATOR THERMAL DAMAGE CURVE.
 - 3. SHUNT TRIP: CONNECTED TO TRIP BREAKER WHEN GENERATOR SET IS SHUT DOWN BY OTHER PROTECTIVE DEVICES.
 - 4. MOUNTING: INTEGRATED INTO THE CONTROL AND MONITORING PANEL.
- 2.07 OUTDOOR ENGINE-GENERATOR ENCLOSURE – SKINTIGHT
 - (A) ACCEPTABLE MANUFACTURERS: MANUFACTURER OF ENGINE GENERATOR SYSTEM.

- (B) CONSTRUCTION: GALVANIZED, REINFORCED STEEL PANELS WITH HINGED, LOCKABLE ACCESS PANEL POSITIONED AS REQUIRED FOR ACCESS TO ALL PARTS REQUIRING SERVICE. ALL SYSTEM COMPONENTS, EXCEPT FOR FINAL DIESEL EXHAUST PIPING, SHALL BE COMPLETELY CONTAINED WITHIN THE ENCLOSURE. PROVIDE GASKETED DOOR OPENINGS TO MAINTAIN A WEATHERPROOF ENCLOSURE.
- (C) LOUVERS: STEEL OR ALUMINUM CONSTRUCTION SIZED AS REQUIRED BY ENGINE GENERATOR MANUFACTURER FOR PROPER AIR FLOW. PROVIDE RODENT/BIRD METAL SCREEN OVER OPENINGS.
- (D) FUEL STORAGE AND SUPPLY: AS SPECIFIED IN ABOVE SECTIONS. PROVIDE FACTORY INSTALLED VENTILATION PIPING AS REQUIRED BY ENGINE MANUFACTURER.
- (E) WIND RESISTANCE: 100 MPH.
- (F) SOUND ATTENUATION: ACOUSTICALLY TREAT INSIDE OF ENCLOSURE PLUS INTAKE AND EXHAUST AIR PATHS AS NEEDED TO PROVIDE 78 DB MAXIMUM SOUND PRESSURE LEVELS AT 23 FEET (MEASURED HORIZONTALLY) FROM ENCLOSURE FOR EACH OF THE FOLLOWING OCTAVE BANDS: 63 HZ, 125 HZ, 250 HZ, 500 HZ, 1000 HZ, 2000 HZ, 4000 HZ AND 8000 HZ.
- (G) SOUND ATTENUATION: ACOUSTICALLY TREAT INSIDE OF ENCLOSURE, INTAKE AND EXHAUST AIR PATHS AND DIESEL EXHAUST PATH AS NEEDED TO MEET REQUIREMENTS OF ILLINOIS ADMINISTRATIVE CODE, TITLE 35, SUBTITLE H, CHAPTER I FOR NIGHTTIME HOURS AND FOR ALL OCTAVE BANDS.
- (H) FINISH: FACTORY PRIME AND PAINT WITH MANUFACTURER'S STANDARD COLOR CUSTOM COLOR SELECTED BY ARCHITECT.

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) VERIFY CONCRETE FOUNDATION IS READY TO RECEIVE ENGINE GENERATOR SET.
- (B) VERIFY CONDUIT OPENINGS LOCATIONS OF ENGINE GENERATOR ENCLOSURE PRIOR TO ROUGH-IN.

3.02 INSTALLATION

- (A) ANCHOR ENGINE GENERATOR ENCLOSURE TO CONCRETE FOUNDATION PER MANUFACTURER'S RECOMMENDATIONS.
- (B) INSTALL REMOTE MANUAL STOP STATION AT LOCATION COORDINATED WITH OWNER AND IN VIEW OF GENERATOR. PROVIDE ALL REQUIRED CONDUIT AND WIRING.
- (C) VERIFY PHASE ROTATION OF GENERATOR SOURCE MATCHES PHASE ROTATION OF UTILITY SOURCE PRIOR TO TESTING SYSTEM.
- (D) UTILIZE A QUALIFIED MECHANICAL CONTRACTOR FOR FINAL CONNECTIONS OF FUEL PIPING, ENGINE EXHAUST PIPING AND ASSOCIATED PIPING INSULATION, COOLING SYSTEM AND INTAKE/EXHAUST DUCTWORK, AS NEEDED, FOR A COMPLETE AND FUNCTIONING SYSTEM.
- (E) GROUNDING:
 - 1. ENGINE GENERATOR SET IS A SEPARATELY DERIVED SYSTEM FOR THIS PROJECT. PROVIDE NEUTRAL GROUND BOND AT GENERATOR AND GROUND PER NEC.

3.03 FACTORY QUALITY CONTROL

- (A) PROTOTYPE TESTING: A REPRESENTATIVE ENGINE GENERATOR SYSTEM, COMPARABLE TO THE SET PROVIDED FOR THIS PROJECT, SHALL HAVE BEEN TESTED AT THE FACTORY USING IEEE 115 TESTING PROCEDURES.
- (B) FACTORY ACCEPTANCE TESTING: ARRANGE A SITE VISIT FOR UP TO THREE (3) OWNER'S REPRESENTATIVES, UP TO TWO (2) DESIGN TEAM REPRESENTATIVES AND AT LEAST ONE (1) ELECTRICAL CONTRACTOR REPRESENTATIVE TO THE SELECTED ENGINE GENERATOR MANUFACTURER'S FACTORY. SITE VISIT SHALL INCLUDE FACTORY TOUR AND DEMONSTRATION OF ACTUAL AND FULLY FUNCTIONAL ENGINE GENERATOR SYSTEM BEING PROVIDED FOR THE PROJECT. ALL TRAVEL EXPENSES SHALL BE PAID FOR BY THE COMPANIES SENDING REPRESENTATIVES.

3.04 FIELD QUALITY CONTROL

- (A) MANUFACTURER'S FIELD SERVICES: ENGAGE A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE TO INSPECT, TEST AND ADJUST ENGINE GENERATOR SYSTEM COMPONENTS AND CONNECTIONS TO MEET THE REQUIREMENTS OF THIS SPECIFICATION AND APPLICABLE CODE SECTIONS AND TO PROVIDE TRAINING FOR THE OWNER' REPRESENTATIVES.

3.05 ONSITE ACCEPTANCE TESTING

- (A) THE ENGINEER, OWNER AND AUTHORITY HAVING JURISDICTION SHALL BE NOTIFIED SEVEN (7) DAYS PRIOR TO TESTING TO ALLOW FOR ATTENDANCE, IF DESIRED.
- (B) ALL CONTROL WIRING SHALL BE VERIFIED FOR CORRECTNESS PRIOR TO THE GENERATOR TESTING PROCEDURE LISTED BELOW.
- (C) THE GENERATOR SUPPLIER SHALL FURNISH A LOAD BANK THAT, WHEN COMBINED WITH THE ACTUAL EMERGENCY SYSTEM LOAD, IS EQUAL TO THE NAMEPLATE RATING OF THE GENERATOR. THE LOAD BANK SHALL BE MODULAR IN NATURE TO ALLOW FOR SMALLER AMOUNTS OF LOADS TO BE ADDED GRADUALLY. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING ACTUAL EMERGENCY SYSTEM BUILDING LOAD AND SIZING THE SUPPLEMENTAL LOAD BANK REQUIRED.
- (D) TEST DATA SHALL BE COLLECTED AND RECORDED ON THE FOLLOWING: TIME OF DAY, ENGINE TEMPERATURE, AND OPERATING OIL PRESSURE, BATTERY CHARGING RATE, CRANKING TIME, CRANK-TO-RATED FREQUENCY TIME, LOAD ASSUMPTION-TO-STEADY STATE VOLTAGE AND FREQUENCY STABILIZATION TIME, OPERATING VOLTAGE AND FREQUENCY.
- (E) TESTING PROCEDURE (FOLLOWS NFPA 110 TESTING REQUIREMENTS, WITH ADDITIONS):
 - 1. GENERATOR SHALL NOT BE UTILIZED THE DAY OF THE TEST PRIOR TO THE START OF THE TESTING TO PROVIDE A TRUE "COLD START".
 - 2. WITH THE BUILDING LOAD OPERATING AT NORMAL, INITIATE A POWER FAILURE BY DISCONNECTING THE NORMAL POWER SUPPLY TO THE FACILITY. UTILIZE ONLY THE ACTUAL BUILDING EMERGENCY POWER SYSTEM LOADS FOR THIS TEST.
 - 3. MONITOR AND RECORD REQUIRED TEST INFORMATION AS SPECIFIED IN NFPA 110 2010 EDITION, CHAPTER 7.13.4.1.3.
 - 4. RECONNECT NORMAL POWER SUPPLY TO THE FACILITY AND ALLOW GENERATOR TO COOL DOWN AND SHUT OFF FOR A MINIMUM OF FIVE (5) MINUTES BEFORE CONTINUING TO THE FULL LOAD TESTING REQUIREMENTS.

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5. CONNECT LOAD BANK TO EMERGENCY POWER SYSTEM USING ENGINE GENERATOR SUPPLIER-SUPPLIED TEMPORARY CABLING PLUS ANY REQUIRED DISCONNECT SWITCHES, CIRCUIT BREAKERS OR TERMINATIONS TO MAKE THE SYSTEM OPERATIONAL.
 6. DURING THE ENTIRE FULL LOAD TEST, MONITOR BATTERY CHARGE RATE AT FIVE (5) MINUTE INTERVALS FOR THE FIRST 15 MINUTES AND 15 MINUTE INTERVALS THEREAFTER. CONTINUE MONITORING AND RECORDING LOAD TEST FOR THE REMAINDER OF THE FULL LOAD TEST, NOTING ANY ABNORMAL RESULTANT EFFECTS ON VOLTAGE, FREQUENCY AND CURRENT FROM LOAD CHANGES.
 7. INITIATE THE TWO-HOUR FULL LOAD TEST BY DISCONNECTING NORMAL POWER TO THE FACILITY. UTILIZE THE ACTUAL BUILDING EMERGENCY POWER SYSTEM LOADS, PLUS ADDITIONAL LOAD BANK LOADS TO BRING THE TOTAL LOAD TO 30% OF THE GENERATOR NAMEPLATE RATING. CONTINUE AT 30% TOTAL LOAD FOR THE FIRST 30 MINUTES OF THE FULL LOAD TEST.
 8. ADD ADDITIONAL LOAD BANK LOADS (IF ACTUAL EMERGENCY SYSTEM LOAD IS NOT ENOUGH) TO REACH A MINIMUM OF 50% OF THE GENERATOR NAMEPLATE RATING. CONTINUE AT 50% TOTAL LOAD FOR THE NEXT 30 MINUTES OF THE FULL LOAD TEST.
 9. ADD ADDITIONAL LOAD BANK LOAD (IF ACTUAL EMERGENCY SYSTEM LOAD IS NOT ENOUGH) TO REACH 100% OF THE GENERATOR NAMEPLATE RATING. CONTINUE AT 100% TOTAL LOAD FOR THE FINAL 60 MINUTES OF THE TEST.
 10. RECONNECT NORMAL POWER TO THE FACILITY AND RECORD THE TIME DELAYS TO RETRANSFER AND ENGINE-GENERATOR SHUTDOWN.
 11. WAIT FOR FIVE (5) MINUTES AFTER SHUTDOWN AND IMMEDIATELY INITIATE ANOTHER NORMAL POWER FAILURE. IMMEDIATELY UPON REACHING RATED FREQUENCY, APPLY FULL RATED NAMEPLATE KW (FACILITY LOAD WITH SUPPLEMENTAL LOAD BANK IF REQUIRED) IN ONE (1) STEP.
 12. REDUCE LOAD TO 50% OF THE GENERATOR NAMEPLATE RATING AND SIMULATE AT LEAST TWO (2) SYSTEM ALARMS AND VERIFY REMOTE ANNUNCIATION IN BUILDING.
 13. WITH GENERATOR OPERATING AT 50% OF THE GENERATOR NAMEPLATE RATING, INITIATE AN EMERGENCY MANUAL SHUTDOWN VIA REMOTE EMERGENCY STOP STATION. VERIFY ENGINE SHUTS DOWN AND MAIN OUTPUT CIRCUIT BREAKER SHUNT TRIPS. VERIFY ALARM IS TRANSMITTED TO REMOTE ANNUNCIATOR IN BUILDING.
 14. RESET SYSTEM AND DISENGAGE EMERGENCY STOP PUSHBUTTON.
- (F) FAILURE OF THE SYSTEM DURING THE TESTING PROCESS SHALL RESULT IN A REPEAT OF THE TESTING AT THE CONTRACTOR'S EXPENSE AND MAY INCLUDE EXPENSES FROM ADDITIONAL SITE VISITS BY THE ARCHITECT/OWNER/ENGINEER. IT IS STRONGLY RECOMMENDED THAT THE TESTING REQUIREMENTS OF THIS SECTION BE SUCCESSFULLY ATTEMPTED PRIOR TO THE SITE ACCEPTANCE TESTING FOR THE DESIGN TEAM AND OWNER.

3.06 TRAINING

- (A) A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE SHALL TRAIN OWNER'S REPRESENTATIVE(S) ON THE PROPER OPERATION AND REQUIRED ROUTINE MAINTENANCE OF THE ENGINE GENERATOR SYSTEM AND REMOTE ANNUNCIATORS. TRAINING SHALL BE A COMBINATION OF HANDS-ON FIELD TRAINING, INCLUDING LIVE SYSTEM DEMONSTRATION IF DESIRED BY OWNER, PLUS CLASSROOM INSTRUCTION. TRAINING SHALL NOT EXCEED EIGHT (8) HOURS OVER ONE (1) DAY.

END OF SECTION 26 32 13 – PACKAGED ENGINE GENERATOR SYSTEM

SECTION 26 36 00 - TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) THIS SECTION INCLUDES THE FOLLOWING EQUIPMENT:

1. AUTOMATIC TRANSFER SWITCHES.
2. AUTOMATIC TRANSFER SWITCHES WITH BYPASS/ISOLATION.
3. ENCLOSURE.
4. CONTROLS AND INDICATION.
5. REMOTE ANNUNCIATION AND CONTROL.
6. ACCESSORIES.

1.03 REFERENCES

- (A) COMPLY WITH THE FOLLOWING CODES/STANDARDS:

1. UL 1008 – STANDARD FOR AUTOMATIC TRANSFER SWITCHES.
2. NFPA 70 – NATIONAL ELECTRICAL CODE.
3. NFPA 110 – EMERGENCY AND STANDBY POWER SYSTEMS.
4. IEEE STANDARD 446 – IEEE RECOMMENDED PRACTICE FOR EMERGENCY AND STANDBY POWER SYSTEMS FOR COMMERCIAL AND INDUSTRIAL APPLICATIONS.
5. UL 891 – SWITCHBOARDS.

1.04 SUBMITTALS

- (A) SUBMIT A COMPREHENSIVE, PROJECT-SPECIFIC BILL OF MATERIALS CLEARLY INDICATING ALL SELECTED TRANSFER SWITCH OPTIONS AND ALL INCLUDED ACCESSORIES.
- (B) SUBMIT DETAILED TECHNICAL CUT SHEETS FOR ALL MAJOR COMPONENTS AND ACCESSORIES INCLUDING, BUT NOT LIMITED TO, TRANSFER SWITCH, COMMUNICATION INTERFACES, OPTION CARDS AND REMOTE ANNUNCIATOR.
- (C) SUBMIT PROJECT SPECIFIC CAD-STYLE DRAWINGS SHOWING ELEVATION VIEWS OF THE TRANSFER SWITCH WITH DIMENSIONS, PLUS ALL APPLICABLE WIRING AND INTERCONNECTION DIAGRAMS FOR THE SELECTED OPTIONS.
- (D) SUBMIT PROOF OF WITHSTAND AND CLOSE-ON RATING.

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(E) SUBMIT WARRANTY INFORMATION MEETING THE REQUIREMENTS OF THIS SPECIFICATION SECTION.

1.05 OPERATIONAL AND MAINTENANCE DATA

(A) SUBMIT DOCUMENTS UNDER THE PROVISIONS OF SECTION 26 05 00 AND DIVISION 01, PLUS THE FOLLOWING:

1. INCLUDE COPY OF ALL APPROVED TRANSFER SWITCH SHOP DRAWING MATERIALS.
2. INCLUDE TYPE INSTRUCTIONS FOR NORMAL AND EMERGENCY SYSTEM OPERATION, PRODUCT SERVICE MANUAL AND REQUIRED YEARLY MAINTENANCE SCHEDULE.
3. INCLUDE TYPED COPY OF FACTORY START-UP CHECKLIST AND SITE ACCEPTANCE TEST RESULTS.

1.06 WARRANTY

(A) ALL PRODUCTS SHALL BE WARRANTED BY THE MANUFACTURER AGAINST DEFECTS IN MATERIAL AND WORKMANSHIP FOR A PERIOD OF TWO (2) YEARS. FACTORY START-UP SHALL INITIATE THE WARRANTY PERIOD.

1.07 QUALITY ASSURANCE

(A) TRANSFER SWITCH MANUFACTURER:

1. THE TRANSFER SWITCH SHALL BE THE STANDARD OF A SINGLE MANUFACTURER WITH NO LESS THAN FIVE (5) YEARS OF TRANSFER SWITCH MANUFACTURER EXPERIENCE. THE TRANSFER SWITCH SHALL BE BUILT, TESTED AND SHIPPED BY THIS SINGLE MANUFACTURER.

(B) TRANSFER SWITCH SUPPLIER:

1. THE SUPPLIER SHALL BE THE TRANSFER SWITCH MANUFACTURER'S AUTHORIZED LOCAL REPRESENTATIVE, WHO SHALL PROVIDE INITIAL START-UP SERVICES, TRAINING AND BE RESPONSIBLE FOR CONDUCTING FIELD ACCEPTANCE TESTING.
2. THE SUPPLIER SHALL HAVE A SERVICE FACILITY LOCATED WITHIN 100 MILES OF THE PROJECT SITE.

1.08 PROJECT CONDITIONS

(A) TRANSFER SWITCH AND ALL COMPONENTS SHALL BE SUITABLE FOR PROPER OPERATION WITHIN THE FOLLOWING ENVIRONMENTAL PARAMETERS:

1. AMBIENT TEMPERATURE: -30 DEG F TO 120 DEG F.
2. RELATIVE HUMIDITY: 0 TO 95%, NON-CONDENSING.
3. ALTITUDE: SEA LEVEL TO 2,000 FEET WITHOUT DE-RATING.

1.09 COORDINATION

(A) PROVIDE 4" THICK CONCRETE HOUSEKEEPING PAD FOR ALL FLOOR MOUNTED TRANSFERS SWITCHES. PAD SHALL EXTEND 6" PAST FOOTPRINT OF THE TRANSFER SWITCH ON ALL SIDES.

- (B) PROVIDE 4" THICK CONCRETE HOUSEKEEPING PAD OF SUFFICIENT STRENGTH FOR ALL FLOOR MOUNTED BYPASS/ISOLATION TRANSFER SWITCHES. PAD SHALL EXTEND 6" PAST FOOTPRINT OF THE TRANSFER SWITCH ON THE SIDES AND REAR OF THE ENCLOSURE. CONFIRM WITH THE TRANSFER SWITCH MANUFACTURER IF THE DRAWOUT PORTION OF THE TRANSFER SWITCH REQUIRES A LEVEL SURFACE FOR SUPPORT. IF SO, EXTEND THE FRONT SIDE OF THE HOUSEKEEPING PAD TO ALLOW FOR RACK-OUT OF THE TRANSFER SWITCH. IF NOT, CONCRETE PAD SHALL EXTEND 6" FROM THE FACE OF THE TRANSFER SWITCH.

1.10 SPARE COMPONENTS

- (A) PROVIDE ONE SET OF TOOLS REQUIRED FOR PREVENTATIVE MAINTENANCE OF THE TRANSFER SWITCH. SUPPLY TOOLS IN A METAL TOOL BOX.

- (B) PROVIDE ONE SET OF FUSES FOR EACH FUSE SIZE USED.

1.11 MAINTENANCE SERVICE CONTRACT

- (A) INCLUDE THE SERVICES OF A FACTORY AUTHORIZED TRANSFER SWITCH SERVICE COMPANY FOR ONE (1) YEAR AFTER THE INITIAL, SUCCESSFUL SITE ACCEPTANCE TESTING TO PROVIDE TRANSFER SWITCH MANUFACTURER RECOMMENDED ROUTINE MAINTENANCE AND TESTING INCLUDING PARTS, LABOR AND TRAVEL EXPENSES.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURES

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING MANUFACTURERS. THE MANUFACTURER LISTED FIRST IS THE BASIS OF DESIGN AND SETS THE LEVEL OF QUALITY REQUIRED FOR THIS EQUIPMENT.

1. RUSSELECTRIC
2. CATERPILLAR
3. KOHLER
4. CUMMINS
5. GE/ZENITH
6. GENERAC

2.02 AUTOMATIC TRANSFER SWITCH – NON-BYPASS/ISOLATION

- (A) FACTORY ASSEMBLED AND TESTED AUTOMATIC TRANSFER SWITCH, LISTED FOR EMERGENCY SERVICE.
- (B) RATING: REFER TO RISER DIAGRAM FOR AMPERAGE RATINGS, 208/120 VOLT, 3-PHASE, 60 HERTZ, 4-POLE WITH SWITCHED NEUTRAL. ALL TRANSFER SWITCH BUSSING AND/OR CONDUCTORS SHALL BE COPPER. PROVIDE FULLY RATED NEUTRAL TRANSFER CONTACTS.
- (C) OPEN TRANSITION TYPE. OPEN TRANSITION TYPE TRANSFER SWITCHES SHALL FUNCTION IN A BREAK-BEFORE-MAKE FASHION WITHOUT PARALLELING WITH UTILITY DURING A TRANSFER.
- (D) DESCRIPTION: THE TRANSFER SWITCH SHALL BE ELECTRICALLY OPERATED AND MECHANICAL HELD UTILIZING HEAVY-DUTY SILVER ALLOY CONTACTS WITH ARC CHUTES.

2.03 TRANSFER SWITCH ENCLOSURE

- (A) TYPE: NEMA 1.
- (B) CONTROLLER AND POWER METER DISPLAY SHALL BE FLUSH MOUNTED IN FACE OF ENCLOSURE.
- (C) MANUAL CONTROL SWITCHES, WHEN SPECIFIED, SHALL BE INSTALLED IN THE FACE OF THE TRANSFER SWITCH AND BE OPERABLE WITHOUT OPENING FRONT COVER. PROVIDE A LOCKABLE, POLYCARBONATE, GASKETED PROTECTIVE COVER OVER THE CONTROLLER FOR OUTDOOR APPLICATIONS.
- (D) NON-BYPASS/ISOLATION TRANSFER SWITCHES IN INTERIOR INSTALLATIONS AND RATED LESS THAN OR EQUAL TO 2,000 AMPS SHALL ALLOW FOR WALL OR FLOOR INSTALLATION WITH NO REAR ACCESS REQUIREMENTS. TYPE OF INSTALLATION (E.G. ISLAND OR AGAINST WALL) AS SHOWN ON PLANS.
- (E) FINISH: PRIME AND PAINT ENCLOSURE IN FACTORY STANDARD COLOR. FINISH SHALL RESIST CORROSION. PROVIDE SUITABLE FINISH FOR OUTDOOR INSTALLATION.

2.04 WITHSTAND AND CLOSING RATING (WCR)

- (A) THE TRANSFER SWITCH SHALL BE SERIES RATED PER UL 1008 WITH THE UPSTREAM OVER-CURRENT PROTECTIVE DEVICE. THE FOLLOWING MINIMUM RATINGS SHALL APPLY BASED ON TRANSFER SWITCH AMP RATING, UNLESS NOTED OTHERWISE ON PLANS:

TRANSFER SWITCH RATING (IN AMPS)	WITHSTAND/CLOSING RATING USING ANY UPSTREAM CIRCUIT BREAKER (IN AMPS)
<= 250	22,000
> 250 AND < 600	42,000
>= 600 AND <= 1,200	65,000
> 1,200	85,000

- (B) IF A SPECIFIC MODEL OF BREAKER IS REQUIRED UPSTREAM OF THE TRANSFER SWITCH TO ATTAIN THE REQUIRED WCR, IT IS THE RESPONSIBILITY OF THE ELECTRICAL CONTRACTOR TO FACILITATE COORDINATION BETWEEN THE TRANSFER SWITCH MANUFACTURER AND THE ELECTRICAL PANEL MANUFACTURER TO PROVIDE THE APPROPRIATE EQUIPMENT.

2.05 CONTROLS AND INDICATION

- (A) A MICROPROCESSOR-BASED CONTROLLER SHALL BE PROVIDED IN THE TRANSFER SWITCH ENCLOSURE WITH A HUMAN INTERFACE LCD SCREEN PROVIDED FLUSH MOUNTED IN THE FRONT COVER. ALL WIRING SHALL BE NEATLY ORGANIZED USING A WIRING HARNESS. THE HARNESS SHALL INCLUDE A SIMPLE DISCONNECTING MEANS TO ENABLE THE REMOVAL AND REPLACEMENT OF THE CONTROLLER.
- (B) ALL RELAYS SHALL BE INDUSTRIAL GRADE PLUG-IN TYPE WITH DUST COVERS.
- (C) THE CONTROLLER SHALL BE POWERED BY THE GENERATOR BATTERY SYSTEM. PROVIDE ALL REQUIRED WIRING, IN CONDUIT.
- (D) VOLTAGE SENSING:
 - 1. CONTROLLER SHALL MONITOR VOLTAGE OF ALL PHASES OF THE NORMAL POWER SOURCE. PROVIDE FIELD-ADJUSTABLE DROPOUT VOLTAGE AND PICKUP VOLTAGE SETTINGS.

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2. CONTROLLER SHALL MONITOR VOLTAGE OF ALL PHASES OF THE EMERGENCY POWER SOURCE. PROVIDE FIELD-ADJUSTABLE DROPOUT VOLTAGE AND PICKUP VOLTAGE SETTINGS.
3. CLOSED TRANSITION TRANSFER SWITCHES SHALL NOT TRANSFER BETWEEN ENERGIZED SOURCES UNTIL THE VOLTAGE DIFFERENCE IS LESS THAN 5%.

(E) FREQUENCY SENSING:

1. CONTROLLER SHALL MONITOR FREQUENCY OF EMERGENCY POWER SOURCE. PROVIDE FIXED FIELD-ADJUSTABLE DROPOUT FREQUENCY AND PICKUP FREQUENCY SETTINGS.
2. CLOSED TRANSITION TRANSFER SWITCHES SHALL NOT TRANSFER BETWEEN ENERGIZED SOURCES UNTIL THE FREQUENCY DIFFERENCE IS LESS THAN 0.2 HERTZ.

(F) TIME DELAYS:

1. GENERATOR START DELAY, FIELD-ADJUSTABLE.
 - A. INITIAL SETTING: 1 SECOND FOR ATS SERVING LIFE SAFETY LOADS, 5 SECONDS FOR ATS SERVING NON-LIFE SAFETY LOADS.
2. TRANSFER TO EMERGENCY SOURCE DELAY, FIELD-ADJUSTABLE.
 - A. INITIAL SETTING: 0 SECONDS FOR ATS SERVING LIFE SAFETY LOADS, 30 SECONDS FOR ATS SERVING NON-LIFE SAFETY LOADS.
3. RE-TRANSFER TO NORMAL SOURCE DELAY, FIELD-ADJUSTABLE (EMERGENCY SOURCE FAILURE, NORMAL SOURCE IS AVAILABLE), FIELD-ADJUSTABLE.
 - A. INITIAL SETTING: 0 SECOND FOR ALL ATS.
4. RE-TRANSFER TO NORMAL SOURCE DELAY (EMERGENCY SOURCE OPERATIONAL, NORMAL SOURCE BECOMES AVAILABLE), FIELD-ADJUSTABLE.
 - A. INITIAL SETTING: 15 MINUTES FOR ATS SERVING LIFE SAFETY LOADS, 30 MINUTES FOR ATS SERVING NON-LIFE SAFETY LOADS.
5. ENGINE COOL-DOWN DELAY, FIELD-ADJUSTABLE.
 - A. INITIAL SETTING: 5 MINUTES

(G) ENGINE EXERCISER: PROVIDE MANUAL, NON-PROGRAMMABLE AUTOMATIC, PROGRAMMABLE SYSTEM FOR WEEKLY TEST OF ENGINE GENERATOR WITH ENABLE/DISABLE FEATURE, WITH/WITHOUT BUILDING LOAD OPTION AND AUTOMATIC EMERGENCY BYPASS IF ACTUAL FAILURE OF NORMAL POWER SOURCE OCCURS. PROVIDE INTEGRAL POWER SUPPLY VIA LOCAL BATTERY.

1. INITIAL SETTING: START AND RUN GENERATOR FOR 30 MINUTES EVERY 7 DAYS.

(H) PROVIDE THE FOLLOWING LED INDICATOR LIGHTS IN THE FRONT COVER OF THE TRANSFER SWITCH ENCLOSURE:

1. LOAD CONNECTED TO NORMAL
2. LOAD CONNECTED TO EMERGENCY

3. NORMAL SOURCE AVAILABLE
 4. EMERGENCY SOURCE AVAILABLE
- (I) PROVIDE THE FOLLOWING MANUAL CONTROL BUTTONS/SWITCHES IN THE FRONT COVER OF THE TRANSFER SWITCH ENCLOSURE:
1. TRANSFER TEST
 2. TRANSFER DELAY BYPASS
 3. ENGINE EXERCISER INITIATE

2.06 ACCESSORIES

- (A) ENGINE EXERCISER: PROVIDE MANUAL, PROGRAMMABLE SYSTEM FOR WEEKLY TEST OF ENGINE GENERATOR WITH ENABLE/DISABLE FEATURE, WITH/WITHOUT BUILDING LOAD OPTION AND AUTOMATIC EMERGENCY BYPASS IF ACTUAL FAILURE OF NORMAL POWER SOURCE OCCURS. PROVIDE INTEGRAL POWER SUPPLY VIA LOCAL BATTERY.
- (B) IN-PHASE MONITOR: PROHIBITS TRANSFER BETWEEN NEW SOURCE AND LOAD UNTIL WITHIN 30 ELECTRICAL DEGREES.
- (C) ELEVATOR PRE-TRANSFER SIGNAL: SIGNALS THE ELEVATOR CONTROLLER 30 SECONDS PRIOR TO TRANSFER POWER TO THE OTHER SOURCE, ALLOWING THE ELEVATOR TIME TO REACH A FLOOR LANDING. PROVIDE OUTPUT CONTACTS IN THE TRANSFER SWITCH AND CABLING IN CONDUIT BETWEEN THE TRANSFER SWITCH CONTROLLER AND ELEVATOR CONTROLLER. COORDINATE WITH ELEVATOR CONTRACTOR.
- (D) POWER MONITOR:
1. PROVIDE MICRO-PROCESSOR BASED METERING ON THE LOAD SIDE OF THE TRANSFER SWITCH. PROVIDE A LOCAL LCD DISPLAY WITH NAVIGATIONAL BUTTONS IN THE FACE OF THE TRANSFER SWITCH ENCLOSURE CAPABLE OF DISPLAYING THE FOLLOWING ELECTRICAL CHARACTERISTICS:
 - A. VOLTAGE (L-L, L-N IN VOLTS)
 - B. FREQUENCY (IN HERTZ)
 - C. CURRENT (L-L, L-N IN AMPS)
 - D. REAL POWER PER PHASE (IN KW)
 - E. REACTIVE POWER PER PHASE (IN KVAR)
 - F. APPARENT POWER PER PHASE (IN KVA)
 - G. POWER FACTOR

2.07 REMOTE ANNUNCIATION AND REMOTE CONTROL

- (A) REMOTE ANNUNCIATOR: PROVIDE ONE (1), FLUSH SURFACE MOUNTED UNIT AT LOCATION COORDINATED WITH OWNER OR AS SHOWN ON PLANS. ALL TRANSFER SWITCHES SHALL BE INCLUDED INTO A COMMON DISPLAY. ANNUNCIATOR SHALL UTILIZE LED LIGHTS TO INDICATE EACH TRANSFER SWITCH STATUS AND POSITION PLUS A GENERAL ALARM LIGHT. ANNUNCIATOR SHALL ALSO INCLUDE A SWITCH OR PUSHBUTTON FOR REMOTE

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TEST AND REMOTE MANUAL TRANSFER OF EACH TRANSFER SWITCH INDIVIDUALLY. PROVIDE ALL CABLING, PER MANUFACTURER'S RECOMMENDATIONS, IN CONDUIT.

(B) GRAPHICAL ANNUNCIATION AND CONTROL:

1. SYSTEM DESCRIPTION: PROVIDE A COMPUTER SOFTWARE BASED CONTROL AND MONITORING SYSTEM FOR ALL TRANSFER SWITCHES AND ENGINE GENERATORS WITH THE FOLLOWING COMPONENTS:
 - A. INTERFACE MODULES, AS NEEDED, FOR EACH TRANSFER SWITCH OR ENGINE-GENERATOR TO ENABLE CONNECTION TO THE NETWORK.
 - B. ALL DATA CABLING BETWEEN INTERFACES, PER MANUFACTURER'S RECOMMENDATIONS, IN CONDUIT.
 - C. CONVERTER MODULE, AS NEEDED, FOR COMPATIBILITY AND CONNECTION WITH THE OWNER'S INTRANET.
 - D. SOFTWARE PROGRAM, MICROSOFT WINDOWS COMPATIBLE AND CUSTOMIZED FOR THE PROJECT.
 - E. SOFTWARE LICENSES/KEYS AND ACCESS TO FUTURE SOFTWARE UPGRADES.
2. SOFTWARE CAPABILITIES: PROVIDE THE FOLLOWING INFORMATION/CONTROL AS PART OF THE SOFTWARE PROGRAM.
 - A. FOR EACH TRANSFER SWITCHES:
 - (1) NAMEPLATE INFORMATION (AMP RATING, VOLTAGE, ETC.)
 - (2) STATUS (LOAD ON NORMAL, ETC.)
 - (3) REMOTE TESTING AND REMOTE TRANSFER
 - (4) TIME DELAY SETTINGS MODIFICATION
 - (5) ENGINE EXERCISER PROGRAMMING
 - (6) HISTORICAL EVENT LOG VIEWING
 - B. FOR EACH ENGINE GENERATORS:
 - (1) NAMEPLATE INFORMATION (AMP RATING, VOLTAGE, ETC.)
 - (2) STATUS (GENERATOR SUPPLYING LOAD, ETC.)
 - (3) ALARMS AND WARNINGS FROM GENERATOR CONTROLLER
 - (4) GENERATOR REMOTE START/STOP
 - (5) ELECTRICAL OUTPUT DATA (VOLTS, AMPS, KW, FREQUENCY, ETC.)
3. PERSONAL COMPUTERS FOR THE SOFTWARE WILL BE PROVIDED BY THE OWNER.

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PART 3 - EXECUTION

3.01 INSTALLATION

- (A) INSTALL CONCRETE HOUSEKEEPING PADS FOR ALL FLOOR MOUNTED TRANSFER SWITCHES.
- (B) INSTALL TRANSFER SWITCHES, PER MANUFACTURER'S RECOMMENDATIONS, AT LOCATIONS SHOWN ON PLANS AND AFTER BEING COORDINATED WITH ALL TRADES ON THE PROJECT.
- (C) INSTALL ALL CONTROL WIRING, PER MANUFACTURER'S RECOMMENDATIONS, IN CONDUIT, BETWEEN TRANSFER SWITCHES AND ENGINE-GENERATOR SYSTEM REQUIRED FOR PROPER OPERATION.
- (D) INSTALL REMOTE ANNUNCIATORS, PER MANUFACTURER'S RECOMMENDATIONS, AT LOCATIONS COORDINATED WITH OWNER OR AS SHOWN ON PLANS.
- (E) ADJUST TIME DELAY SETTINGS OF TRANSFER SWITCHES PER DIRECTION OF PROJECT ENGINEER.

3.02 FIELD QUALITY CONTROL

- (A) MANUFACTURER'S FIELD SERVICES: ENGAGE A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE TO INSPECT, TEST AND ADJUST TRANSFER SWITCHES AND CONNECTIONS TO MEET THE REQUIREMENTS OF THIS SPECIFICATION SECTION OR AS NEEDED TO CREATE A COMPLETE AND OPERATING SYSTEM AND TO PROVIDE TRAINING FOR THE OWNER'S REPRESENTATIVES.

3.03 SITE ACCEPTANCE TESTING

- (A) THE FACTORY-AUTHORIZED SERVICE REPRESENTATIVE SHALL BE PRESENT DURING THE EMERGENCY POWER SYSTEM TESTING.
- (B) THE FACTORY-AUTHORIZED SERVICE REPRESENTATIVE SHALL DEMONSTRATE PROPER REMOTE ALARM ANNUNCIATION BY SIMULATING ALARM AND WARNINGS AT THE TRANSFER SWITCHES.
- (C) TESTING OF THE TRANSFER SWITCHES SHALL COINCIDE WITH TESTING OF THE ENGINE GENERATOR SYSTEM IN ORDER TO CONFIRM FUNCTIONALITY OF THE ENTIRE EMERGENCY POWER SYSTEM (ENGINE GENERATORS AND TRANSFER SWITCHES). REFER TO TESTING PROCEDURES DETAILED IN SECTION 26 32 13.
- (D) FAILURE OF THE TRANSFER SWITCHES DURING THE EMERGENCY POWER SYSTEM TESTING SHALL RESULT IN RETESTING THE SYSTEM AT THE CONTRACTOR'S EXPENSE AND MAY INCLUDE EXPENSES FROM ADDITIONAL SITE VISITS BY THE ARCHITECT/OWNER/ENGINEER. IT IS STRONGLY RECOMMENDED THAT THE TESTING REQUIREMENTS OF 26 32 13 BE SUCCESSFULLY ATTEMPTED PRIOR TO THE SITE ACCEPTANCE TESTING FOR THE DESIGN TEAM AND OWNER.

3.04 TRAINING

- (A) A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE SHALL TRAIN THE OWNER'S REPRESENTATIVE(S) ON THE PROPER OPERATION AND REQUIRED ROUTINE MAINTENANCE OF THE TRANSFER SWITCH AND REMOTE ANNUNCIATORS. TRAINING SHALL BE A COMBINATION OF HANDS-ON FIELD TRAINING, INCLUDING LIVE SYSTEM DEMONSTRATION IF DESIRED BY OWNER, PLUS CLASSROOM INSTRUCTION. TRAINING SHALL NOT EXCEED EIGHT (8) HOURS OVER ONE DAY.

END OF SECTION 26 36 00 – TRANSFER SWITCHES

SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- (A) Section includes lightning protection system for ordinary structures.

1.03 ACTION SUBMITTALS

- (A) Product Data: For each type of product.

- (B) Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.04 INFORMATIONAL SUBMITTALS

- (A) Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

- (B) Qualification Data: For Installer.

- (C) Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

1.05 QUALITY ASSURANCE

- (A) Installer Qualifications: LPI Master Installer.

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PART 2 - PRODUCTS

2.01 MANUFACTURERS

- (A) Harger
- (B) Rubbins Lightning, Inc.
- (C) Thompson Lightning Protection, Inc.

2.02 PERFORMANCE REQUIREMENTS

- (A) NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.
- (B) UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.
- (C) Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.03 MATERIALS

(A) Air Terminals:

- 1. Aluminum unless otherwise indicated.
- 2. 1/2-inch (12.7-mm) diameter by 12 inches (305 mm) long unless otherwise indicated.
- 3. Rounded tip.

(B) Air Terminal Bracing:

- 1. Aluminum.
- 2. 1/4-inch (6-mm) diameter rod.

(C) Class 1 Main Conductors:

- 1. Aluminum: 98,600 circular mils in diameter.

(D) Secondary Conductors:

- 1. Aluminum: 41,400 circular mils in diameter.

(E) Ground Loop Conductor: Stranded copper.

(F) Ground Rods:

- 1. Material: Solid copper.
- 2. Diameter: 5/8 inch (16 mm).
- 3. Rods shall be not less than 120 inches (3050 mm) long.

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- (G) Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.01 INSTALLATION

- (A) Install lightning protection components and systems according to NFPA 780.
- (B) Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.
- (C) Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed systems in NFPA 780.
1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
 2. Install conduit where necessary to comply with conductor concealment requirements.
 3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- (D) Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.02 CONNECTIONS

- (A) Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- (B) Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors.
- (C) Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.03 CORROSION PROTECTION

- (A) Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- (B) Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

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3.04 FIELD QUALITY CONTROL

(A) Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.
2. Perform inspections to obtain an LPI certification.

(B) Prepare test and inspection reports and certificates.

END OF SECTION 26 41 13

SECTION 26 51 13 - LUMINAIRES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) EXTENT OF LUMINAIRES WORK IS INDICATED BY DRAWINGS AND SCHEDULES.

- (B) MATERIALS COVERED IN THIS SECTION INCLUDE THE FOLLOWING:

1. LUMINAIRES.
2. EXIT SIGNS.
3. LAMPS.

1.03 SUBMITTALS

- (A) FOR EACH LUMINAIRE TYPE LISTED ON THE "LUMINAIRE SCHEDULE" ON THE DRAWINGS, SUBMIT THE FOLLOWING INFORMATION FOR REVIEW:

1. A CUT SHEET FOR EACH LUMINAIRE WITH TYPE DESIGNATION LISTED AT THE TOP OF THE SHEET. CLEARLY IDENTIFY FULL LUMINAIRE PART NUMBER AND ALL INCLUDED OPTIONS. CUT SHEET SHALL CONTAIN PHOTOMETRICS AND LIST LUMINAIRE EFFICIENCY.
2. FOR EXTERIOR, POLE-MOUNTED LUMINAIRES INCLUDE A CUT SHEET OF THE PROPOSED POLE. CLEARLY IDENTIFY FULL PART NUMBER AND ALL INCLUDED OPTIONS.
3. DRIVER CUT SHEET FROM AN ACCEPTABLE MANUFACTURER WITH SPECIFIC MODEL NUMBER IDENTIFIED. INDICATE ON THE CUT SHEET EACH LUMINAIRE TYPE UTILIZING THE BALLAST.
4. LAMP CUT SHEET FROM AN ACCEPTABLE MANUFACTURER WITH SPECIFIC MODEL NUMBER IDENTIFIED. INDICATE ON THE CUT SHEET EACH LUMINAIRE TYPE UTILIZING THE LAMP.
5. INCLUDE WARRANTY INFORMATION THAT MEETS OR EXCEEDS REQUIREMENTS INDICATED IN THE SPECIFICATIONS OR ON PLANS.

1.04 WARRANTY

- (A) PROVIDE MATERIAL MANUFACTURER'S WRITTEN WARRANTIES, AS FOLLOWS:

1. STANDARD LUMINAIRES: ONE (1) YEAR
2. LED LUMINAIRES: FIVE (5) YEARS.
3. FLUORESCENT/COMPACT FLUORESCENT BALLASTS: FIVE (5) YEARS
4. EXIT SIGNS: FIVE (5) YEARS

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LUMINAIRES
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5. LAMPS: MANUFACTURER'S STANDARD WARRANTY BASED ON LAMP AND DRIVER TYPES.

PART 2 - PRODUCTS

2.01 LUMINAIRES - GENERAL

- (A) LETTERS (A, B, C, ETC.) NEAR EACH LUMINAIRE SYMBOL SHOWN ON THE DRAWINGS CORRESPOND TO THE "LUMINAIRE SCHEDULE", ALSO ON THE DRAWINGS.
- (B) THE TYPE AND ACCEPTABLE MANUFACTURERS OF ALL LUMINAIRES SHALL BE AS INDICATED ON THE LUMINAIRES SCHEDULE AND DRAWINGS.
1. ADDITIONAL PRODUCTS FROM MANUFACTURERS NOT LISTED ON THE SCHEDULE OR DRAWINGS MAY BE SUBMITTED FOR REVIEW AND PRE-APPROVAL BY THE ARCHITECT AND ENGINEER.
2. PRIOR APPROVALS MUST BE SUBMITTED 10 DAYS PRIOR TO BID OR PRIOR TO LAST ADDENDUM.
- (C) ALL RECESSED LUMINAIRES SHALL BE PROVIDED WITH RUBBER OR FIBERGLASS GASKETS OR OF EQUIVALENT MATERIAL TO PREVENT LIGHT LEAKS AROUND FLUSH TRIM. LUMINAIRES SHALL BE PROVIDED WITH PROPER THERMAL PROTECTION AS REQUIRED FOR SURROUNDING ENVIRONMENT. EXTERIOR LUMINAIRES SHALL BE FURNISHED WITH WEATHERPROOF, NEOPRENE GASKETS SUITABLE FOR OUTDOOR INSTALLATIONS.
- (D) ALL ACRYLIC LENSES SHALL BE PRISMATIC AND NOT LESS THAN 0.125-INCHES THICK NOMINAL. LENSED LUMINAIRES INSTALLED IN KITCHENS AND OTHER AREAS INDICATED ON THE DRAWINGS SHALL HAVE PRISMS INVERTED TO PROVIDE SMOOTH CLEANING SURFACE.
- (E) NO LABELS ON THE LUMINAIRES SHALL BE VISIBLE FROM A FLOOR-STANDING POSITION.
- (F) ALL COMPONENTS OF ALL LUMINAIRES SHALL BE UL LISTED.
- (G) ALL LUMINAIRES FINISHES SHALL BE FACTORY APPLIED UNLESS SPECIFICALLY NOTED OTHERWISE. REFER TO SCHEDULE ON DRAWINGS FOR FINISH COLOR.
- (H) PROVIDE FACTORY INSTALLED INTEGRAL DISCONNECTING MEANS FOR FLUORESCENT LUMINAIRES PER 2014 NEC ARTICLE 410.130 (G). NOTE THAT EXCEPTION NO. 4 WILL NOT BE ACCEPTED.
- (I) ALL FLUORESCENT LUMINAIRES SHALL BE PAINTED AFTER FABRICATION. HOUSINGS FOR RECESSED FLUORESCENT LUMINAIRES SHALL HAVE A MINIMUM DEPTH OF 4". PROVIDE EXTRUDED ALUMINUM TYPE DOOR FRAMES WHERE LUMINAIRES ARE SPECIFIED WITH ALUMINUM DOOR FRAMES.
- (J) LED DOWNLIGHTS SHALL HAVE MATTE ALZAK FINISH SELF-TRIMMING REFLECTORS. LED DOWNLIGHTS SHALL HAVE HARDWARE MOUNTING FOR REFLECTOR, SPRING CLIPS ARE NOT ACCEPTABLE.
- (K) CONTRACTOR SHALL FIELD VERIFY VOLTAGE OF ALL LUMINAIRES PRIOR TO ORDERING.
- (L) WHERE LUMINAIRES ARE SHOWN WITH LAMPS SWITCHED SEPARATELY, PROVIDE QUANTITY OF BALLASTS ACCORDINGLY. PROVIDE INSIDE LAMP(S) SWITCHED SEPARATE FROM OUTSIDE LAMPS UNLESS NOTED OTHERWISE.
- (M) POLE MOUNTED EXTERIOR LUMINAIRES
1. LUMINAIRES SHALL BE UL WET LOCATION LISTED.

2. LIGHT POLES SHALL BE PER LUMINAIRE SCHEDULE AND STEEL OF THE DIAMETER AND LENGTH AS NOTED ON THE SCHEDULE.
3. LUMINAIRES SHALL BE PROVIDED WITH A HINGED, TEMPERED GLASS LENS.
4. PROVIDE FACTORY INSTALLED VIBRATION DAMPENERS IN ALL POLES 20-FEET IN LENGTH AND LONGER.

2.02 EXIT SIGNS

- (A) ACCEPTABLE MANUFACTURERS: REFER TO LUMINAIRE SCHEDULE ON PLANS.
- (B) DESCRIPTION: LIFE SAFETY LUMINAIRES WITH INTEGRAL LED LAMP SOURCE, UL 924 AND NFPA 101 COMPLIANT. LUMINAIRES HOUSING SHALL BE IMPACT-RESISTANT THERMOPLASTIC WITH RED 'EXIT' LETTERING AND CHEVRONS AS SHOWN ON PLANS. ALL EXTERIOR UNITS SHALL HAVE A DIE-CAST ALUMINUM, NEMA 4X RATED HOUSING.
- (C) FOR COLD ENVIRONMENT APPLICATIONS, THE UNIT SHALL BE RATED FOR A MINIMUM OF 0°F TEMPERATURES USING INTEGRAL STRIP HEATER(S) OR OTHER PROVEN METHOD.

2.03 LIGHT EMITTING DIODES (LED) SYSTEMS

- (A) ACCEPTABLE MANUFACTURERS: REFER TO LUMINAIRE SCHEDULE ON PLANS.
1. THE MANUFACTURER AND MODEL LISTED ON THE LUMINAIRE SCHEDULE IS THE BASIS OF DESIGN AND REPRESENTS THE QUALITY LEVEL AND REQUIRED OPTIONS. ANY PROPOSED EQUAL LUMINAIRES SUBMITTED FOR REVIEW AND PRE-APPROVAL BY THE ENGINEER SHALL MEET OR EXCEED THE PERFORMANCE OF THE BASIS OF DESIGN.
- (B) EACH LED-CONTAINING LUMINAIRES SHALL BE TESTED AS A COMPLETE LIGHTING SYSTEM UNDER THE REQUIREMENTS OF IESNA LM-79, LM-80 AND UTILIZE ABSOLUTE PHOTOMETRY.
- (C) PROVIDE EACH LUMINAIRES WITH AN LED DRIVER THAT HAS BEEN TESTED AND APPROVED FOR USE WITH THE LED ARRAY IN THE LUMINAIRES. LUMINAIRES INSTALLED IN LOW AMBIENT TEMPERATURE AREAS SHALL HAVE LED DRIVERS SPECIFICALLY DESIGNED FOR LOW TEMPERATURE STARTING. LUMINAIRES INSTALLED IN HIGH AMBIENT TEMPERATURE AREAS SHALL HAVE LED DRIVERS SPECIFICALLY DESIGNED FOR HIGH TEMPERATURE STARTING.
- (D) CORRELATED COLOR TEMPERATURE (CCT) SHALL BE AS NOTED ON THE LUMINAIRE SCHEDULE ON PLANS.

PART 3 - EXECUTION

3.01 INSPECTION

- (A) EXAMINE AREAS AND CONDITIONS UNDER WHICH LUMINAIRES ARE TO BE INSTALLED AND SUBSTRATE WHICH WILL SUPPORT LUMINAIRES. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF LUMINAIRES

- (A) INSTALL LUMINAIRES AT LOCATIONS AND HEIGHTS AS INDICATED, IN ACCORDANCE WITH LUMINAIRES MANUFACTURER'S WRITTEN INSTRUCTIONS, APPLICABLE REQUIREMENTS OF NEC, NECA'S "STANDARD OF INSTALLATION", NEMA STANDARDS AND WITH RECOGNIZED INDUSTRY PRACTICES TO ENSURE THAT LUMINAIRES FULFILL REQUIREMENTS.

- (B) COORDINATE WITH OTHER ELECTRICAL WORK AS APPROPRIATE TO PROPERLY INTERFACE INSTALLATION OF LUMINAIRES WITH OTHER WORK.
- (C) WHERE RECESSED LUMINAIRES ARE SPECIFIED, CONTRACTOR SHALL PROVIDE PLASTER FRAMES OR OTHER FRAMING DEVICES TO THE CEILING CONTRACTOR PRIOR TO THE INSTALLATION OF THE LUMINAIRES AND SHALL BE RESPONSIBLE TO SEE THAT THE PROPER LUMINAIRES ARE FURNISHED FOR THE SPECIFIC CEILING USED.
- (D) INDEPENDENTLY SUPPORT EACH LAY-IN LUMINAIRES INSTALLED IN AN ACOUSTICAL CEILING USING 2 #12 STEEL WIRES CONNECTED TO OPPOSITE ENDS OF THE LUMINAIRES HOUSING AND ANCHORED TO STRUCTURE (FLOOR DECK, METAL TRUSS, ETC.) ABOVE. IN NO CASE SHALL ANY LUMINAIRES BE HUNG FROM PLASTER, PLASTERBOARD, ACOUSTIC OR INSULATING MATERIALS OR SUPPORTED SOLELY BY AN ACOUSTICAL CEILING GRID.
- (E) WHERE LIGHT POLES ARE USED, FASTEN LUMINAIRES SECURELY TO POLES, INSTALL CONCRETE BASE AND ENSURE THAT POLES ARE INSTALLED PLUMB.
- (F) WHERE RECESSED LUMINAIRES ARE INSTALLED IN FIRE-RATED CEILINGS OR WALLS, CONTRACTOR SHALL PROVIDE AN ENCLOSURE APPROVED BY AUTHORITIES HAVING JURISDICTION TO SURROUND EACH LUMINAIRES AS REQUIRED TO MAINTAIN THE FIRE INTEGRITY RATING OF THE CEILING. ADEQUATE CLEARANCE BETWEEN LUMINAIRES AND ENCLOSURE SHALL BE PROVIDED IN ACCORDANCE WITH LUMINAIRES MANUFACTURERS RECOMMENDATIONS. VERIFY CLEARANCE REQUIREMENTS WITH LUMINAIRES MANUFACTURER PRIOR TO INSTALLATION OF LUMINAIRES.

3.03 ADJUSTING AND CLEANING

- (A) CLEAN LUMINAIRES OF DIRT AND DEBRIS UPON COMPLETION OF INSTALLATION.
- (B) PROTECT INSTALLED LUMINAIRES FROM DAMAGE DURING CONSTRUCTION PERIOD.

3.04 FIELD QUALITY CONTROL

- (A) UPON COMPLETION OF INSTALLATION OF LUMINAIRES, AND AFTER BUILDING CIRCUITRY HAS BEEN ENERGIZED, APPLY ELECTRICAL ENERGY TO DEMONSTRATE CAPABILITY AND COMPLIANCE WITH REQUIREMENTS. WHERE POSSIBLE, CORRECT MALFUNCTIONING UNITS AT SITE, THEN RETEST TO DEMONSTRATE COMPLIANCE; OTHERWISE, REMOVE AND REPLACE WITH NEW UNITS AND PROCEED WITH RETESTING.
- (B) CONTRACTOR SHALL PERFORM 'BURN-IN' PERIOD FOR ALL FLUORESCENT, COMPACT FLUORESCENT AND HID LAMPS PER LAMP MANUFACTURER'S RECOMMENDATIONS. LAMPS SHALL NOT BE DIMMED DURING THIS PERIOD.

3.05 GROUNDING

- (A) PROVIDE EQUIPMENT GROUNDING CONNECTIONS FOR LUMINAIRES AS REQUIRED BY NEC AND OTHER DIVISION 26 SECTIONS. TIGHTEN CONNECTIONS TO COMPLY WITH TIGHTENING TORQUES SPECIFIED IN UL STANDARD 486A TO ASSURE PERMANENT AND EFFECTIVE GROUNDS.

END OF SECTION 26 51 13 - LUMINAIRES

SECTION 27 10 10 - TELECOMMUNICATION CABLING SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SCOPE

- (A) THIS SPECIFICATION ESTABLISHES THE GENERAL SPECIFICATIONS FOR A "UNIVERSAL" PREMISE DISTRIBUTION SYSTEM THAT WILL SUPPORT ALL INDUSTRY STANDARDS COMPLIANT APPLICATIONS AND ALLOW TOTAL END TO END SOLUTION ON SHARED MEDIA TO MEET THE VOICE, DATA, IMAGE AND SENSOR COMMUNICATIONS NEEDS OF THE OWNER.
- (B) THE DATA SYSTEM SHALL CONSIST OF HORIZONTAL COPPER CABLES, FIBER OPTIC BACKBONE CABLING, JACKS, PATCH PANELS AND EQUIPMENT RACKS.
- (C) THE TELEPHONE SYSTEM SHALL CONSIST OF HORIZONTAL COPPER CABLES, COPPER BACKBONE CABLING, JACKS AND TERMINATIONS.
- (D) THE INTENT OF THIS SYSTEM IS THAT WIRING FOR DATA OUTLETS AND WIRING FOR TELEPHONE OUTLETS IS THE SAME AND INTERCHANGEABLE BETWEEN THE OUTLET AND THE TERMINATION IN THE WIRING CLOSET.

1.03 GENERAL SPECIFICATION INFORMATION

- (A) ALL COPPER CABLING MATERIALS AND COMPONENTS SHALL COMPLY WITH CATEGORY 6 PERFORMANCE REQUIREMENTS OF THE TIA/EIA-568-B.2 STANDARD WHICH SPECIFIES A MINIMUM BANDWIDTH OF 250 MHZ.
- (B) ALL FIBER OPTIC CABLING MATERIALS AND COMPONENTS SHALL COMPLY WITH THE PERFORMANCE REQUIREMENTS OF THE TIA/EIA-568-B.3 STANDARD.
- (C) THE TELECOMMUNICATION SYSTEM SHALL INCLUDE INSTALLATION AND TESTING OF ALL CABLING, EQUIPMENT AND MATERIALS NECESSARY TO FORM COMPLETE AND OPERATIONAL SYSTEMS.
- (D) THE CABLE LENGTHS ON ALL HORIZONTAL RUNS SHALL NOT EXCEED 90-METERS (295-FEET).
- (E) ALL WORK SHALL CONFORM TO THE LATEST EDITION OF THE NATIONAL ELECTRICAL CODE, THE BUILDING CODE AND ALL LOCAL CODES AND ORDINANCES AS APPLICABLE. TIA/EIA 568B AND EIA/TIA 569A SHALL BE ADHERED TO DURING ALL INSTALLATION ACTIVITIES. METHODOLOGIES OUTLINED IN THE LATEST EDITION OF THE BICSI TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL SHALL ALSO BE USED DURING ALL INSTALLATION ACTIVITIES. SHOULD CONFLICTS EXIST WITH THE FOREGOING, THE AUTHORITY HAVING JURISDICTION OF ENFORCEMENT WILL HAVE RESPONSIBILITY FOR MAKING INTERPRETATION.
- (F) THE INSTALLER WILL BE RESPONSIBLE FOR KEEPING ALL ASPECTS OF THE CABLE SYSTEM WITHIN FIRE CODES DURING CONSTRUCTION AND AT THE PROJECTS COMPLETION.

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1.04 QUALITY ASSURANCE

- (A) THE TELECOMMUNICATION CONTRACTOR SHALL HAVE NOT LESS THAN FIVE (5) YEARS EXPERIENCE INSTALLING TELECOMMUNICATION SYSTEMS AND SHALL HAVE A REGISTERED COMMUNICATIONS DISTRIBUTION DESIGNER (RCDD) ON STAFF. THE PROJECT TELECOMMUNICATION INSTALLER SHALL HAVE NOT LESS THAN THREE (3) YEARS' EXPERIENCE INSTALLING TELECOMMUNICATION SYSTEMS. THE CONTRACTOR SHALL PROVIDE NOT LESS THAN SIX (6) REFERENCES FOR PROJECTS OF SIMILAR SCOPE AND SPECIFICATIONS. PROOF OF EXPERIENCE AND QUALIFICATIONS WILL BE REQUIRED.
- (B) CONTRACTOR SHALL BE CERTIFIED BY MANUFACTURER PRIOR TO SUBMITTING THE BID.

1.05 DESCRIPTION OF WORK

- (A) THE INSTALLER SHALL FURNISH AND INSTALL ALL MATERIALS NECESSARY TO RUN CABLING FROM EACH WORK AREA JACK TO THE TELECOMMUNICATION'S CLOSET AND PROVIDE FIBER OPTIC AND/OR COPPER CABLE BETWEEN THE CLOSETS.
- (B) THE INSTALLER WILL TEST ALL CABLES AFTER INSTALLATION TO INSURE PROPER CONNECTIONS AND SHOW COMPLIANCE WITH THE SPECIFIED STANDARDS.

1.06 SYSTEM WARRANTY

- (A) THE TELECOMMUNICATION CONTRACTOR SHALL BE AUTHORIZED BY A MANUFACTURER TO PROVIDE A 15 YEAR CERTIFIED SYSTEM. THE WARRANTY SHALL INCLUDE:
1. FIFTEEN YEAR APPLICATION ASSURANCE WARRANTY CERTIFYING THAT THE WIRING SYSTEM WILL SUPPORT ALL THE APPLICATIONS THAT IT WAS DESIGNED TO SUPPORT AS SPECIFIED HEREIN.
 2. FIFTEEN YEAR EXTENDED PRODUCT WARRANTY FOR ALL PASSIVE PRODUCTS INSTALLED IN THE CABLING SYSTEM.
 3. FIFTEEN YEAR LABOR WARRANTY FOR THE REPLACEMENT OF ANY INSTALLED CABLING SYSTEM PRODUCT FOUND TO BE DEFECTIVE.
- (B) THE TELECOMMUNICATION CONTRACTOR SHALL SUBMIT ALL NECESSARY PAPERWORK TO THE MANUFACTURER AND PROVIDE TO THE OWNER THE MANUFACTURER'S FIFTEEN YEAR WARRANTY CERTIFICATE.
- (C) THE TELECOMMUNICATION CONTRACTOR SHALL PROVIDE AN OUTLINE OF PROCEDURES FOR FOLLOW-UP WARRANTY WORK. THIS OUTLINE SHOULD INCLUDE EXPECTED TIME RESPONSE AND TELEPHONE NUMBERS FOR SERVICE AND LABOR NEEDED.

1.07 SUBMITTALS

- (A) AS A MINIMUM, THE FOLLOWING ITEMS SHALL BE SUBMITTED FOR APPROVAL.
1. EXPERIENCE, QUALIFICATIONS AND CONTRACTOR CERTIFICATION.
 2. A COPY OF THE SYSTEM WARRANTY WRITTEN FOR THIS PROJECT.
 3. MANUFACTURER'S DATA SHEETS FOR ALL PRODUCTS USED.

4. ONE-LINE SCHEMATIC DRAWING SHOWING QUANTITY, LOCATION AND CONNECTION OF ALL TELECOMMUNICATION COMPONENTS. THIS SHALL INCLUDE ELEVATIONS OF ALL EQUIPMENT RACKS INDICATING PATCH PANELS, EQUIPMENT SHELVES AND REQUIRED SPACE.
5. TEST RESULTS, RECORD DRAWINGS AND DOCUMENTATION.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE TELECOMMUNICATION SYSTEMS OF ONE (1) OF THE FOLLOWING: SYSTEM WARRANTY SHALL BE WRITTEN THROUGH THE CONNECTIVITY MANUFACTURER.

1. BELDEN IBDN.
2. HUBBELL.
3. MOLEX.
4. PANDUIT.
5. SYSTIMAX.
6. UNIPRISE.

2.02 UNSHIELDED TWISTED PAIR CABLE SYSTEM FOR DATA AND TELEPHONE

- (A) HORIZONTAL CABLE. CABLE SHALL BE LABEL-VERIFIED. CABLE JACKET SHALL BE FACTORY MARKED AT REGULAR INTERVALS INDICATING VERIFYING ORGANIZATION AND PERFORMANCE LEVEL. CONDUCTORS SHALL BE 4-PAIR SOLID UNTINNED COPPER 23 OR 24 AWG. CABLE SHALL BE PLENUM RATED CMP PER NFPA 70.
- (B) BACKBONE CABLE. CABLE SHALL BE LABEL-VERIFIED. CABLE JACKET SHALL BE FACTORY MARKED AT REGULAR INTERVALS INDICATING VERIFYING ORGANIZATION AND PERFORMANCE LEVEL. CONDUCTORS SHALL BE MULTI-PAIR SOLID UNTINNED COPPER 24 AWG AND ASSEMBLED INTO BINDER GROUPS OF 25 PAIR OF PARTS THEREOF FOLLOWING THE STANDARD INDUSTRY COLOR CODES. CABLE SHALL BE CATEGORY 3 AND SHALL BE PLENUM RATED CMP PER NFPA 70.
- (C) DATA OUTLETS. OUTLET PLATES SHALL COME EQUIPPED WITH MODULAR JACKS, QUANTITY AS INDICATED ON THE DRAWINGS. MODULAR JACKS SHALL BE 8-POSITION JACKS. MODULAR JACK PIN/PAIR CONFIGURATION SHALL BE T568B. VERIFY PIN/PAIR CONFIGURATION WITH OWNER PRIOR TO INSTALLATION. MODULAR JACKS SHALL BE UNKEYED. FACEPLATES SHALL BE LABELED FACE PLATES WITH RECESSED LABELING FIELD INCLUDED TO ACCEPT LABEL CARD AND CLEAR PLASTIC COVER. FACEPLATE MATERIAL AND FINISH SHALL MATCH FACEPLATES FOR OTHER WIRING DEVICES IN THE SAME ROOM OR SPACE. WALL MOUNTED TELEPHONE OUTLETS SHALL BE LOCATED AT 48-INCHES ABOVE FINISHED FLOOR. FACE PLATE SHALL CONSIST OF TWO (2) MOUNTING POSTS AND SHALL BE STAINLESS STEEL. (SEE DIVISION 26 SPECIFICATION SECTION WIRING DEVICES FOR MATERIAL AND FINISH).
- (D) TELEPHONE OUTLETS. OUTLET PLATES SHALL COME EQUIPPED WITH MODULAR JACKS, QUANTITY AS INDICATED ON THE DRAWINGS. MODULAR JACKS SHALL BE 8-POSITION JACKS. MODULAR JACK PIN/PAIR CONFIGURATION SHALL BE T568B. (VERIFY PIN/PAIR CONFIGURATION WITH OWNER PRIOR TO INSTALLATION.) FACEPLATES SHALL BE LABELED FACEPLATES WITH RECESSED LABELING FIELD INCLUDED TO ACCEPT LABEL CARD AND CLEAR PLASTIC COVER. WHERE INDICATED ON THE DRAWINGS TELEPHONE JACKS SHALL BE COMBINED WITH DATA JACKS IN THE SAME WALL PLATE. FACEPLATE MATERIAL AND FINISH SHALL MATCH FACEPLATES FOR OTHER WIRING DEVICES

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IN THE SAME ROOM OR SPACE. BLACK COVER PLATES TO BE ADDED FOR UNUSED OPENINGS. (SEE DIVISION 26 SPECIFICATION SECTION WIRING DEVICES FOR MATERIAL AND FINISH).

1. WALL MOUNTED TELEPHONE OUTLETS SHALL BE LOCATED AT 48-INCHES ABOVE FINISHED FLOOR. FACE PLATES SHALL CONSIST OF TWO MOUNTING POSTS AND SHALL BE STAINLESS STEEL.
- (E) PATCH PANELS FOR DATA. PATCH PANELS SHALL CONSIST OF 8-POSITION MODULAR JACKS, WITH REAR MOUNTED TYPE 110 INSULATION DISPLACEMENT CONNECTORS, ARRANGED IN ROWS OR COLUMNS ON 19-INCH RACK MOUNTED PANELS. JACK PIN/PAIR CONFIGURATION SHALL BE T568B. (VERIFY PIN/PAIR CONFIGURATION WITH OWNER PRIOR TO INSTALLATION.) JACKS SHALL BE UNKEYED. PANELS SHALL BE PROVIDED WITH LABELING SPACE. PATCH PANELS SHALL BE 48 PORT. PROVIDE QUANTITY OF PATCH PANELS REQUIRED TO ACCOMMODATE THE INSTALLED CABLE PLANT PLUS 20% SPARES.
- (F) TERMINAL BLOCKS FOR TELEPHONE. TERMINAL BLOCKS SHALL BE WALL-MOUNTED WIRE TERMINATION UNITS CONSISTING OF INSULATION DISPLACEMENT CONNECTORS MOUNTED IN PLASTIC BLOCKS, FRAMES OR HOUSINGS. BLOCKS SHALL BE TYPE 110. BLOCKS SHALL BE MOUNTED ON STANDOFFS AND SHALL INCLUDE CABLE MANAGEMENT HARDWARE. INSULATION DISPLACEMENT CONNECTORS SHALL TERMINATE 22- OR 24-GAUGE SOLID COPPER WIRE AS A MINIMUM AND SHALL BE CONNECTED IN PAIRS SO THAT HORIZONTAL CABLE AND CONNECTED JUMPER WIRES ARE ON SEPARATE CONNECTED TERMINALS.
- (G) CABLE SUPPORTS. CABLE SUPPORTS SHALL BE CADDY 425 STRAPS.
- (H) PATCH CORDS. PATCH CORDS WILL BE PROVIDED BY THE OWNER.

2.03 FIBER OPTIC CABLE SYSTEM

- (A) MULTIMODE 12 STRAND FIBER OPTIC BACKBONE CABLE SHALL BE USED TO CONNECT ALL TELECOMMUNICATION CLOSETS. CABLE SHALL BE 62.5/125 MICROMETER MULTIMODE GRADED INDEX OPTICAL FIBER CABLE. CABLE CONSTRUCTION SHALL BE TIGHT BUFFERED TYPE. INDIVIDUAL FIBERS SHALL BE COLOR CODED FOR IDENTIFICATION. CABLE SHALL BE IMPRINTED WITH FIBER COUNT AND AGGREGATE LENGTH AT REGULAR INTERVALS. CABLE SHALL BE PLENUM RATED OFNP PER NFPA 70.
- (B) CONNECTORS SHALL BE DUPLEX SC TYPE. CONNECTORS SHALL BE FIELD INSTALLABLE. CONNECTORS SHALL UTILIZE ADHESIVE FOR FIBER ATTACHMENT TO FERRULE. CONNECTORS SHALL TERMINATE FIBER SIZES AS REQUIRED FOR THE SERVICE.
- (C) PATCH PANELS. FIBER OPTIC ADAPTERS SHALL BE PROVIDED TO ALIGN AND JOIN THE FIBER OPTIC CONNECTORS ALLOWING A MEANS TO CROSS CONNECT OR INTERCONNECT PREMISES EQUIPMENT TO THE OPTICAL FIBER CABLING. ADAPTERS SHALL BE HOUSED IN RACK MOUNTED PANELS AND SHALL HAVE SLIDING DRAWERS TO STORE FIBER LOOPS AND TINTED REMOVABLE PLEXIGLAS COVERS TO PROTECT THE FIBER CONNECTORS. QUANTITY OF ADAPTERS SHALL BE SUFFICIENT TO ACCOMMODATE THE INSTALLED CABLE PLANT PLUS 20% SPARE.
- (D) PATCH CORDS. PATCH CORDS WILL BE PROVIDED BY THE OWNER.

2.04 EQUIPMENT RACKS – FLOOR MOUNTED

- (A) FLOOR MOUNTED EQUIPMENT RACKS SHALL BE ALUMINUM RELAY RACKS WITH UPRIGHTS TO MOUNT EQUIPMENT 19-INCHES WIDE. UPRIGHTS SHALL BE A 3-INCH DEEP CHANNEL 1-1/4-INCHES WIDE, DRILLED AND TAPPED 12-24 IN A 1/2-INCH PATTERN. RACKS SHALL BE PROVIDED WITH A STANDARD TOP CROSSMEMBER, AND PREDRILLED BASE PLATE TO ALLOW FLOOR FASTENING. OPEN FRAME EQUIPMENT RACKS SHALL BE 7-FEET IN HEIGHT AND CLEAR COATED. EACH RACK SHALL HAVE NOT LESS THAN 40% AVAILABLE SPACE FOR USE BY OWNER AT COMPLETION OF CABLE INSTALLATION.

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- (B) CABLE GUIDES SHALL BE SPECIFICALLY MANUFACTURED FOR THE PURPOSE OF ROUTING CABLES, WIRES AND PATCH CORDS HORIZONTALLY AND VERTICALLY ON 19-INCH EQUIPMENT RACKS. CABLE GUIDES SHALL CONSIST OF RING OR BRACKET-LIKE DEVICES MOUNTED ON RACK PANELS FOR HORIZONTAL USE OR INDIVIDUALLY MOUNTED FOR VERTICAL USE. CABLE GUIDES SHALL MOUNT TO RACKS BY SCREWS AND/OR NUTS AND LOCKWASHERS. PROVIDE SUFFICIENT QUANTITY OF CABLE GUIDES TO FILL RACK (FOR BOTH ACTIVE AND SPARE SECTIONS OF RACK).
- (C) FURNISH A MINIMUM OF TWO (2) SINGLE-SIDED 15-INCH DEEP COMPONENT SHELVES PER RACK.

2.05 EQUIPMENT MOUNTING BACKBOARD

- (A) THREE-QUARTER INCH (3/4-INCH) PLYWOOD BACKBOARDS SHALL BE PROVIDED, SIZED AS SHOWN. BACKBOARDS SHALL BE PAINTED WITH TWO (2) COATS OF WHITE OR LIGHT COLORED FIRE RETARDANT PAINT.

PART 3 - INSTALLATION

3.01 GENERAL

- (A) SYSTEM COMPONENTS AND APPURTENANCES SHALL BE INSTALLED IN ACCORDANCE WITH NFPA 70, MANUFACTURER'S INSTRUCTIONS AND AS SHOWN. NECESSARY INTERCONNECTIONS, SERVICES, AND ADJUSTMENTS REQUIRED FOR A COMPLETE AND OPERABLE SIGNAL DISTRIBUTION SYSTEM SHALL BE PROVIDED. COMPONENTS SHALL BE LABELED IN ACCORDANCE WITH TIA/EIA 606. PENETRATIONS IN FIRE-RATED CONSTRUCTION SHALL BE FIRESTOPPED. CONDUITS, OUTLETS AND RACEWAYS SHALL BE INSTALLED IN ACCORDANCE WITH DIVISION 26. WIRING SHALL BE INSTALLED IN ACCORDANCE WITH EIA/TIA 569A. WIRING, AND TERMINAL BLOCKS AND OUTLETS SHALL BE MARKED IN ACCORDANCE WITH TIA/EIA 606. CABLES SHALL NOT BE INSTALLED IN THE SAME CABLE TRAY, UTILITY POLE COMPARTMENT, OR FLOOR TRENCH COMPARTMENT WITH AC POWER CABLES. CABLES NOT INSTALLED IN CONDUIT OR WIREWAYS SHALL BE PROPERLY SECURED AND NEAT IN APPEARANCE AND, IF INSTALLED IN PLENUMS OR OTHER SPACES USED FOR ENVIRONMENTAL AIR, SHALL COMPLY WITH NFPA 70 REQUIREMENTS FOR THIS TYPE OF INSTALLATION.
- (B) HORIZONTAL DISTRIBUTION CABLE. ALL CABLES SHALL BE INSTALLED IN A CONTINUOUS RACEWAY FROM EACH DATA OUTLET BOX TO DATA RACK. OUTLET BOX SHALL BE 4-INCH X 4-INCH X 2-1/8-INCH DEEP BOX WITH SINGLE GANG PLASTER RING. PROVIDE A CONTINUOUS RACEWAY TO TELECOMMUNICATION CLOSET IN AREAS WITHOUT ACCESSIBLE CEILINGS. CONDUIT SIZE SHALL BE 1-INCH MINIMUM. PROVIDE INSULATED BUSHING AT EACH END OF CONDUIT. THE RATED CABLE PULLING TENSION SHALL NOT BE EXCEEDED. CABLE SHALL NOT BE STRESSED SUCH THAT TWISTING, STRETCHING OR KINKING OCCURS. CABLE SHALL NOT BE SPLICED. COPPER CABLE NOT IN A WIREWAY SHALL BE SUSPENDED A MINIMUM OF 8-INCHES ABOVE CEILINGS BY CABLE SUPPORTS NO GREATER THAN 48-INCHES APART. CABLE SHALL NOT BE RUN THROUGH STRUCTURAL MEMBERS OR IN CONTACT WITH PIPES, DUCTS OR OTHER POTENTIALLY DAMAGING ITEMS. PLACEMENT OF CABLE PARALLEL TO POWER CONDUCTORS SHALL BE AVOIDED, IF POSSIBLE; A MINIMUM SEPARATION OF 12-INCHES SHALL BE MAINTAINED WHEN SUCH PLACEMENT CANNOT BE AVOIDED. CABLES SHALL BE TERMINATED; NO CABLE SHALL CONTAIN UNTERMINATED ELEMENTS. MINIMUM BENDING RADIUS SHALL NOT BE EXCEEDED DURING INSTALLATION OR ONCE INSTALLED. CABLE TIES SHALL NOT BE EXCESSIVELY TIGHTENED SUCH THAT THE TRANSMISSION CHARACTERISTICS OF THE CABLE ARE ALTERED.
- (C) FIBER BACKBONE CABLE. FIBER OPTIC CABLES SHALL BE INSTALLED IN 1-INCH ORANGE PLENUM RATED INNER DUCT. VERTICAL CABLE SUPPORT INTERVALS SHALL BE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS. CABLE BEND RADIUS SHALL NOT BE LESS THAN 10 TIMES THE OUTSIDE DIAMETER OF THE CABLE DURING INSTALLATION AND ONCE INSTALLED. MAXIMUM TENSILE STRENGTH RATING OF THE CABLE SHALL NOT BE EXCEEDED. CABLE SHALL NOT BE SPLICED. ALL STRANDS OF THE FIBER OPTIC CABLE SHALL BE TERMINATED.

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- (D) LABELING. AS A MINIMUM EVERY JACK, CABLE AND PATCH PANEL SHALL BE LABELED AS TO ITS FUNCTION AND A UNIQUE NUMBER TO IDENTIFY CABLE LINK. THE LABELING SCHEME SHALL BE APPROVED BY THE OWNER AND IN GENERAL SHALL CONFORM TO CLASS 1 OR CLASS 2 ADMINISTRATION STANDARDS PER TIA/EIA 606 (CLASS 1 STANDARDS APPLY TO FACILITIES WITHOUT BACKBONE CABLES). LABELS AT A MINIMUM SHALL BE TYPEWRITTEN OR COMPUTER PRINTER GENERATED ON THE LABELING FIELD CARDS.
- (E) TERMINAL BLOCKS SHALL BE WALL MOUNTED IN ORDERLY ROWS AND COLUMNS. ADEQUATE VERTICAL AND HORIZONTAL WIRE ROUTING AREAS SHALL BE PROVIDED BETWEEN GROUPS OF BLOCKS. INDUSTRY STANDARD WIRE ROUTING GUIDES SHALL BE UTILIZED.
- (F) PATCH PANELS SHALL BE MOUNTED IN EQUIPMENT RACKS. CABLE GUIDES SHALL BE PROVIDED ABOVE, BELOW AND BETWEEN EACH PANEL.
- (G) OPEN FRAME EQUIPMENT RACKS SHALL BE BOLTED TO THE FLOOR. CABLE GUIDES SHALL BE BOLTED OR SCREWED TO RACKS. RACKS SHALL BE INSTALLED LEVEL. GANGED RACKS SHALL BE BOLTED TOGETHER. GANGED RACK CABINETS SHALL HAVE ADJACENT SIDE PANELS REMOVED.
- (H) EQUIPMENT TO BE RACK MOUNTED SHALL BE SECURELY FASTENED TO RACKS BY MEANS OF THE MANUFACTURER'S RECOMMENDED FASTENERS.
- (I) CABLE MANAGEMENT: PROVIDE CABLE TRAY AND OTHER WIRE MANAGEMENT HARDWARE AS REQUIRED TO PROPERLY SUPPORT ALL CABLE WITHIN TELECOMMUNICATIONS CLOSETS. BUNDLES OF CABLE WITHOUT WIRE MANAGEMENT WILL NOT BE ACCEPTED.
- (J) CABLE TIES: PROVIDE VELCRO (HOOK AND LOOP) CABLE TIES FOR ALL CABLE TIES IN TELECOMMUNICATIONS CLOSETS.

3.02 TERMINATION

- (A) CABLES AND CONDUCTORS SHALL SWEEP INTO TERMINATION AREAS; CABLES AND CONDUCTORS SHALL NOT BEND AT RIGHT ANGLES. MANUFACTURER'S MINIMUM BENDING RADIUS SHALL NOT BE EXCEEDED. WHEN THERE ARE MULTIPLE SYSTEM TYPE DROPS TO INDIVIDUAL WORKSTATIONS, RELATIVE POSITION FOR EACH SYSTEM SHALL BE MAINTAINED ON EACH SYSTEM TERMINATION BLOCK OR PATCH PANEL.
- (B) PROVIDE SERVICE LOOPS ABOVE THE CEILINGS AT THE WORKSTATION LOCATION AND IN THE TELECOMMUNICATION CLOSET. AT THE WORKSTATION PROVIDE A MINIMUM CABLE SLACK OF 12-INCHES FOR UTP, CABLES AND 40-INCHES FOR OPTICAL FIBER CABLES. IN THE TELECOMMUNICATION CLOSETS PROVIDE A MINIMUM CABLE SLACK OF 10-FEET FOR BOTH UTP AND OPTICAL FIBER CABLES. CABLE SLACK SHALL BE NEATLY LAYED IN AND SUPPORTED BY CABLE TRAYS LOCATED ABOVE THE EQUIPMENT RACKS.
- (C) UNSHIELDED TWISTED PAIR CABLE: EACH PAIR SHALL BE TERMINATED ON APPROPRIATE OUTLETS, TERMINAL BLOCKS OR PATCH PANELS. PAIRS SHALL REMAIN TWISTED TOGETHER TO WITHIN THE PROPER DISTANCE FROM THE TERMINATION. CONDUCTORS SHALL NOT BE DAMAGED WHEN REMOVING INSULATION. WIRE INSULATION SHALL NOT BE DAMAGED WHEN REMOVING OUTER JACKET.
- (D) FIBER OPTIC CABLE: EACH FIBER SHALL HAVE CONNECTORS INSTALLED. THE PULL STRENGTH BETWEEN THE CONNECTOR AND THE ATTACHED FIBER SHALL BE NOT LESS THAN 25 LBS.

3.03 GROUNDING

- (A) SIGNAL DISTRIBUTION SYSTEM GROUND SHALL BE INSTALLED IN THE TELECOMMUNICATIONS ENTRANCE FACILITY AND IN EACH TELECOMMUNICATIONS CLOSET IN ACCORDANCE WITH TIA/EIA 607. EQUIPMENT RACKS SHALL BE CONNECTED TO THE ELECTRICAL SAFETY GROUND.

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3.04 TESTING

- (A) MATERIALS AND DOCUMENTATION TO BE FURNISHED UNDER THIS SPECIFICATION ARE SUBJECT TO INSPECTIONS AND TESTS. ALL COMPONENTS SHALL BE TERMINATED PRIOR TO TESTING. EQUIPMENT AND SYSTEMS WILL NOT BE ACCEPTED UNTIL THE REQUIRED INSPECTIONS AND TESTS HAVE BEEN MADE, DEMONSTRATING THAT THE SIGNAL DISTRIBUTION SYSTEM CONFORMS TO THE SPECIFIED REQUIREMENTS, AND THAT THE REQUIRED EQUIPMENT, SYSTEMS AND DOCUMENTATION HAVE BEEN PROVIDED.
- (B) UNSHIELDED TWISTED PAIR TESTS: CORRECT COLOR CODING AND TERMINATION OF EACH PAIR SHALL BE VERIFIED IN THE COMMUNICATIONS CLOSET AND AT THE OUTLET. HORIZONTAL WIRING SHALL BE TESTED FROM AND INCLUDING THE TERMINATION DEVICE IN THE COMMUNICATIONS CLOSET TO AND INCLUDING THE MODULAR JACK IN EACH ROOM. THESE TESTS SHALL BE COMPLETED AND ALL ERRORS CORRECTED BEFORE ANY OTHER TESTS ARE STARTED. ALL UTP LINKS SHALL BE TESTED USING AN APPROVED TEST SET. TESTING SHALL USE THE PERMANENT LINK TEST PROCEDURE. CABLES WHICH CONTAIN FAILED CIRCUITS SHALL BE REPLACED AND RETESTED TO VERIFY THE STANDARD IS MET.
- (C) FIBER OPTIC CABLE: UNLESS STATED OTHERWISE, TESTS SHALL BE PERFORMED FROM BOTH ENDS OF EACH CIRCUIT. CONNECTORS SHALL BE VISUALLY INSPECTED FOR SCRATCHES, PITS OR CHIPS AND SHALL BE RETERMINATED IF ANY OF THESE CONDITIONS EXIST. EACH FIBER SHALL BE TESTED FOR INSERTION LOSS AT 850 AND 1300 NM USING A FIBER OPTIC CERTIFICATION TEST SET. FIBERS THAT DO NOT MEET THE CRITERIA OF TIA/EIA 568B.1 SHALL BE REPLACED AND/OR RE-TERMINATED AND THEN RETESTED TO VERIFY THE STANDARD IS MET. TEST RESULTS SHALL INCLUDE THE CALCULATED MAXIMUM LINK ATTENUATION ACCEPTANCE VALUES ALONG WITH THE ACTUAL TEST RESULT FOR EACH FIBER TESTED.
- (D) THE ENGINEER MAY REQUEST THAT A 10% RANDOM FIELD RETEST BE CONDUCTED ON THE CABLE SYSTEM IN THE PRESENCE OF THE ENGINEER AT NO ADDITIONAL COST TO VERIFY DOCUMENTED FINDINGS. TESTS SHALL BE A REPEAT OF THOSE DEFINED ABOVE. IF FINDINGS CONTRADICT THE DOCUMENTATION SUBMITTED BY THE CONTRACTOR, ADDITIONAL TESTING CAN BE REQUESTED TO THE EXTENT DETERMINED NECESSARY BY THE ENGINEER, INCLUDING A 100% RETEST. THIS RETEST SHALL BE PROVIDED AT NO ADDITIONAL COST.
- (E) TEST DOCUMENTATION: ALL TEST RESULTS SHALL BE DOCUMENTED AND FURNISHED TO THE OWNER IN BOTH ELECTRONIC AND HARD COPY FORMAT. THE HARD COPY SHALL BE FURNISHED WITH A 3-RING BINDER AND PROPERLY ORGANIZED. REQUIREMENTS FOR ELECTRONIC COPY SHALL BE COORDINATED WITH OWNER.

3.05 COMPLETION OF PROJECT

- (A) THE PROJECT WILL NOT BE CONSIDERED COMPLETE UNTIL AFTER THE INSTALLER HAS FINISHED THE FOLLOWING TASKS:
1. ALL TESTING HAS BEEN COMPLETED AND THE INSTALLER CERTIFIES THAT THE INSTALLATION MEETS ALL SPECIFIED TOLERANCES. THE INSTALLER SHALL SUBMIT ALL TEST DOCUMENTATION AND RESULTS TO THE ENGINEER.
 2. ALL CEILING TILES, WHERE APPLICABLE, THAT MAY HAVE BEEN REMOVED BY THE INSTALLER HAVE BEEN REPLACED AND CLEAN-UP OF DEBRIS CREATED DURING THE INSTALLATION PROCESS HAS BEEN FINISHED.
 3. PROVIDE RECORD DRAWINGS THAT INCLUDES; AS-BUILT INFORMATION, CABLE ROUTING, JACK LOCATIONS AND TELECOMMUNICATION ROOM LAYOUTS. JACK LOCATIONS SHALL BE IDENTIFIED BY THEIR SEQUENTIAL NUMBER AS DEFINED ELSEWHERE IN THIS DOCUMENT. NUMBERING, ICONS AND DRAWING CONVENTIONS USED SHALL BE CONSISTENT THROUGHOUT ALL DOCUMENTATION PROVIDED.
 4. ALL DOCUMENTATION AND DRAWINGS HAVE BEEN SUBMITTED TO THE ENGINEER.

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5. ALL LOCATIONS HAVE BEEN LABELED ON THE FACEPLATE AND THE PATCH PANEL IN ACCORDANCE TO LABELING REQUIREMENTS AS SPECIFIED. LABELING SHALL INCLUDE CLOSET LOCATIONS, ROOM NUMBERS AND JACK LOCATIONS.

END OF SECTION 27 10 10 – TELECOMMUNICATION CABLING SYSTEM

SECTION 27 41 33 - TELEVISION SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) THESE SPECIFICATIONS INCLUDE THE FURNISHING OF ALL LABOR AND MATERIALS NECESSARY FOR THE INSTALLATION OF A COMPLETE AND OPERATING SYSTEM.

PART 2 - PRODUCTS

2.01 EQUIPMENT FURNISHED

- (A) AMPLIFIERS, SPLITTERS, CABLES, JACKS, CONDUIT, BOXES, ETC. SHALL BE INCLUDED AS REQUIRED TO PROVIDE A MINIMUM OF 6 DB AT EACH ANTENNA OUTLET. COORDINATE SATELITE TV SERVICE REQUIREMENTS WITH SERVICE PROVIDER FOR A COMPLETE AND OPERATIONAL SATELITE TV SYSTEM.
- (B) ALL ANTENNA CABLE SHALL BE PLENUM-RATED, 100% DUAL SHIELDED, 18-GAUGE, RG6 CABLE LISTED FOR CATV USE.
- (C) PROVIDE F CONNECTOR AT EACH ANTENNA OUTLET SHOWN ON DRAWINGS. A TERMINATOR SHALL BE PROVIDED FOR EACH UNUSED OUTLET. FACEPLATE MATERIAL AND FINISH SHALL MATCH FACEPLATES FOR OTHER WIRING DEVICES IN THE SAME ROOM OR SPACE (SEE DIVISION 26 SPECIFICATION SECTION WIRING DEVICES FOR MATERIAL AND FINISH).
- (D) PROVIDE 3/4-INCH PLYWOOD BACK BOARDS WHERE SHOWN ON THE DRAWINGS PAINTED WITH TWO (2) COATS OF GRAY FIRE-RESISTANT PAINT.

PART 3 - EXECUTION

3.01 INSTALLATION

- (A) THIS INSTALLATION MUST BE DONE IN ACCORDANCE WITH THE REQUIREMENTS OF THE CABLE TV SERVICE PROVIDER AND THE GENERAL SPECIFICATIONS HEREWITH. CONTRACTOR SHALL VERIFY ALL MATERIAL AND INSTALLATION REQUIREMENTS PRIOR TO SUBMITTING SHOP DRAWINGS.
- (B) PROVIDE SERVICE CONDUIT PER SATELITE TV PROVIDERS REQUIREMENTS AND/OR AS SHOWN ON DRAWINGS.
- (C) FOR EACH ANTENNA OUTLET SHOWN ON THE DRAWINGS, THE CONTRACTOR SHALL PROVIDE A 1-INCH CONDUIT FROM OUTLET TO AN ACCESSIBLE SPACE ABOVE THE CEILING.
- (D) PROVIDE A CONTINUOUS CABLE FROM EACH ANTENNA OUTLET SHOWN TO CLOSEST TELEVISION TERMINATION BOARD/RACK. PROVIDE PERMANENT LABELS ON THE ENDS OF THE CABLES TO INDICATE CORRESPONDING ROOM NAME AND NUMBER.

END OF SECTION 27 41 33 – TELEVISION SYSTEM

SECTION 28 13 00 – ACCESS CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) SECTION INCLUDES:

1. SECURITY ACCESS CENTRAL-CONTROL STATION.
2. ONE OR MORE SECURITY ACCESS NETWORKED WORKSTATIONS.
3. SECURITY ACCESS OPERATING SYSTEM AND APPLICATION SOFTWARE.
4. SECURITY ACCESS CONTROLLERS CONNECTED TO HIGH-SPEED ELECTRONIC-DATA TRANSMISSION NETWORK.

- (B) WORK INCLUDES A COMPLETE AND FUNCTIONING SYSTEM TO THE BUILDING. THE INSTALLED ACCESS CONTROL SYSTEM SHALL BE CAPABLE OF INTEGRATING WITH THE VIDEO SURVEILLANCE SYSTEM.

1.03 DEFINITIONS

- (A) CCTV: CLOSED-CIRCUIT TELEVISION.

- (B) CPU: CENTRAL PROCESSING UNIT.

- (C) CREDENTIAL: DATA ASSIGNED TO AN ENTITY AND USED TO IDENTIFY THAT ENTITY.

- (D) DPI: DOTS PER INCH.

- (E) DTS: DIGITAL TERMINATION SERVICE. A MICROWAVE-BASED, LINE-OF-SIGHT COMMUNICATION PROVIDED DIRECTLY TO THE END USER.

- (F) GFI: GROUND FAULT INTERRUPTER.

- (G) IDENTIFIER: A CREDENTIAL CARD; KEYPAD PERSONAL IDENTIFICATION NUMBER; OR CODE, BIOMETRIC CHARACTERISTIC, OR OTHER UNIQUE IDENTIFICATION ENTERED AS DATA INTO THE ENTRY-CONTROL DATABASE FOR THE PURPOSE OF IDENTIFYING AN INDIVIDUAL. WHERE THIS TERM IS PRESENTED WITH AN INITIAL CAPITAL LETTER, THIS DEFINITION APPLIES.

- (H) I/O: INPUT/OUTPUT.

- (I) LAN: LOCAL AREA NETWORK.

- (J) LOCATION: A LOCATION ON THE NETWORK HAVING A PC-TO-CONTROLLER COMMUNICATIONS LINK, WITH ADDITIONAL CONTROLLERS AT THE LOCATION CONNECTED TO THE PC-TO-CONTROLLER LINK WITH A TIA 485-A COMMUNICATIONS LOOP. WHERE THIS TERM IS PRESENTED WITH AN INITIAL CAPITAL LETTER, THIS DEFINITION APPLIES.

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ACCESS CONTROL
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- (K) PC: PERSONAL COMPUTER. APPLIES TO THE CENTRAL STATION, WORKSTATIONS, AND FILE SERVERS.
- (L) PCI BUS: PERIPHERAL COMPONENT INTERCONNECT. A PERIPHERAL BUS PROVIDING A HIGH-SPEED DATA PATH BETWEEN THE CPU AND THE PERIPHERAL DEVICES SUCH AS A MONITOR, DISK DRIVE, OR NETWORK.
- (M) PDF: PORTABLE DOCUMENT FORMAT. THE FILE FORMAT USED BY THE ADOBE DOCUMENT-EXCHANGE-SYSTEM SOFTWARE FROM ADOBE.
- (N) RAS: REMOTE ACCESS SERVICES.
- (O) RF: RADIO FREQUENCY.
- (P) ROM: READ-ONLY MEMORY. ROM DATA ARE MAINTAINED THROUGH LOSSES OF POWER.
- (Q) TCP/IP: TRANSPORT CONTROL PROTOCOL/INTERNET PROTOCOL INCORPORATED INTO MICROSOFT WINDOWS.
- (R) TWAIN: TECHNOLOGY WITHOUT AN INTERESTING NAME. A PROGRAMMING INTERFACE THAT LETS A GRAPHICS APPLICATION, SUCH AS AN IMAGE EDITING PROGRAM OR DESKTOP PUBLISHING PROGRAM, ACTIVATE A SCANNER, FRAME GRABBER, OR OTHER IMAGE-CAPTURING DEVICE.
- (S) UPS: UNINTERRUPTIBLE POWER SUPPLY.
- (T) USB: UNIVERSAL SERIAL BUS.
- (U) WAN: WIDE AREA NETWORK.
- (V) WAV: THE DIGITAL AUDIO FORMAT USED IN MICROSOFT WINDOWS.
- (W) WMP: WINDOWS MEDIA PLAYER.
- (X) WIEGAND: PATENTED MAGNETIC PRINCIPLE THAT USES SPECIALLY TREATED WIRES EMBEDDED IN THE CREDENTIAL CARD.
- (Y) WINDOWS: OPERATING SYSTEM BY MICROSOFT CORPORATION.
- (Z) WORKSTATION: A PC WITH SOFTWARE THAT IS CONFIGURED FOR SPECIFIC, LIMITED SECURITY-SYSTEM FUNCTIONS.
- (AA) WYSIWYG: WHAT YOU SEE IS WHAT YOU GET. TEXT AND GRAPHICS APPEAR ON THE SCREEN THE SAME AS THEY WILL IN PRINT.

1.04 ACTION SUBMITTALS

- (A) PRODUCT DATA: FOR EACH TYPE OF PRODUCT INDICATED. INCLUDE RATED CAPACITIES, OPERATING CHARACTERISTICS, AND FURNISHED SPECIALTIES AND ACCESSORIES. REFERENCE EACH PRODUCT TO A LOCATION ON DRAWINGS. TEST AND EVALUATION DATA PRESENTED IN PRODUCT DATA SHALL COMPLY WITH SIA BIO-01.
- (B) SHOP DRAWINGS: INCLUDE PLANS, ELEVATIONS, SECTIONS, DETAILS, AND ATTACHMENTS TO OTHER WORK.
1. DIAGRAMS FOR CABLE MANAGEMENT SYSTEM.
 2. WIRING DIAGRAMS. FOR POWER, SIGNAL, AND CONTROL WIRING.

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3. BATTERY AND CHARGER CALCULATIONS FOR CENTRAL STATION, WORKSTATIONS, AND CONTROLLERS.

1.05 QUALITY ASSURANCE

- (A) INSTALLER QUALIFICATIONS: SHALL HAVE FIVE (5) YEARS OF EXPERIENCE INSTALLING ACCESS CONTROL SYSTEMS.
- (B) SOURCE LIMITATIONS: OBTAIN CENTRAL STATION, WORKSTATIONS, CONTROLLERS, IDENTIFIER READERS, AND ALL SOFTWARE THROUGH ONE SOURCE FROM SINGLE MANUFACTURER.
- (C) ELECTRICAL COMPONENTS, DEVICES, AND ACCESSORIES: LISTED AND LABELED AS DEFINED IN NFPA 70, BY A QUALIFIED TESTING AGENCY, AND MARKED FOR INTENDED LOCATION AND APPLICATION.
- (D) COMPLY WITH NFPA 70, "NATIONAL ELECTRICAL CODE."

1.06 DELIVERY, STORAGE, AND HANDLING

- (A) CENTRAL STATION, WORKSTATIONS, AND CONTROLLERS:
1. STORE IN TEMPERATURE- AND HUMIDITY-CONTROLLED ENVIRONMENT IN ORIGINAL MANUFACTURER'S SEALED CONTAINERS. MAINTAIN AMBIENT TEMPERATURE BETWEEN 50 AND 85 DEG F (10 AND 30 DEG C), AND NOT MORE THAN 80 PERCENT RELATIVE HUMIDITY, NONCONDENSING.
 2. SAVE ORIGINAL MANUFACTURER'S CONTAINERS AND PACKING MATERIALS AND DELIVER AS DIRECTED UNDER PROVISIONS COVERING EXTRA MATERIALS.

1.7 PROJECT CONDITIONS

- (A) ENVIRONMENTAL CONDITIONS: SYSTEM SHALL BE CAPABLE OF WITHSTANDING THE FOLLOWING ENVIRONMENTAL CONDITIONS WITHOUT MECHANICAL OR ELECTRICAL DAMAGE OR DEGRADATION OF OPERATING CAPABILITY:
1. INDOOR, CONTROLLED ENVIRONMENT: NEMA 250, TYPE 1 ENCLOSURE. SYSTEM COMPONENTS, EXCEPT THE CENTRAL-STATION CONTROL UNIT, INSTALLED IN TEMPERATURE-CONTROLLED INDOOR ENVIRONMENTS SHALL BE RATED FOR CONTINUOUS OPERATION IN AMBIENT CONDITIONS OF 36 TO 122 DEG F (2 TO 50 DEG C) DRY BULB AND 20 TO 90 PERCENT RELATIVE HUMIDITY, NONCONDENSING.
 2. OUTDOOR ENVIRONMENT: NEMA 250, TYPE 3R ENCLOSURES. SYSTEM COMPONENTS INSTALLED IN LOCATIONS EXPOSED TO WEATHER SHALL BE RATED FOR CONTINUOUS OPERATION IN AMBIENT CONDITIONS OF MINUS 30 TO PLUS 122 DEG F (MINUS 34 TO PLUS 50 DEG C) DRY BULB AND 20 TO 90 PERCENT RELATIVE HUMIDITY, CONDENSING. RATE FOR CONTINUOUS OPERATION WHERE EXPOSED TO RAIN AS SPECIFIED IN NEMA 250, WINDS UP TO 85 MPH (137 KM/H) AND SNOW COVER UP TO 24 INCHES (610 MM) THICK.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- (A) AUTOMATED LOGIC SYSTEM.

2.02 DESCRIPTION

- (A) SECURITY ACCESS SYSTEM: PC-BASED CENTRAL STATION AND FIELD-INSTALLED CONTROLLERS, CONNECTED BY A HIGH-SPEED ELECTRONIC-DATA TRANSMISSION NETWORK.
- (B) SYSTEM SOFTWARE: BASED ON WINDOWS CENTRAL-STATION, WORKSTATION OPERATING SYSTEM, SERVER OPERATING SYSTEM, AND APPLICATION SOFTWARE. SOFTWARE SHALL HAVE THE FOLLOWING CAPABILITIES:
1. MULTIUSER AND MULTITASKING TO ALLOW FOR INDEPENDENT ACTIVITIES AND MONITORING TO OCCUR SIMULTANEOUSLY AT DIFFERENT WORKSTATIONS.
 2. GRAPHICAL USER INTERFACE TO SHOW PULL-DOWN MENUS AND A MENU-TREE FORMAT THAT COMPLIES WITH INTERFACE GUIDELINES OF MICROSOFT WINDOWS.
 3. OPEN-ARCHITECTURE SYSTEM THAT ALLOWS IMPORTING AND EXPORTING OF DATA AND INTERFACING WITH OTHER SYSTEMS THAT ARE COMPATIBLE WITH MICROSOFT WINDOWS.
 4. PASSWORD-PROTECTED OPERATOR LOGIN AND ACCESS.
 5. OPEN-DATABASE-CONNECTIVITY COMPLIANT.
- (C) NETWORK CONNECTING THE CENTRAL STATION AND WORKSTATIONS SHALL BE A LAN USING MICROSOFT WINDOWS-BASED TCP/IP WITH A CAPACITY OF CONNECTING UP TO 99 WORKSTATIONS. SYSTEM SHALL BE PORTABLE ACROSS MULTIPLE COMMUNICATION PLATFORMS WITHOUT CHANGING SYSTEM SOFTWARE.
- (D) NETWORK(S) CONNECTING PCS AND CONTROLLERS SHALL CONSIST OF ONE OR MORE OF THE FOLLOWING:
1. LOCAL AREA, IEEE 802.3 FAST ETHERNET, STAR TOPOLOGY NETWORK BASED ON TCP/IP.
 2. DIRECT-CONNECTED, RS-232 CABLE FROM THE COM PORT OF THE CENTRAL STATION TO THE FIRST CONTROLLER, THEN RS-485 CABLE TO INTERCONNECT THE REMAINING CONTROLLERS AT THAT LOCATION.

2.03 OPERATION

- (A) SECURITY ACCESS SYSTEM SHALL USE A SINGLE DATABASE FOR ACCESS-CONTROL AND CREDENTIAL-CREATION FUNCTIONS.
- (B) DISTRIBUTED PROCESSING: A FULLY DISTRIBUTED PROCESSING SYSTEM.
1. ACCESS-CONTROL INFORMATION, INCLUDING TIME, DATE, VALID CODES, ACCESS LEVELS, AND SIMILAR DATA, SHALL BE DOWNLOADED TO CONTROLLERS SO EACH CONTROLLER CAN MAKE ACCESS-CONTROL DECISIONS.
 2. INTERMEDIATE CONTROLLERS FOR ACCESS CONTROL ARE PROHIBITED.
 3. IN THE EVENT THAT COMMUNICATIONS WITH THE CENTRAL CONTROLLER ARE LOST, CONTROLLERS SHALL AUTOMATICALLY BUFFER EVENT TRANSACTIONS UNTIL COMMUNICATIONS ARE RESTORED, AT WHICH TIME BUFFERED EVENTS SHALL BE UPLOADED TO THE CENTRAL STATION.
- (C) DATA CAPACITY:
1. 130 DIFFERENT CARD-READER FORMATS.

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(D) LOCATION CAPACITY:

1. 128 READER-CONTROLLED DOORS.
2. 50,000 TOTAL-ACCESS CREDENTIALS.
3. 2048 SUPERVISED ALARM INPUTS.
4. 2048 PROGRAMMABLE OUTPUTS.

(E) SYSTEM NETWORK REQUIREMENTS:

1. SYSTEM COMPONENTS SHALL BE INTERCONNECTED AND SHALL PROVIDE AUTOMATIC COMMUNICATION OF STATUS CHANGES, COMMANDS, FIELD-INITIATED INTERRUPTS, AND OTHER COMMUNICATIONS REQUIRED FOR PROPER SYSTEM OPERATION.
2. COMMUNICATION SHALL NOT REQUIRE OPERATOR INITIATION OR RESPONSE AND SHALL RETURN TO NORMAL AFTER PARTIAL- OR TOTAL-NETWORK INTERRUPTION SUCH AS POWER LOSS OR TRANSIENT UPSET.
3. SYSTEM SHALL AUTOMATICALLY ANNUNCIATE COMMUNICATION FAILURES TO THE OPERATOR AND SHALL IDENTIFY THE COMMUNICATIONS LINK THAT HAS EXPERIENCED A PARTIAL OR TOTAL FAILURE.
4. COMMUNICATIONS CONTROLLER MAY BE USED AS AN INTERFACE BETWEEN THE CENTRAL-STATION DISPLAY SYSTEMS AND THE FIELD DEVICE NETWORK. COMMUNICATIONS CONTROLLER SHALL PROVIDE FUNCTIONS REQUIRED TO ATTAIN THE SPECIFIED NETWORK COMMUNICATIONS PERFORMANCE.

(F) CENTRAL STATION SHALL PROVIDE OPERATOR INTERFACE, INTERACTION, DISPLAY, CONTROL, AND DYNAMIC AND REAL-TIME MONITORING. CENTRAL STATION SHALL CONTROL SYSTEM NETWORKS TO INTERCONNECT ALL SYSTEM COMPONENTS, INCLUDING WORKSTATIONS AND FIELD-INSTALLED CONTROLLERS.

(G) FIELD EQUIPMENT SHALL INCLUDE CONTROLLERS, SENSORS, AND CONTROLS.

1. CONTROLLERS SHALL SERVE AS AN INTERFACE BETWEEN THE CENTRAL STATION AND SENSORS AND CONTROLS.
2. DATA EXCHANGE BETWEEN THE CENTRAL STATION AND THE CONTROLLERS SHALL INCLUDE DOWN-LINE TRANSMISSION OF COMMANDS, SOFTWARE, AND DATABASES TO CONTROLLERS.
3. THE UP-LINE DATA EXCHANGE FROM THE CONTROLLER TO THE CENTRAL STATION SHALL INCLUDE STATUS DATA SUCH AS INTRUSION ALARMS, STATUS REPORTS, AND ENTRY-CONTROL RECORDS.

(H) FALSE-ALARM REDUCTION: THE DESIGN OF THE CENTRAL STATION AND CONTROLLERS SHALL CONTAIN FEATURES TO REDUCE FALSE ALARMS. EQUIPMENT AND SOFTWARE SHALL COMPLY WITH SIA CP-01.

(I) DATA LINE SUPERVISION: SYSTEM SHALL INITIATE AN ALARM IN RESPONSE TO OPENING, CLOSING, SHORTING, OR GROUNDING OF DATA TRANSMISSION LINES.

(J) DOOR HARDWARE INTERFACE:

1. COMPLY WITH REQUIREMENTS IN "DOOR HARDWARE" SPECIFICATIONS FOR DOOR HARDWARE REQUIRED TO BE MONITORED OR CONTROLLED BY THE SECURITY ACCESS SYSTEM.

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2. ELECTRICAL CHARACTERISTICS OF CONTROLLERS SHALL MATCH THE SIGNAL AND POWER REQUIREMENTS OF DOOR HARDWARE.

2.04 APPLICATION SOFTWARE

(A) SYSTEM SOFTWARE: BASED ON MICROSOFT WINDOWS CENTRAL-STATION AND WORKSTATION OPERATING SYSTEM AND APPLICATION SOFTWARE.

1. MULTIUSER MULTITASKING SHALL ALLOW INDEPENDENT ACTIVITIES AND MONITORING TO OCCUR SIMULTANEOUSLY AT DIFFERENT WORKSTATIONS.
2. GRAPHICAL USER INTERFACE SHALL SHOW PULL-DOWN MENUS AND A MENU-TREE FORMAT.
3. CAPABILITY FOR FUTURE ADDITIONS WITHIN THE INDICATED SYSTEM SIZE LIMITS.
4. OPEN ARCHITECTURE THAT ALLOWS IMPORTING AND EXPORTING OF DATA AND INTERFACING WITH OTHER SYSTEMS THAT ARE COMPATIBLE WITH OPERATING SYSTEM.
5. PASSWORD-PROTECTED OPERATOR LOGIN AND ACCESS.

(B) APPLICATION SOFTWARE: INTERFACE BETWEEN THE ALARM ANNUNCIATION AND ENTRY-CONTROL CONTROLLERS TO MONITOR SENSORS, OPERATE DISPLAYS, REPORT ALARMS, GENERATE REPORTS, AND HELP TRAIN SYSTEM OPERATORS.

1. RESIDE AT THE CENTRAL STATION, WORKSTATIONS, AND CONTROLLERS AS REQUIRED TO PERFORM SPECIFIED FUNCTIONS.
2. OPERATE AND MANAGE PERIPHERAL DEVICES.
3. MANAGE FILES FOR DISK I/O, INCLUDING CREATING, DELETING, AND COPYING FILES; AND AUTOMATICALLY MAINTAIN A DIRECTORY OF ALL FILES, INCLUDING SIZE AND LOCATION OF EACH SEQUENTIAL AND RANDOM-ORDERED RECORD.
4. IMPORT CUSTOM ICONS INTO GRAPHICS TO REPRESENT ALARMS AND I/O DEVICES.
5. GLOBALLY LINK I/O SO THAT ANY I/O CAN LINK TO ANY OTHER I/O WITHIN THE SAME LOCATION WITHOUT REQUIRING INTERACTION WITH THE HOST PC. THIS OPERATION SHALL BE AT THE CONTROLLER.
6. GLOBALLY CODE I/O LINKS SO THAT ANY ACCESS-GRANTED EVENT CAN LINK TO ANY I/O WITH THE SAME LOCATION WITHOUT REQUIRING INTERACTION WITH THE HOST PC. THIS OPERATION SHALL BE AT THE CONTROLLER.
7. MESSAGES FROM PC TO CONTROLLERS AND CONTROLLERS TO CONTROLLERS SHALL BE ON A POLLED NETWORK THAT UTILIZES CHECK SUMMING AND ACKNOWLEDGMENT OF EACH MESSAGE. COMMUNICATION SHALL BE AUTOMATICALLY VERIFIED, BUFFERED, AND RETRANSMITTED IF MESSAGE IS NOT ACKNOWLEDGED.
8. SELECTABLE POLL FREQUENCY AND MESSAGE TIME-OUT SETTINGS SHALL HANDLE BANDWIDTH AND LATENCY ISSUES FOR TCP/IP, RF, AND OTHER PC-TO-CONTROLLER COMMUNICATIONS METHODS BY CHANGING THE POLLING FREQUENCY AND THE AMOUNT OF TIME THE SYSTEM WAITS FOR A RESPONSE.

9. AUTOMATIC AND ENCRYPTED BACKUPS FOR DATABASE AND HISTORY BACKUPS SHALL BE AUTOMATICALLY STORED AT THE CENTRAL-CONTROL PC AND ENCRYPTED WITH A NINE-CHARACTER ALPHANUMERIC PASSWORD THAT MUST BE USED TO RESTORE OR READ DATA CONTAINED IN BACKUP.
10. OPERATOR AUDIT TRAIL FOR RECORDING AND REPORTING ALL CHANGES MADE TO DATABASE AND SYSTEM SOFTWARE.

(C) WORKSTATION SOFTWARE:

1. PASSWORD LEVELS SHALL BE INDIVIDUALLY CUSTOMIZED AT EACH WORKSTATION TO ALLOW OR DISALLOW OPERATOR ACCESS TO PROGRAM FUNCTIONS FOR EACH LOCATION.
2. WORKSTATION EVENT FILTERING SHALL ALLOW USER TO DEFINE EVENTS AND ALARMS THAT WILL BE DISPLAYED AT EACH WORKSTATION. IF AN ALARM IS UNACKNOWLEDGED (NOT HANDLED BY ANOTHER WORKSTATION) FOR A PRESET AMOUNT OF TIME, THE ALARM WILL AUTOMATICALLY APPEAR ON THE FILTERED WORKSTATION.

(D) CONTROLLER SOFTWARE:

1. CONTROLLERS SHALL OPERATE AS AUTONOMOUS, INTELLIGENT PROCESSING UNITS.
 - A. CONTROLLERS SHALL MAKE DECISIONS ABOUT ACCESS CONTROL, ALARM MONITORING, LINKING FUNCTIONS, AND DOOR-LOCKING SCHEDULES FOR THEIR OPERATION, INDEPENDENT OF OTHER SYSTEM COMPONENTS.
 - B. CONTROLLERS SHALL BE PART OF A FULLY DISTRIBUTED PROCESSING-CONTROL NETWORK.
 - C. THE PORTION OF THE DATABASE ASSOCIATED WITH A CONTROLLER, AND CONSISTING OF PARAMETERS, CONSTRAINTS, AND THE LATEST VALUE OR STATUS OF POINTS CONNECTED TO THAT CONTROLLER, SHALL BE MAINTAINED IN THE CONTROLLER.
2. THE FOLLOWING FUNCTIONS SHALL BE FULLY IMPLEMENTED AND OPERATIONAL WITHIN EACH CONTROLLER:
 - A. MONITORING INPUTS.
 - B. CONTROLLING OUTPUTS.
 - C. AUTOMATICALLY REPORTING ALARMS TO THE CENTRAL STATION.
 - D. REPORTING OF SENSOR AND OUTPUT STATUS TO THE CENTRAL STATION ON REQUEST.
 - E. MAINTAINING REAL TIME, AUTOMATICALLY UPDATED BY THE CENTRAL STATION AT LEAST ONCE A DAY.
 - F. COMMUNICATING WITH THE CENTRAL STATION.
 - G. EXECUTING CONTROLLER RESIDENT PROGRAMS.
 - H. DIAGNOSING.

- I. DOWNLOADING AND UPLOADING DATA TO AND FROM THE CENTRAL STATION.
3. CONTROLLER OPERATIONS AT A LOCATION:
- A. CONTROLLERS CONNECTED TO TIA 485-A COMMUNICATIONS LOOP, GLOBALLY OPERATING I/O LINKING AND ANTI-PASSBACK FUNCTIONS BETWEEN CONTROLLERS WITHIN THE SAME LOCATION WITHOUT CENTRAL-STATION OR WORKSTATION INTERVENTION. LINKING AND ANTI-PASSBACK SHALL REMAIN FULLY FUNCTIONAL WITHIN THE SAME LOCATION EVEN WHEN THE CENTRAL STATION OR WORKSTATIONS ARE OFF-LINE.
 - B. IN THE EVENT OF COMMUNICATION FAILURE BETWEEN THE CENTRAL STATION AND A LOCATION, THERE SHALL BE NO DEGRADATION IN OPERATIONS AT THE CONTROLLERS AT THAT LOCATION. CONTROLLERS AT EACH LOCATION SHALL BE CONNECTED TO A MEMORY BUFFER WITH A CAPACITY TO STORE UP TO 10,000 EVENTS; THERE SHALL BE NO LOSS OF TRANSACTIONS IN SYSTEM HISTORY FILES UNTIL THE BUFFER OVERFLOWS.
 - C. BUFFERED EVENTS SHALL BE HANDLED IN A FIRST-IN-FIRST-OUT MODE OF OPERATION.
4. INDIVIDUAL CONTROLLER OPERATION:
- A. CONTROLLERS SHALL TRANSMIT ALARMS, STATUS CHANGES, AND OTHER DATA TO THE CENTRAL STATION WHEN COMMUNICATIONS CIRCUITS ARE OPERABLE. IF COMMUNICATIONS ARE NOT AVAILABLE, CONTROLLERS SHALL FUNCTION IN A STAND-ALONE MODE; OPERATIONAL DATA, INCLUDING THE STATUS AND ALARM DATA NORMALLY TRANSMITTED TO THE CENTRAL STATION, SHALL BE STORED FOR LATER TRANSMISSION TO THE CENTRAL STATION. STORAGE CAPACITY FOR THE LATEST 1024 EVENTS SHALL BE PROVIDED AT EACH CONTROLLER.
 - B. CARD-READER PORTS OF A CONTROLLER SHALL BE CUSTOM CONFIGURABLE FOR AT LEAST 120 DIFFERENT CARD-READER OR KEYPAD FORMATS. MULTIPLE READER OR KEYPAD FORMATS MAY BE USED SIMULTANEOUSLY AT DIFFERENT CONTROLLERS OR WITHIN THE SAME CONTROLLER.
 - C. CONTROLLERS SHALL PROVIDE A RESPONSE TO CARD READERS OR KEYPAD ENTRIES IN LESS THAN 0.25 SECONDS, REGARDLESS OF SYSTEM SIZE.
 - D. CONTROLLERS THAT ARE RESET, OR POWERED UP FROM A NONPOWERED STATE, SHALL AUTOMATICALLY REQUEST A PARAMETER DOWNLOAD AND REBOOT TO THEIR PROPER WORKING STATE. THIS SHALL HAPPEN WITHOUT ANY OPERATOR INTERVENTION.
 - E. INITIAL STARTUP: WHEN CONTROLLERS ARE BROUGHT ON-LINE, DATABASE PARAMETERS SHALL BE AUTOMATICALLY DOWNLOADED TO THEM. AFTER INITIAL DOWNLOAD IS COMPLETED, ONLY DATABASE CHANGES SHALL BE DOWNLOADED TO EACH CONTROLLER.
 - F. ON FAILURE FOR ANY REASON, CONTROLLERS SHALL PERFORM AN ORDERLY SHUTDOWN AND FORCE CONTROLLER OUTPUTS TO A PREDETERMINED FAILURE-MODE STATE, CONSISTENT WITH THE FAILURE MODES SHOWN AND THE ASSOCIATED CONTROL DEVICE.

- G. AFTER POWER IS RESTORED, FOLLOWING A POWER FAILURE, STARTUP SOFTWARE SHALL INITIATE SELF-TEST DIAGNOSTIC ROUTINES, AFTER WHICH CONTROLLERS SHALL RESUME NORMAL OPERATION.
- H. AFTER CONTROLLER FAILURE, IF THE DATABASE AND APPLICATION SOFTWARE ARE NO LONGER RESIDENT, CONTROLLERS SHALL NOT RESTART BUT SHALL REMAIN IN THE FAILURE MODE UNTIL REPAIRED. IF DATABASE AND APPLICATION PROGRAMS ARE RESIDENT, CONTROLLERS SHALL IMMEDIATELY RESUME OPERATION. IF NOT, SOFTWARE SHALL BE RESTORED AUTOMATICALLY FROM THE CENTRAL STATION.

5. COMMUNICATIONS MONITORING:

- A. SYSTEM SHALL MONITOR AND REPORT STATUS OF TIA 485-A COMMUNICATIONS LOOP OF EACH LOCATION.
- B. COMMUNICATION STATUS WINDOW SHALL DISPLAY WHICH CONTROLLERS ARE CURRENTLY COMMUNICATING, A TOTAL COUNT OF MISSED POLLS SINCE MIDNIGHT, AND WHICH CONTROLLER LAST MISSED A POLL.
- C. COMMUNICATION STATUS WINDOW SHALL SHOW THE TYPE OF CPU, THE TYPE OF I/O BOARD, AND THE AMOUNT OF RAM FOR EACH CONTROLLER.

- 6. OPERATING SYSTEMS SHALL INCLUDE A REAL-TIME CLOCK FUNCTION THAT MAINTAINS SECONDS, MINUTES, HOURS, DAY, DATE, AND MONTH. THE REAL-TIME CLOCK SHALL BE AUTOMATICALLY SYNCHRONIZED WITH THE CENTRAL STATION AT LEAST ONCE A DAY TO PLUS OR MINUS 10 SECONDS. THE TIME SYNCHRONIZATION SHALL BE AUTOMATIC, WITHOUT OPERATOR ACTION AND WITHOUT REQUIRING SYSTEM SHUTDOWN.

(E) PC-TO-CONTROLLER COMMUNICATIONS:

- 1. CENTRAL-STATION OR WORKSTATION COMMUNICATIONS SHALL USE THE FOLLOWING:
 - A. TCP/IP LAN INTERFACE CARDS.

(F) CONTROLLER-TO-CONTROLLER COMMUNICATIONS:

- 1. TIA 485-A, FOUR-WIRE, POINT-TO-POINT, REGENERATIVE (REPEATER) COMMUNICATIONS NETWORK METHODOLOGY.
- 2. TIA 485-A COMMUNICATIONS SIGNAL SHALL BE REGENERATED AT EACH CONTROLLER.

(G) DATABASE DOWNLOADS:

- 1. ALL DATA TRANSMISSIONS FROM PCS TO A LOCATION, AND BETWEEN CONTROLLERS AT A LOCATION, SHALL INCLUDE A COMPLETE DATABASE CHECKSUM TO CHECK THE INTEGRITY OF THE TRANSMISSION. IF THE DATA CHECKSUM DOES NOT MATCH, A FULL DATA DOWNLOAD SHALL BE AUTOMATICALLY RETRANSMITTED.
- 2. IF A CONTROLLER IS RESET FOR ANY REASON, IT SHALL AUTOMATICALLY REQUEST AND RECEIVE A DATABASE DOWNLOAD FROM THE PC. THE DOWNLOAD SHALL RESTORE DATA STORED AT THE CONTROLLER TO THEIR NORMAL WORKING STATE AND SHALL TAKE PLACE WITH NO OPERATOR INTERVENTION.

(H) OPERATOR INTERFACE:

1. INPUTS IN SYSTEM SHALL HAVE TWO ICON REPRESENTATIONS, ONE FOR THE NORMAL STATE AND ONE FOR THE ABNORMAL STATE.
2. WHEN VIEWING AND CONTROLLING INPUTS, DISPLAYED ICONS SHALL AUTOMATICALLY CHANGE TO THE PROPER ICON TO DISPLAY THE CURRENT SYSTEM STATE IN REAL TIME. ICONS SHALL ALSO DISPLAY THE INPUT'S STATE, WHETHER ARMED OR BYPASSED, AND IF THE INPUT IS IN THE ARMED OR BYPASSED STATE DUE TO A TIME ZONE OR A MANUAL COMMAND.
3. OUTPUTS IN SYSTEM SHALL HAVE TWO ICON REPRESENTATIONS, ONE FOR THE SECURE (LOCKED) STATE AND ONE FOR THE OPEN (UNLOCKED) STATE.
4. ICONS DISPLAYING STATUS OF THE I/O POINTS SHALL BE CONSTANTLY UPDATED TO SHOW THEIR CURRENT REAL-TIME CONDITION WITHOUT PROMPTING BY THE OPERATOR.
5. THE OPERATOR SHALL BE ABLE TO SCROLL THE LIST OF I/OS AND PRESS THE APPROPRIATE TOOLBAR BUTTON, OR RIGHT CLICK, TO COMMAND THE SYSTEM TO PERFORM THE DESIRED FUNCTION.
6. GRAPHIC MAPS OR DRAWINGS CONTAINING INPUTS, OUTPUTS, AND OVERRIDE GROUPS SHALL INCLUDE THE FOLLOWING:
 - A. DATABASE TO IMPORT AND STORE FULL-COLOR MAPS OR DRAWINGS AND ALLOW FOR INPUT, OUTPUT, AND OVERRIDE GROUP ICONS TO BE PLACED ON MAPS.
 - B. MAPS TO PROVIDE REAL-TIME DISPLAY ANIMATION AND ALLOW FOR CONTROL OF POINTS ASSIGNED TO THEM.
 - C. SYSTEM TO ALLOW INPUTS, OUTPUTS, AND OVERRIDE GROUPS TO BE PLACED ON DIFFERENT MAPS.
 - D. SOFTWARE TO ALLOW CHANGING THE ORDER OR PRIORITY IN WHICH MAPS WILL BE DISPLAYED.
7. OVERRIDE GROUPS CONTAINING I/OS:
 - A. SYSTEM SHALL INCORPORATE OVERRIDE GROUPS THAT PROVIDE THE OPERATOR WITH THE STATUS AND CONTROL OVER USER-DEFINED "SETS" OF I/OS WITH A SINGLE ICON.
 - B. ICON SHALL CHANGE AUTOMATICALLY TO SHOW THE LIVE SUMMARY STATUS OF POINTS IN THAT GROUP.
 - C. OVERRIDE GROUP ICON SHALL PROVIDE A METHOD TO MANUALLY CONTROL OR SET TO TIME-ZONE POINTS IN THE GROUP.
 - D. OVERRIDE GROUP ICON SHALL ALLOW THE EXPANDING OF THE GROUP TO SHOW ICONS REPRESENTING THE LIVE STATUS FOR EACH POINT IN THE GROUP, INDIVIDUAL CONTROL OVER EACH POINT, AND THE ABILITY TO COMPRESS THE INDIVIDUAL ICONS BACK INTO ONE SUMMARY ICON.

8. SCHEDULE OVERRIDES OF I/Os AND OVERRIDE GROUPS:

- A.** TO ACCOMMODATE TEMPORARY SCHEDULE CHANGES THAT DO NOT FALL WITHIN THE HOLIDAY PARAMETERS, THE OPERATOR SHALL HAVE THE ABILITY TO OVERRIDE SCHEDULES INDIVIDUALLY FOR EACH INPUT, OUTPUT, OR OVERRIDE GROUP.
- B.** EACH SCHEDULE SHALL BE COMPOSED OF A MINIMUM OF TWO DATES WITH SEPARATE TIMES FOR EACH DATE.
- C.** THE FIRST TIME AND DATE SHALL BE ASSIGNED THE OVERRIDE STATE THAT THE POINT SHALL ADVANCE TO WHEN THE TIME AND DATE BECOME CURRENT.
- D.** THE SECOND TIME AND DATE SHALL BE ASSIGNED THE STATE THAT THE POINT SHALL RETURN TO WHEN THE TIME AND DATE BECOME CURRENT.

9. COPY COMMAND IN DATABASE SHALL ALLOW FOR LIKE DATA TO BE COPIED AND THEN EDITED FOR SPECIFIC REQUIREMENTS, TO REDUCE REDUNDANT DATA ENTRY.

(I) OPERATOR ACCESS CONTROL:

- 1.** CONTROL OPERATOR ACCESS TO SYSTEM CONTROLS THROUGH PASSWORD-PROTECTED OPERATOR LEVELS. SYSTEM OPERATORS AND MANAGERS WITH APPROPRIATE PASSWORD CLEARANCES SHALL BE ABLE TO CHANGE OPERATOR LEVELS FOR OPERATORS.
- 2.** THREE SUCCESSIVE ATTEMPTS BY AN OPERATOR TO EXECUTE FUNCTIONS BEYOND THEIR DEFINED LEVEL DURING A 24-HOUR PERIOD SHALL INITIATE A SOFTWARE TAMPER ALARM.
- 3.** A MINIMUM OF 32 PASSWORDS SHALL BE AVAILABLE WITH THE SYSTEM SOFTWARE. SYSTEM SHALL DISPLAY THE OPERATOR'S NAME OR INITIALS IN THE CONSOLE'S FIRST FIELD. SYSTEM SHALL PRINT THE OPERATOR'S NAME OR INITIALS, ACTION, DATE, AND TIME ON THE SYSTEM PRINTER AT LOGIN AND LOGOFF.
- 4.** THE PASSWORD SHALL NOT BE DISPLAYED OR PRINTED.
- 5.** EACH PASSWORD SHALL BE DEFINABLE AND ASSIGNABLE FOR THE FOLLOWING:
 - A.** SELECTED COMMANDS TO BE USABLE.
 - B.** ACCESS TO SYSTEM SOFTWARE.
 - C.** ACCESS TO APPLICATION SOFTWARE.
 - D.** INDIVIDUAL ZONES THAT ARE TO BE ACCESSED.
 - E.** ACCESS TO DATABASE.

(J) OPERATOR COMMANDS:

- 1.** COMMAND INPUT: PLAIN-LANGUAGE WORDS AND ACRONYMS SHALL ALLOW OPERATORS TO USE THE SYSTEM WITHOUT EXTENSIVE TRAINING OR DATA-PROCESSING BACKGROUNDS. SYSTEM PROMPTS SHALL BE A WORD, A PHRASE, OR AN ACRONYM.
- 2.** COMMAND INPUTS SHALL BE ACKNOWLEDGED AND PROCESSING SHALL START.

3. TASKS THAT ARE EXECUTED BY OPERATOR'S COMMANDS SHALL INCLUDE THE FOLLOWING:

- A. ACKNOWLEDGE ALARMS: USED TO ACKNOWLEDGE THAT THE OPERATOR HAS OBSERVED THE ALARM MESSAGE.
- B. SYSTEM TEST: ALLOWS THE OPERATOR TO INITIATE A SYSTEM-WIDE OPERATIONAL TEST.
- C. ZONE TEST: ALLOWS THE OPERATOR TO INITIATE AN OPERATIONAL TEST FOR A SPECIFIC ZONE.
- D. PRINT REPORTS.
- E. CHANGE OPERATOR: USED FOR CHANGING OPERATORS.
- F. DISPLAY GRAPHICS: USED TO SHOW ANY GRAPHIC DISPLAYS IMPLEMENTED IN THE SYSTEM. GRAPHIC DISPLAYS SHALL BE COMPLETED WITHIN 20 SECONDS FROM TIME OF OPERATOR COMMAND.
- G. RUN SYSTEM TESTS.
- H. GENERATE AND FORMAT REPORTS.
- I. REQUEST HELP WITH THE SYSTEM OPERATION.
 - (1) INCLUDE IN MAIN MENUS.
 - (2) PROVIDE UNIQUE, DESCRIPTIVE, CONTEXT-SENSITIVE HELP FOR SELECTIONS AND FUNCTIONS WITH THE PRESS OF ONE FUNCTION KEY.
 - (3) PROVIDE NAVIGATION TO SPECIFIC TOPIC FROM WITHIN THE FIRST HELP WINDOW.
 - (4) HELP SHALL BE ACCESSIBLE OUTSIDE THE APPLICATION PROGRAM.

4. COMMAND INPUT ERRORS: SHOW OPERATOR INPUT ASSISTANCE WHEN A COMMAND CANNOT BE EXECUTED BECAUSE OF OPERATOR INPUT ERRORS. ASSISTANCE SCREEN SHALL USE PLAIN-LANGUAGE WORDS AND PHRASES TO EXPLAIN WHY THE COMMAND CANNOT BE EXECUTED. ERROR RESPONSES THAT REQUIRE AN OPERATOR TO LOOK UP A CODE IN A MANUAL OR OTHER DOCUMENT ARE NOT ACCEPTABLE. CONDITIONS CAUSING OPERATOR ASSISTANCE MESSAGES INCLUDE THE FOLLOWING:

- A. COMMAND ENTERED IS INCORRECT OR INCOMPLETE.
- B. OPERATOR IS RESTRICTED FROM USING THAT COMMAND.
- C. COMMAND ADDRESSES A POINT THAT IS DISABLED OR OUT OF SERVICE.
- D. COMMAND ADDRESSES A POINT THAT DOES NOT EXIST.
- E. COMMAND IS OUTSIDE THE SYSTEM'S CAPACITY.

(K) ALARM MONITORING: MONITOR SENSORS, CONTROLLERS, AND DTS CIRCUITS AND NOTIFY OPERATORS OF AN ALARM CONDITION. DISPLAY HIGHER-PRIORITY ALARMS FIRST AND, WITHIN ALARM PRIORITIES, DISPLAY THE OLDEST UNACKNOWLEDGED ALARM FIRST. OPERATOR ACKNOWLEDGMENT OF ONE ALARM SHALL NOT BE CONSIDERED ACKNOWLEDGMENT OF OTHER ALARMS NOR SHALL IT INHIBIT REPORTING OF SUBSEQUENT ALARMS.

1. DISPLAYED ALARM DATA SHALL INCLUDE TYPE OF ALARM, LOCATION OF ALARM, AND SECONDARY ALARM MESSAGES.

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2. PRINTED ALARM DATA SHALL INCLUDE TYPE OF ALARM, LOCATION OF ALARM, DATE AND TIME (TO NEAREST SECOND) OF OCCURRENCE, AND OPERATOR RESPONSES.
3. MAPS SHALL AUTOMATICALLY DISPLAY THE ALARM CONDITION FOR EACH INPUT ASSIGNED TO THAT MAP IF THAT OPTION IS SELECTED FOR THAT INPUT LOCATION.
4. ALARMS INITIATE A STATUS OF "PENDING" AND REQUIRE THE FOLLOWING TWO HANDLING STEPS BY OPERATORS:
 - A. FIRST OPERATOR STEP: "ACKNOWLEDGED." THIS ACTION SHALL SILENCE SOUNDS ASSOCIATED WITH THE ALARM. THE ALARM REMAINS IN THE SYSTEM "ACKNOWLEDGED" BUT "UN-RESOLVED."
 - B. SECOND OPERATOR STEP: OPERATORS ENTER THE RESOLUTION OR OPERATOR COMMENT, GIVING THE DISPOSITION OF THE ALARM EVENT. THE ALARM SHALL THEN CLEAR.
5. EACH WORKSTATION SHALL DISPLAY THE TOTAL PENDING ALARMS AND TOTAL UNRESOLVED ALARMS.
6. EACH ALARM POINT SHALL BE PROGRAMMABLE TO DISALLOW THE RESOLUTION OF ALARMS UNTIL THE ALARM POINT HAS RETURNED TO ITS NORMAL STATE.
7. ALARMS SHALL TRANSMIT TO THE CENTRAL STATION IN REAL TIME EXCEPT FOR ALLOWING CONNECTION TIME FOR DIAL-UP LOCATIONS.
8. ALARMS SHALL BE DISPLAYED AND MANAGED FROM A MINIMUM OF FOUR DIFFERENT WINDOWS.
 - A. INPUT STATUS WINDOW: OVERLAY STATUS ICON WITH A LARGE RED BLINKING ICON. SELECTING THE ICON WILL ACKNOWLEDGE THE ALARM.
 - B. HISTORY LOG TRANSACTION WINDOW: DISPLAY NAME, TIME, AND DATE IN RED TEXT. SELECTING RED TEXT WILL ACKNOWLEDGE THE ALARM.
 - C. ALARM LOG TRANSACTION WINDOW: DISPLAY NAME, TIME, AND DATE IN RED. SELECTING RED TEXT WILL ACKNOWLEDGE THE ALARM.
 - D. GRAPHIC MAP DISPLAY: DISPLAY A STEADY COLORED ICON REPRESENTING EACH ALARM INPUT LOCATION. CHANGE ICON TO FLASHING RED WHEN THE ALARM OCCURS. CHANGE ICON FROM FLASHING RED TO STEADY RED WHEN THE ALARM IS ACKNOWLEDGED.
9. ONCE AN ALARM IS ACKNOWLEDGED, THE OPERATOR SHALL BE PROMPTED TO ENTER COMMENTS ABOUT THE NATURE OF THE ALARM AND ACTIONS TAKEN. OPERATOR'S COMMENTS MAY BE MANUALLY ENTERED OR SELECTED FROM A PROGRAMMED PREDEFINED LIST, OR A COMBINATION OF BOTH.
10. FOR LOCATIONS WHERE THERE ARE REGULAR ALARM OCCURRENCES, PROVIDE PROGRAMMED COMMENTS. SELECTING THAT COMMENT SHALL CLEAR THE ALARM.
11. THE TIME AND NAME OF THE OPERATOR WHO ACKNOWLEDGED AND RESOLVED THE ALARM SHALL BE RECORDED IN THE DATABASE.

12. IDENTICAL ALARMS FROM THE SAME ALARM POINT SHALL BE ACKNOWLEDGED AT THE SAME TIME THE OPERATOR ACKNOWLEDGES THE FIRST ALARM. IDENTICAL ALARMS SHALL BE RESOLVED WHEN THE FIRST ALARM IS RESOLVED.
 13. ALARM FUNCTIONS SHALL HAVE PRIORITY OVER DOWNLOADING, RETRIEVING, AND UPDATING DATABASE FROM WORKSTATIONS AND CONTROLLERS.
 14. WHEN A READER-CONTROLLED OUTPUT (RELAY) IS OPENED, THE CORRESPONDING ALARM POINT SHALL BE AUTOMATICALLY BYPASSED.
- (L) MONITOR DISPLAY: DISPLAY TEXT AND GRAPHIC MAPS THAT INCLUDE ZONE STATUS INTEGRATED INTO THE DISPLAY. COLORS ARE USED FOR THE VARIOUS COMPONENTS AND CURRENT DATA. COLORS SHALL BE UNIFORM THROUGHOUT THE SYSTEM.
1. GRAPHICS:
 - A. SUPPORT GRAPHIC DISPLAY MAPS AND ALLOW IMPORT OF MAPS FROM A MINIMUM OF 16 STANDARD FORMATS FROM ANOTHER DRAWING OR GRAPHICS PROGRAM.
 - B. ALLOW I/O TO BE PLACED ON GRAPHIC MAPS BY THE DRAG-AND-DROP METHOD.
 - C. OPERATORS SHALL BE ABLE TO VIEW THE INPUTS, OUTPUTS, AND THE POINT'S NAME BY MOVING THE MOUSE CURSOR OVER THE POINT ON THE GRAPHIC MAP.
 - D. INPUTS OR OUTPUTS MAY BE PLACED ON MULTIPLE GRAPHIC MAPS. THE OPERATOR SHALL BE ABLE TO TOGGLE TO VIEW GRAPHIC MAPS ASSOCIATED WITH I/OS.
 - E. EACH GRAPHIC MAP SHALL HAVE A DISPLAY-ORDER SEQUENCE NUMBER ASSOCIATED WITH IT TO PROVIDE A PREDETERMINED ORDER WHEN TOGGLED TO DIFFERENT VIEWS.
 - F. CAMERA ICONS SHALL HAVE THE ABILITY TO BE PLACED ON GRAPHIC MAPS THAT, WHEN SELECTED BY AN OPERATOR, WILL OPEN A VIDEO WINDOW, DISPLAY THE CAMERA ASSOCIATED WITH THAT ICON, AND PROVIDE PAN-TILT-ZOOM CONTROL.
 - G. INPUT, OUTPUT, OR CAMERA PLACED ON A MAP SHALL ALLOW THE ABILITY TO ARM OR BYPASS AN INPUT, OPEN OR SECURE AN OUTPUT, OR CONTROL THE PAN-TILT-ZOOM FUNCTION OF THE SELECTED CAMERA.
- (M) REPORT-GENERATOR SOFTWARE: INCLUDE COMMANDS TO GENERATE REPORTS FOR DISPLAYING, PRINTING, AND STORING ON DISK AND TAPE. REPORTS SHALL BE STORED BY TYPE, DATE, AND TIME. REPORT PRINTING SHALL BE THE LOWEST-PRIORITY ACTIVITY. REPORT-GENERATION MODE SHALL BE OPERATOR SELECTABLE BUT SET UP INITIALLY AS PERIODIC, AUTOMATIC, OR ON REQUEST. INCLUDE TIME AND DATE PRINTED AND THE NAME OF OPERATOR GENERATING THE REPORT. REPORT FORMATS MAY BE CONFIGURED BY OPERATORS.
1. AUTOMATIC PRINTING: SETUP SHALL SPECIFY, MODIFY, OR INHIBIT THE REPORT TO BE GENERATED; THE TIME THE INITIAL REPORT IS TO BE GENERATED; THE TIME INTERVAL BETWEEN REPORTS; THE END OF THE PERIOD; AND THE DEFAULT PRINTER.
 2. PRINTING ON REQUEST: AN OPERATOR MAY REQUEST A PRINTOUT OF ANY REPORT.
 3. ACCESS AND SECURE REPORTS: DOCUMENT ZONES PLACED IN ACCESS, THE TIME PLACED IN ACCESS, AND THE TIME PLACED IN SECURE MODE.

4. CUSTOM REPORTS: REPORTS TAILORED TO EXACT REQUIREMENTS OF WHO, WHAT, WHEN, AND WHERE. AS AN OPTION, CUSTOM REPORT FORMATS MAY BE STORED FOR FUTURE PRINTING.
5. AUTOMATIC HISTORY REPORTS: NAMED, SAVED, AND SCHEDULED FOR AUTOMATIC GENERATION.
6. CARDHOLDER REPORTS: INCLUDE DATA, OR SELECTED PARTS OF THE DATA, AS WELL AS THE ABILITY TO BE SORTED BY NAME, CARD NUMBER, IMPRINTED NUMBER, OR BY ANY OF THE USER-DEFINED FIELDS.
7. CARDHOLDER BY READER REPORTS: BASED ON WHO HAS ACCESS TO A SPECIFIC READER OR GROUP OF READERS BY SELECTING THE READERS FROM A LIST.
8. CARDHOLDER BY ACCESS-LEVEL REPORTS: DISPLAY EVERYONE THAT HAS BEEN ASSIGNED TO THE SPECIFIED ACCESS LEVEL.
9. WHO IS "IN" (MUSTER) REPORT:
 - A. EMERGENCY MUSTER REPORT: ONE-CLICK OPERATION ON TOOLBAR LAUNCHES REPORT.
 - B. CARDHOLDER REPORT. CONTAIN A COUNT OF PERSONS WHO ARE "IN" AT A SELECTED LOCATION AND A DETAILED LISTING OF NAME, DATE, AND TIME OF LAST USE, SORTED BY THE LAST READER USED OR BY THE GROUP ASSIGNMENT.
10. PANEL LABELS REPORTS: PRINTOUT OF CONTROL-PANEL FIELD DOCUMENTATION INCLUDING THE ACTUAL LOCATION OF EQUIPMENT, PROGRAMMING PARAMETERS, AND WIRING IDENTIFICATION. MAINTAIN SYSTEM INSTALLATION DATA WITHIN SYSTEM DATABASE SO THAT DATA ARE AVAILABLE ON-SITE AT ALL TIMES.
11. ACTIVITY AND ALARM ON-LINE PRINTING: ACTIVITY PRINTERS FOR USE AT WORKSTATIONS; PRINTS ALL EVENTS, OR ALARMS ONLY.
12. HISTORY REPORTS: CUSTOM REPORTS THAT ALLOW THE OPERATOR TO SELECT ANY DATE, TIME, EVENT TYPE, DEVICE, OUTPUT, INPUT, OPERATOR, LOCATION, NAME, OR CARDHOLDER TO BE INCLUDED OR EXCLUDED FROM THE REPORT.
 - A. INITIALLY STORE HISTORY ON THE HARD DISK OF THE HOST PC.
 - B. PERMIT VIEWING OF THE HISTORY ON WORKSTATIONS OR PRINT HISTORY TO ANY SYSTEM PRINTER.
 - C. THE REPORT SHALL BE DEFINABLE BY A RANGE OF DATES AND TIMES WITH THE ABILITY TO HAVE A DAILY START AND STOP TIME OVER A GIVEN DATE RANGE.
 - D. EACH REPORT SHALL DEPICT THE DATE, TIME, EVENT TYPE, EVENT DESCRIPTION, AND DEVICE; OR I/O NAME, CARDHOLDER GROUP ASSIGNMENT, AND CARDHOLDER NAME OR CODE NUMBER.
 - E. EACH LINE OF A PRINTED REPORT SHALL BE NUMBERED TO ENSURE THAT THE INTEGRITY OF THE REPORT HAS NOT BEEN COMPROMISED.
 - F. TOTAL NUMBER OF LINES OF THE REPORT SHALL BE GIVEN AT THE END OF THE REPORT. IF THE REPORT IS RUN FOR A SINGLE EVENT SUCH AS "ALARMS," THE TOTAL SHALL REFLECT HOW MANY ALARMS OCCURRED DURING THAT PERIOD.

13. REPORTS SHALL HAVE THE FOLLOWING FOUR OPTIONS:
 - A. VIEW ON SCREEN.
 - B. PRINT TO SYSTEM PRINTER. INCLUDE AUTOMATIC PRINT SPOOLING AND "PRINT TO" OPTIONS IF MORE THAN ONE PRINTER IS CONNECTED TO THE SYSTEM.
 - C. "SAVE TO FILE" WITH FULL PATH STATEMENT.
 - D. SYSTEM SHALL HAVE THE ABILITY TO PRODUCE A REPORT INDICATING STATUS OF SYSTEM INPUTS AND OUTPUTS OR OF INPUTS AND OUTPUTS THAT ARE ABNORMAL, OUT OF TIME ZONE, MANUALLY OVERRIDDEN, NOT REPORTING, OR IN ALARM.
14. CUSTOM CODE LIST SUBROUTINE: ALLOW THE ACCESS CODES OF SYSTEM TO BE SORTED AND PRINTED ACCORDING TO THE FOLLOWING CRITERIA:
 - A. ACTIVE, INACTIVE, OR FUTURE ACTIVATE OR DEACTIVATE.
 - B. CODE NUMBER, NAME, OR IMPRINTED CARD NUMBER.
 - C. GROUP, LOCATION ACCESS LEVELS.
 - D. START AND STOP CODE RANGE.
 - E. CODES THAT HAVE NOT BEEN USED SINCE A SELECTABLE NUMBER OF DAYS.
 - F. IN, OUT, OR EITHER STATUS.
 - G. CODES WITH TRACE DESIGNATION.
15. THE REPORTS OF SYSTEM DATABASE SHALL ALLOW OPTIONS SO THAT EVERY DATA FIELD MAY BE PRINTED.
16. THE REPORTS OF SYSTEM DATABASE SHALL BE CONSTRUCTED SO THAT THE ACTUAL POSITION OF THE PRINTED DATA SHALL CLOSELY MATCH THE POSITION OF THE DATA ON THE DATA-ENTRY WINDOWS.

2.05 SYSTEM DATABASE

- (A) DATABASE AND DATABASE MANAGEMENT SOFTWARE SHALL DEFINE AND MODIFY EACH POINT IN DATABASE USING OPERATOR COMMANDS. DEFINITION SHALL INCLUDE PARAMETERS AND CONSTRAINTS ASSOCIATED WITH EACH SYSTEM DEVICE.
- (B) DATABASE OPERATIONS:
 1. SYSTEM DATA MANAGEMENT SHALL BE IN A HIERARCHICAL MENU-TREE FORMAT, WITH NAVIGATION THROUGH EXPANDABLE MENU BRANCHES AND MANIPULATED WITH USE OF MENUS AND ICONS IN A MAIN MENU AND SYSTEM TOOLBAR.
 2. NAVIGATIONAL AIDS:
 - A. TOOLBAR ICONS FOR ADD, DELETE, COPY, PRINT, CAPTURE IMAGE, ACTIVATE, DEACTIVATE, AND MUSTER REPORT.

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- B. POINT AND CLICK FEATURE TO FACILITATE DATA MANIPULATION.
 - C. NEXT AND PREVIOUS COMMAND BUTTONS VISIBLE WHEN EDITING DATABASE FIELDS TO FACILITATE NAVIGATION FROM ONE RECORD TO THE NEXT.
 - D. COPY COMMAND AND COPY TOOL IN THE TOOLBAR TO COPY DATA FROM ONE RECORD TO CREATE A NEW SIMILAR RECORD.
3. DATA ENTRY SHALL BE AUTOMATICALLY CHECKED FOR DUPLICATE AND ILLEGAL DATA AND SHALL BE VERIFIED FOR VALID FORMAT.
4. SYSTEM SHALL GENERATE A MEMO OR NOTE FIELD FOR EACH ITEM THAT IS STORED IN DATABASE, ALLOWING THE STORING OF INFORMATION ABOUT ANY DEFINING CHARACTERISTICS OF THE ITEM. MEMO FIELD IS USED FOR NOTING THE PURPOSE FOR WHICH THE ITEM WAS ENTERED, REASONS FOR CHANGES THAT WERE MADE, AND THE LIKE.
- (C) FILE MANAGEMENT:
- 1. FILE MANAGEMENT SHALL INCLUDE DATABASE BACKUP AND RESTORATION SYSTEM, ALLOWING SELECTION OF STORAGE MEDIA, INCLUDING 3.5-INCH FLOPPY DISK, ZIP AND JAZ DRIVES, AND DESIGNATED NETWORK RESOURCES.
 - 2. OPERATIONS SHALL BE BOTH MANUAL AND AUTOMATIC MODES. THE NUMBER OF AUTOMATIC SEQUENTIAL BACKUPS BEFORE THE OLDEST BACKUP WILL BE OVERWRITTEN; FIFO MODE SHALL BE OPERATOR SELECTABLE.
 - 3. BACKUP PROGRAM SHALL PROVIDE MANUAL OPERATION FROM ANY PC ON THE LAN AND SHALL OPERATE WHILE SYSTEM REMAINS OPERATIONAL.
- (D) OPERATOR PASSWORDS:
- 1. SUPPORT INDIVIDUAL SYSTEM OPERATORS, EACH WITH A UNIQUE PASSWORD.
 - 2. ALLOW PASSWORDS TO BE CASE SENSITIVE.
 - 3. PASSWORDS SHALL NOT BE DISPLAYED WHEN ENTERED.
 - 4. PASSWORDS SHALL HAVE UNIQUE AND CUSTOMIZABLE PASSWORD PROFILE, AND ALLOW SEVERAL OPERATORS TO SHARE A PASSWORD PROFILE. INCLUDE THE FOLLOWING FEATURES IN THE PASSWORD PROFILE:
 - A. PREDETERMINE THE HIGHEST-LEVEL PASSWORD PROFILE FOR ACCESS TO ALL FUNCTIONS AND AREAS OF PROGRAM.
 - B. ALLOW OR DISALLOW OPERATOR ACCESS TO ANY PROGRAM OPERATION, INCLUDING THE FUNCTIONS OF VIEW, ADD, EDIT, AND DELETE.
 - C. RESTRICT DOORS TO WHICH AN OPERATOR CAN ASSIGN ACCESS.
 - 5. OPERATORS SHALL USE A USER NAME AND PASSWORD TO LOG ON TO SYSTEM. THIS USER NAME AND PASSWORD SHALL BE USED TO ACCESS DATABASE AREAS AND PROGRAMS AS DETERMINED BY THE ASSOCIATED PROFILE.

6. MAKE PROVISION TO ALLOW THE OPERATOR TO LOG OFF WITHOUT FULLY EXITING PROGRAM. USER MAY BE LOGGED OFF BUT PROGRAM WILL REMAIN RUNNING WHILE DISPLAYING THE LOGIN WINDOW FOR THE NEXT OPERATOR.

(E) ACCESS CARD/CODE OPERATION AND MANAGEMENT: ACCESS AUTHORIZATION SHALL BE BY CARD, BY A MANUALLY ENTERED CODE (PIN), OR BY A COMBINATION OF BOTH (CARD PLUS PIN).

1. ACCESS AUTHORIZATION SHALL VERIFY THE FACILITY CODE FIRST, THE CARD OR CARD-AND-PIN VALIDATION SECOND, AND THE ACCESS LEVEL (TIME OF DAY, DAY OF WEEK, DATE), ANTI-PASSBACK STATUS, AND NUMBER OF USES LAST.
2. USE DATA-ENTRY WINDOWS TO VIEW, EDIT, AND ISSUE ACCESS LEVELS. ACCESS-AUTHORIZATION ENTRY-MANAGEMENT SYSTEM SHALL MAINTAIN AND COORDINATE ALL ACCESS LEVELS TO PREVENT DUPLICATION OR THE INCORRECT CREATION OF LEVELS.
3. ALLOW ASSIGNMENT OF MULTIPLE CARDS/CODES TO A CARDHOLDER.
4. ALLOW ASSIGNMENT OF UP TO FOUR ACCESS LEVELS FOR EACH LOCATION TO A CARDHOLDER. EACH ACCESS LEVEL MAY CONTAIN ANY COMBINATION OF DOORS.
5. EACH DOOR MAY BE ASSIGNED FOUR TIME ZONES.
6. ACCESS CODES MAY BE UP TO 11 DIGITS IN LENGTH.
7. SOFTWARE SHALL ALLOW THE GROUPING OF LOCATIONS SO CARDHOLDER DATA CAN BE SHARED BY ALL LOCATIONS IN THE GROUP.
8. VISITOR ACCESS: ISSUE A VISITOR BADGE FOR DATA TRACKING OR PHOTO ID PURPOSES WITHOUT ASSIGNING THAT PERSON A CARD OR CODE.
9. CARDHOLDER TRACING: ALLOW FOR SELECTION OF CARDHOLDER FOR TRACING. MAKE A SPECIAL AUDIBLE AND VISIBLE ANNUNCIATION AT CONTROL STATION WHEN A SELECTED CARD OR CODE IS USED AT A DESIGNATED CODE READER. ANNUNCIATION SHALL INCLUDE AN AUTOMATIC DISPLAY OF THE CARDHOLDER IMAGE.
10. ALLOW EACH CARDHOLDER TO BE GIVEN EITHER AN UNLIMITED NUMBER OF USES OR A NUMBER FROM ONE TO 9999 THAT REGULATES THE NUMBER OF TIMES THE CARD CAN BE USED BEFORE IT IS AUTOMATICALLY DEACTIVATED.
11. PROVIDE FOR CARDS AND CODES TO BE ACTIVATED AND DEACTIVATED MANUALLY OR AUTOMATICALLY BY DATE. PROVIDE FOR MULTIPLE DEACTIVATE DATES TO BE PREPROGRAMMED.

(F) SECURITY ACCESS INTEGRATION:

1. PHOTO ID BADGING AND PHOTO VERIFICATION SHALL USE THE SAME DATABASE AS THE SECURITY ACCESS AND MAY QUERY DATA FROM CARDHOLDER, GROUP, AND OTHER PERSONAL INFORMATION TO BUILD A CUSTOM ID BADGE.
2. AUTOMATIC OR MANUAL IMAGE RECALL AND MANUAL ACCESS BASED ON PHOTO VERIFICATION SHALL ALSO BE A MEANS OF ACCESS VERIFICATION AND ENTRY.
3. SYSTEM SHALL ALLOW SORTING OF CARDHOLDERS TOGETHER BY GROUP OR OTHER CHARACTERISTIC FOR A FAST AND EFFICIENT METHOD OF REPORTING ON, AND ENABLING OR DISABLING, CARDS OR CODES.

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(G) GROUP:

1. GROUP NAMES MAY BE USED TO SORT CARDHOLDERS INTO GROUPS THAT ALLOW THE OPERATOR TO DETERMINE THE TENANT, VENDOR, CONTRACTOR, DEPARTMENT, DIVISION, OR ANY OTHER DESIGNATION OF A GROUP TO WHICH THE PERSON BELONGS.
2. SYSTEM SOFTWARE SHALL HAVE THE CAPACITY TO ASSIGN ONE OF 32,000 GROUP NAMES TO AN ACCESS AUTHORIZATION.
3. MAKE PROVISION IN SOFTWARE TO DEACTIVATE AND REACTIVATE ALL ACCESS AUTHORIZATIONS ASSIGNED TO A PARTICULAR GROUP.
4. ALLOW SORTING OF HISTORY REPORTS AND CODE LIST PRINTOUTS BY GROUP NAME.

(H) ACCESS LEVELS:

1. ONE LEVEL SHALL BE PREDEFINED AS THE MASTER ACCESS LEVEL. THE MASTER ACCESS LEVEL SHALL WORK AT ALL DOORS AT ALL TIMES AND OVERRIDE ANY ANTI-PASSBACK.
2. SYSTEM SHALL ALLOW FOR ACCESS TO BE RESTRICTED TO ANY AREA BY READER AND BY TIME. ACCESS LEVELS SHALL DETERMINE WHEN AND WHERE AN IDENTIFIER IS AUTHORIZED.
3. SYSTEM SHALL BE ABLE TO CREATE MULTIPLE DOOR AND TIME-ZONE COMBINATIONS UNDER THE SAME ACCESS LEVEL SO THAT AN IDENTIFIER MAY BE VALID DURING DIFFERENT TIME PERIODS AT DIFFERENT READERS EVEN IF THE READERS ARE ON THE SAME CONTROLLER.

2.06 SURGE AND TAMPER PROTECTION

(A) SURGE PROTECTION: PROTECT COMPONENTS FROM VOLTAGE SURGES ORIGINATING EXTERNAL TO EQUIPMENT HOUSING AND ENTERING THROUGH POWER, COMMUNICATION, SIGNAL, CONTROL, OR SENSING LEADS. INCLUDE SURGE PROTECTION FOR EXTERNAL WIRING OF EACH CONDUCTOR-ENTRY CONNECTION TO COMPONENTS.

(B) TAMPER PROTECTION: TAMPER SWITCHES ON ENCLOSURES, CONTROL UNITS, PULL BOXES, JUNCTION BOXES, CABINETS, AND OTHER SYSTEM COMPONENTS SHALL INITIATE A TAMPER-ALARM SIGNAL WHEN UNIT IS OPENED OR PARTIALLY DISASSEMBLED. CONTROL-STATION CONTROL-UNIT ALARM DISPLAY SHALL IDENTIFY TAMPER ALARMS AND INDICATE LOCATIONS.

2.07 CENTRAL-STATION HARDWARE

(A) CENTRAL-STATION COMPUTER: PROVIDE RACK MOUNTED CENTRAL-STATION COMPUTER. THE CPU OPERATING SPEED SHALL BE AT LEAST 3.0 GHZ.

1. MEMORY: 3 GB OF USABLE INSTALLED MEMORY, EXPANDABLE TO A MINIMUM OF 16 GB WITHOUT ADDITIONAL CHASSIS OR POWER SUPPLIES.
2. POWER SUPPLY: MINIMUM CAPACITY OF 250 W.
3. REAL-TIME CLOCK:
 - A. ACCURACY: PLUS OR MINUS ONE MINUTE PER MONTH.
 - B. TIME-KEEPING FORMAT: 24-HOUR TIME FORMAT INCLUDING SECONDS, MINUTES, HOURS, DATE, DAY, AND MONTH; RESETTABLE BY SOFTWARE.

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- C. CLOCK SHALL FUNCTION FOR ONE YEAR WITHOUT POWER.
 - D. PROVIDE AUTOMATIC TIME CORRECTION ONCE EVERY 24 HOURS BY SYNCHRONIZING CLOCK WITH THE TIME SERVICE DEPARTMENT OF THE U.S. NAVAL OBSERVATORY.
- 4. SERIAL PORTS: PROVIDE TWO TIA 232-F SERIAL PORTS FOR GENERAL USE, WITH ADDITIONAL PORTS AS REQUIRED. DATA TRANSMISSION RATES SHALL BE SELECTABLE UNDER PROGRAM CONTROL.
 - 5. PARALLEL PORT: AN ENHANCED PARALLEL PORT.
 - 6. LAN ADAPTER CARD: 10/100 MBPS PCI BUS, INTERNAL NETWORK INTERFACE CARD.
 - 7. SOUND CARD: FOR PLAYBACK AND RECORDING OF DIGITAL WAV SOUND FILES THAT ARE ASSOCIATED WITH AUDIBLE WARNING AND ALARM FUNCTIONS.
 - 8. COLOR MONITOR: NOT LESS THAN 17 INCHES (430 MM), WITH A MINIMUM RESOLUTION OF 1280 BY 1024 PIXELS, NONINTERLACED, AND A MAXIMUM DOT PITCH OF 0.28 MM. THE VIDEO CARD SHALL SUPPORT AT LEAST 256 COLORS AT A RESOLUTION OF 1280 BY 1024 AT A MINIMUM REFRESH RATE OF 70 HZ.
 - 9. KEYBOARD: WITH A MINIMUM OF 64 CHARACTERS, STANDARD ASCII CHARACTER SET BASED ON ANSI INCITS 154.
 - 10. MOUSE: STANDARD, COMPATIBLE WITH THE INSTALLED SOFTWARE.
 - 11. SPECIAL-FUNCTION KEYBOARD ATTACHMENTS OR SPECIAL-FUNCTION KEYS TO FACILITATE DATA INPUT OF THE FOLLOWING OPERATOR TASKS:
 - A. HELP.
 - B. ALARM ACKNOWLEDGE.
 - C. PLACE ZONE IN ACCESS.
 - D. PLACE ZONE IN SECURE.
 - E. SYSTEM TEST.
 - F. PRINT REPORTS.
 - G. CHANGE OPERATOR.
 - 12. DISK STORAGE SHALL INCLUDE THE FOLLOWING, EACH WITH APPROPRIATE CONTROLLER:
 - A. MINIMUM 10 GB HARD DISK, MAXIMUM AVERAGE ACCESS TIME OF 10 MS.
 - B. DVD/CD-ROM DRIVE.
 - C. USB.
 - 13. INTERFACE: BIDIRECTIONAL PARALLEL, AND UNIVERSAL SERIAL BUS.
 - 14. LAN ADAPTER CARD: 10/100 MBPS INTERNAL NETWORK INTERFACE CARD.
- (B) UPS: PROVIDE RACK MOUNTED UPS TO POWER CENTRAL STATION HARDWARE FOR A MINIMUM OF 15 SECONDS.

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2.08 CONTROLLERS

- (A) CONTROLLERS: INTELLIGENT PERIPHERAL CONTROL UNIT, COMPLYING WITH UL 294, THAT STORES TIME, DATE, VALID CODES, ACCESS LEVELS, AND SIMILAR DATA DOWNLOADED FROM THE CENTRAL STATION OR WORKSTATION FOR CONTROLLING ITS OPERATION.
- (B) SUBJECT TO COMPLIANCE WITH REQUIREMENTS IN THIS ARTICLE, MANUFACTURERS MAY USE MULTIPURPOSE CONTROLLERS.
- (C) BATTERY BACKUP: SEALED, LEAD ACID; SIZED TO PROVIDE RUN TIME DURING A POWER OUTAGE OF 90 MINUTES, COMPLYING WITH UL 924.
- (D) ENTRY-CONTROL CONTROLLER:
 - 1. FUNCTION: PROVIDE LOCAL ENTRY-CONTROL FUNCTIONS INCLUDING ONE- AND TWO-WAY COMMUNICATIONS WITH ACCESS-CONTROL DEVICES SUCH AS CARD READERS, KEYPADS, BIOMETRIC PERSONNEL IDENTITY-VERIFICATION DEVICES, DOOR STRIKES, MAGNETIC LATCHES, GATE AND DOOR OPERATORS, AND EXIT PUSH BUTTONS.
 - A. OPERATE AS A STAND-ALONE PORTAL CONTROLLER USING THE DOWNLOADED DATABASE DURING PERIODS OF COMMUNICATION LOSS BETWEEN THE CONTROLLER AND THE FIELD-DEVICE NETWORK.
 - B. ACCEPT INFORMATION GENERATED BY THE ENTRY-CONTROL DEVICES; AUTOMATICALLY PROCESS THIS INFORMATION TO DETERMINE VALID IDENTIFICATION OF THE INDIVIDUAL PRESENT AT THE PORTAL:
 - (1) ON AUTHENTICATION OF THE CREDENTIALS OR INFORMATION PRESENTED, CHECK PRIVILEGES OF THE IDENTIFIED INDIVIDUAL, ALLOWING ONLY THOSE ACTIONS GRANTED AS PRIVILEGES.
 - (2) PRIVILEGES SHALL INCLUDE, BUT ARE NOT LIMITED TO, TIME OF DAY CONTROL, DAY OF WEEK CONTROL, GROUP CONTROL, AND VISITOR ESCORT CONTROL.
 - C. MAINTAIN A DATE-, TIME-, AND LOCATION-STAMPED RECORD OF EACH TRANSACTION. A TRANSACTION IS DEFINED AS ANY SUCCESSFUL OR UNSUCCESSFUL ATTEMPT TO GAIN ACCESS THROUGH A CONTROLLED PORTAL BY THE PRESENTATION OF CREDENTIALS OR OTHER IDENTIFYING INFORMATION.
 - 2. INPUTS:
 - A. DATA FROM ENTRY-CONTROL DEVICES; USE THIS INPUT TO CHANGE MODES BETWEEN ACCESS AND SECURE.
 - B. DATABASE DOWNLOADS AND UPDATES FROM THE CENTRAL STATION THAT INCLUDE ENROLLMENT AND PRIVILEGE INFORMATION.
 - 3. OUTPUTS:
 - A. INDICATE SUCCESS OR FAILURE OF ATTEMPTS TO USE ENTRY-CONTROL DEVICES AND MAKE COMPARISONS OF PRESENTED INFORMATION WITH STORED IDENTIFICATION INFORMATION.

- B. GRANT OR DENY ENTRY BY SENDING CONTROL SIGNALS TO PORTAL-CONTROL DEVICES.
 - C. MAINTAIN A DATE-, TIME-, AND LOCATION-STAMPED RECORD OF EACH TRANSACTION AND TRANSMIT TRANSACTION RECORDS TO THE CENTRAL STATION.
 - D. DOOR PROP ALARM: IF A PORTAL IS HELD OPEN FOR LONGER THAN 60 SECONDS, ALARM SOUNDS.
4. WITH POWER SUPPLIES SUFFICIENT TO POWER AT VOLTAGE AND FREQUENCY REQUIRED FOR FIELD DEVICES AND PORTAL-CONTROL DEVICES.
5. DATA LINE PROBLEMS: FOR PERIODS OF LOSS OF COMMUNICATION WITH THE CENTRAL STATION, OR WHEN DATA TRANSMISSION IS DEGRADED AND GENERATING CONTINUOUS CHECKSUM ERRORS, THE CONTROLLER SHALL CONTINUE TO CONTROL ENTRY BY ACCEPTING IDENTIFYING INFORMATION, MAKING AUTHENTICATION DECISIONS, CHECKING PRIVILEGES, AND CONTROLLING PORTAL-CONTROL DEVICES.
- A. STORE TRANSACTIONS DURING PERIODS OF COMMUNICATION LOSS BETWEEN THE CONTROLLER AND ACCESS-CONTROL DEVICES FOR SUBSEQUENT UPLOAD TO THE CENTRAL STATION ON RESTORATION OF COMMUNICATION.

2.9 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- (A) CARD-READER POWER: POWERED FROM ITS ASSOCIATED CONTROLLER, INCLUDING ITS STANDBY POWER SOURCE, AND SHALL NOT DISSIPATE MORE THAN 5 W.
- (B) RESPONSE TIME: CARD READER SHALL RESPOND TO PASSAGE REQUESTS BY GENERATING A SIGNAL THAT IS SENT TO THE CONTROLLER. RESPONSE TIME SHALL BE 800 MS OR LESS, FROM THE TIME THE CARD READER FINISHES READING THE CREDENTIAL CARD UNTIL A RESPONSE SIGNAL IS GENERATED.
- (C) ENCLOSURE: SUITABLE FOR SURFACE, SEMI-FLUSH, PEDESTAL, OR WEATHERPROOF MOUNTING. MOUNTING TYPES SHALL ADDITIONALLY BE SUITABLE FOR INSTALLATION IN THE FOLLOWING LOCATIONS:
 - 1. INDOORS, CONTROLLED ENVIRONMENT.
 - 2. OUTDOORS WITH COLD-WEATHER EQUIPMENT TO EXTEND THE OPERATING TEMPERATURE RANGE AS NEEDED FOR OPERATION AT THE SITE.
- (D) DISPLAY: DIGITAL VISUAL INDICATOR SHALL PROVIDE VISIBLE AND AUDIBLE STATUS INDICATIONS AND USER PROMPTS. INDICATE POWER ON OR OFF, WHETHER USER PASSAGE REQUESTS HAVE BEEN ACCEPTED OR REJECTED, AND WHETHER THE DOOR IS LOCKED OR UNLOCKED.

2.10 ENROLLMENT CENTER

- (A) EQUIPMENT FOR ENROLLING PERSONNEL INTO, AND REMOVING PERSONNEL FROM, SYSTEM DATABASE, USING CENTRAL-STATION EQUIPMENT.
- (B) ENROLLMENT EQUIPMENT SHALL SUPPORT ENCODING OF CREDENTIAL CARDS INCLUDING CRYPTOGRAPHIC AND OTHER INTERNAL SECURITY CHECKS AS REQUIRED FOR SYSTEM.
 - 1. ALLOW ONLY AUTHORIZED ENTRY-CONTROL ENROLLMENT PERSONNEL TO ACCESS THE ENROLLMENT EQUIPMENT USING PASSWORDS.

2. INCLUDE ENROLLMENT-SUBSYSTEM CONFIGURATION CONTROLS AND ELECTRONIC DIAGNOSTIC AIDS FOR SUBSYSTEM SETUP AND TROUBLESHOOTING WITH THE CENTRAL STATION.

3. ENROLLMENT-STATION RECORDS PRINTER SHALL MEET REQUIREMENTS OF THE REPORT PRINTER.

2.11 VIDEO AND CAMERA CONTROL

(A) CONTROL STATION OR DESIGNATED WORKSTATION DISPLAYS LIVE VIDEO FROM A CCTV SOURCE. THE ACCESS CONTROL SYSTEM SHALL BE CAPABLE OF INTEGRATION WITH THE VIDEO SURVEILLANCE SYSTEM.

2.12 CABLES

(A) GENERAL CABLE REQUIREMENTS: AS RECOMMENDED BY SYSTEM MANUFACTURER FOR INTEGRATION REQUIREMENT.

(B) PLENUM-TYPE, TIA 485-A CABLES:

1. TWO PAIRS, NO. 22 AWG, STRANDED (7X30) TINNED COPPER CONDUCTORS, FLUORINATED-ETHYLENE-PROPYLENE INSULATION, UNSHIELDED, AND FLUORINATED-ETHYLENE-PROPYLENE JACKET.

2. NFPA 70, TYPE CMP.

3. FLAME RESISTANCE: NFPA 262 FLAME TEST.

(C) PAIRED, PLENUM-TYPE, LOCK CABLES:

1. ONE PAIR, TWISTED, NO. 16 AWG, STRANDED (19X29) TINNED COPPER CONDUCTORS, PVC INSULATION, UNSHIELDED, AND PVC JACKET.

2. NFPA 70, TYPE CMP.

3. FLAME RESISTANCE: NFPA 262 FLAME TEST.

(D) PAIRED, PLENUM-TYPE, INPUT CABLES:

1. ONE PAIR, TWISTED, NO. 22 AWG, STRANDED (7X30) TINNED COPPER CONDUCTORS, FLUORINATED-ETHYLENE-PROPYLENE INSULATION, ALUMINUM-FOIL/POLYESTER-TAPE SHIELD (FOIL SIDE OUT), WITH NO. 22 AWG DRAIN WIRE, 100 PERCENT SHIELD COVERAGE, AND PLASTIC JACKET.

2. NFPA 70, TYPE CMP.

3. FLAME RESISTANCE: NFPA 262 FLAME TEST.

PART 3 - EXECUTION

3.01 EXAMINATION

(A) EXAMINE PATHWAY ELEMENTS INTENDED FOR CABLES. CHECK RACEWAYS, CABLE TRAYS, AND OTHER ELEMENTS FOR COMPLIANCE WITH SPACE ALLOCATIONS, INSTALLATION TOLERANCES, HAZARDS TO CABLE INSTALLATION, AND OTHER CONDITIONS AFFECTING INSTALLATION.

(B) EXAMINE ROUGHING-IN FOR LAN AND CONTROL CABLE CONDUIT SYSTEMS TO PCS, CONTROLLERS, CARD READERS, AND OTHER CABLE-CONNECTED DEVICES TO VERIFY ACTUAL LOCATIONS OF CONDUIT AND BACK BOXES BEFORE DEVICE INSTALLATION.

(C) PROCEED WITH INSTALLATION ONLY AFTER UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED.

3.02 PREPARATION

(A) COMPLY WITH RECOMMENDATIONS IN SIA CP-01.

(B) COMPLY WITH TIA/EIA 606-A, "ADMINISTRATION STANDARD FOR COMMERCIAL TELECOMMUNICATIONS INFRASTRUCTURE."

(C) OBTAIN DETAILED PROJECT PLANNING FORMS FROM MANUFACTURER OF ACCESS-CONTROL SYSTEM; DEVELOP CUSTOM FORMS TO SUIT PROJECT. FILL IN ALL DATA AVAILABLE FROM PROJECT PLANS AND SPECIFICATIONS AND PUBLISH AS PROJECT PLANNING DOCUMENTS FOR REVIEW AND APPROVAL.

1. RECORD SETUP DATA FOR CONTROL STATION AND WORKSTATIONS.
2. FOR EACH LOCATION, RECORD SETUP OF CONTROLLER FEATURES AND ACCESS REQUIREMENTS.
3. PROPOSE START AND STOP TIMES FOR TIME ZONES AND HOLIDAYS, AND MATCH UP ACCESS LEVELS FOR DOORS.
4. SET UP GROUPS, FACILITY CODES, LINKING, AND LIST INPUTS AND OUTPUTS FOR EACH CONTROLLER.
5. ASSIGN ACTION MESSAGE NAMES AND COMPOSE MESSAGES.
6. SET UP ALARMS. ESTABLISH INTERLOCKS BETWEEN ALARMS, INTRUDER DETECTION, AND VIDEO SURVEILLANCE FEATURES.
7. PREPARE AND INSTALL ALARM GRAPHIC MAPS.
8. DEVELOP USER-DEFINED FIELDS.
9. DEVELOP SCREEN LAYOUT FORMATS.
10. PROPOSE SETUPS FOR GUARD TOURS AND KEY CONTROL.
11. DISCUSS BADGE LAYOUT OPTIONS; DESIGN BADGES.
12. COMPLETE SYSTEM DIAGNOSTICS AND OPERATION VERIFICATION.
13. PREPARE A SPECIFIC PLAN FOR SYSTEM TESTING, STARTUP, AND DEMONSTRATION.
14. DEVELOP ACCEPTANCE TEST CONCEPT AND, ON APPROVAL, DEVELOP SPECIFICS OF THE TEST.

3.03 CABLING

(A) COMPLY WITH NECA 1, "GOOD WORKMANSHIP IN ELECTRICAL CONSTRUCTION."

(B) WIRING METHOD: INSTALL WIRING IN RACEWAY EXCEPT WITHIN CONSOLES, CABINETS, DESKS, AND COUNTERS. CONCEAL RACEWAY AND WIRING EXCEPT IN UNFINISHED SPACES.

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(C) WIRING METHOD: INSTALL WIRING IN RACEWAY AND CABLE TRAY EXCEPT WITHIN CONSOLES, CABINETS, DESKS, AND COUNTERS AND EXCEPT IN ACCESSIBLE CEILING SPACES AND IN GYPSUM BOARD PARTITIONS WHERE UNENCLOSED WIRING METHOD MAY BE USED. USE NRTL-LISTED PLENUM CABLE IN ENVIRONMENTAL AIRSPACES, INCLUDING PLENUM CEILINGS. CONCEAL RACEWAY AND CABLES EXCEPT IN UNFINISHED SPACES.

(D) INSTALL END-OF-LINE RESISTORS AT THE FIELD DEVICE LOCATION AND NOT AT THE CONTROLLER OR PANEL LOCATION.

3.04 CABLE APPLICATION

(A) COMPLY WITH TIA 569-B, "COMMERCIAL BUILDING STANDARD FOR TELECOMMUNICATIONS PATHWAYS AND SPACES."

(B) CABLE APPLICATION REQUIREMENTS ARE MINIMUM REQUIREMENTS AND SHALL BE EXCEEDED IF RECOMMENDED OR REQUIRED BY MANUFACTURER OF SYSTEM HARDWARE.

(C) TIA 232-F CABLING: INSTALL AT A MAXIMUM DISTANCE OF 50 FT. (15 M).

(D) TIA 485-A CABLING: INSTALL AT A MAXIMUM DISTANCE OF 4000 FT. (1220 M).

(E) CARD READERS:

1. INSTALL NUMBER OF CONDUCTOR PAIRS RECOMMENDED BY MANUFACTURER FOR THE FUNCTIONS SPECIFIED.
2. UNLESS MANUFACTURER RECOMMENDS LARGER CONDUCTORS, INSTALL NO. 22 AWG WIRE IF MAXIMUM DISTANCE FROM CONTROLLER TO THE READER IS 250 FT. (75 M), AND INSTALL NO. 20 AWG WIRE IF MAXIMUM DISTANCE IS 500 FT. (150 M).
3. FOR GREATER DISTANCES, INSTALL "EXTENDER" OR "REPEATER" MODULES RECOMMENDED BY MANUFACTURER OF THE CONTROLLER.
4. INSTALL MINIMUM NO. 18 AWG SHIELDED CABLE TO READERS THAT DRAW 50 MA OR MORE.

(F) INSTALL MINIMUM NO. 16 AWG CABLE FROM CONTROLLER TO ELECTRICALLY POWERED LOCKS.

3.05 GROUNDING

(A) COMPLY WITH IEEE 1100, "RECOMMENDED PRACTICE FOR POWER AND GROUNDING ELECTRONIC EQUIPMENT."

(B) GROUND CABLE SHIELDS, DRAIN CONDUCTORS, AND EQUIPMENT TO ELIMINATE SHOCK HAZARD AND TO MINIMIZE GROUND LOOPS, COMMON-MODE RETURNS, NOISE PICKUP, CROSS TALK, AND OTHER IMPAIRMENTS.

(C) BOND SHIELDS AND DRAIN CONDUCTORS TO GROUND AT ONLY ONE POINT IN EACH CIRCUIT.

3.06 INSTALLATION

(A) INSTALL CARD READERS, KEYPADS, PUSH BUTTONS, AND BIOMETRIC READERS.

3.07 IDENTIFICATION

(A) IN ADDITION TO REQUIREMENTS IN THIS ARTICLE, COMPLY WITH APPLICABLE REQUIREMENTS IN SECTION 260553 "IDENTIFICATION FOR ELECTRICAL SYSTEMS" AND WITH TIA/EIA 606-A.

(B) LABEL EACH TERMINAL STRIP AND SCREW TERMINAL IN EACH CABINET, RACK, OR PANEL.

1. ALL WIRING CONDUCTORS CONNECTED TO TERMINAL STRIPS SHALL BE INDIVIDUALLY NUMBERED, AND EACH CABLE OR WIRING GROUP BEING EXTENDED FROM A PANEL OR CABINET TO A BUILDING-MOUNTED DEVICE SHALL BE IDENTIFIED WITH THE NAME AND NUMBER OF THE PARTICULAR DEVICE AS SHOWN.

2. EACH WIRE CONNECTED TO BUILDING-MOUNTED DEVICES IS NOT REQUIRED TO BE NUMBERED AT THE DEVICE IF THE COLOR OF THE WIRE IS CONSISTENT WITH THE ASSOCIATED WIRE CONNECTED AND NUMBERED WITHIN THE PANEL OR CABINET.

(C) AT COMPLETION, CABLE AND ASSET MANAGEMENT SOFTWARE SHALL REFLECT AS-BUILT CONDITIONS.

3.08 SYSTEM SOFTWARE AND HARDWARE

(A) DEVELOP, INSTALL, AND TEST SOFTWARE AND HARDWARE, AND PERFORM DATABASE TESTS FOR THE COMPLETE AND PROPER OPERATION OF SYSTEMS INVOLVED. ASSIGN SOFTWARE LICENSE TO OWNER.

3.09 FIELD QUALITY CONTROL

(A) PERFORM TESTS AND INSPECTIONS.

1. MANUFACTURER'S FIELD SERVICE: ENGAGE A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE TO INSPECT COMPONENTS, ASSEMBLIES, AND EQUIPMENT INSTALLATIONS, INCLUDING CONNECTIONS, AND TO ASSIST IN TESTING.

(B) TESTS AND INSPECTIONS:

1. TEST EACH CIRCUIT AND COMPONENT OF EACH SYSTEM. TESTS SHALL INCLUDE, BUT ARE NOT LIMITED TO, MEASUREMENTS OF POWER-SUPPLY OUTPUT UNDER MAXIMUM LOAD, SIGNAL LOOP RESISTANCE, AND LEAKAGE TO GROUND WHERE APPLICABLE. SYSTEM COMPONENTS WITH BATTERY BACKUP SHALL BE OPERATED ON BATTERY POWER FOR A PERIOD OF NOT LESS THAN 10 PERCENT OF THE CALCULATED BATTERY OPERATING TIME. PROVIDE SPECIAL EQUIPMENT AND SOFTWARE IF TESTING REQUIRES SPECIAL OR DEDICATED EQUIPMENT.

2. OPERATIONAL TEST: AFTER INSTALLATION OF CABLES AND CONNECTORS, DEMONSTRATE PRODUCT CAPABILITY AND COMPLIANCE WITH REQUIREMENTS. TEST EACH SIGNAL PATH FOR END-TO-END PERFORMANCE FROM EACH END OF ALL PAIRS INSTALLED. REMOVE TEMPORARY CONNECTIONS WHEN TESTS HAVE BEEN SATISFACTORILY COMPLETED.

(C) DEVICES AND CIRCUITS WILL BE CONSIDERED DEFECTIVE IF THEY DO NOT PASS TESTS AND INSPECTIONS.

(D) PREPARE TEST AND INSPECTION REPORTS.

3.10 STARTUP SERVICE

(A) ENGAGE A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE TO SUPERVISE AND ASSIST WITH STARTUP SERVICE.

1. COMPLETE INSTALLATION AND STARTUP CHECKS ACCORDING TO APPROVED PROCEDURES THAT WERE DEVELOPED IN "PREPARATION" ARTICLE AND WITH MANUFACTURER'S WRITTEN INSTRUCTIONS.
2. ENROLL AND PREPARE BADGES AND ACCESS CARDS FOR OWNER'S OPERATORS, MANAGEMENT, AND SECURITY PERSONNEL.

3.11 PROTECTION

(A) MAINTAIN STRICT SECURITY DURING THE INSTALLATION OF EQUIPMENT AND SOFTWARE. ROOMS HOUSING THE CONTROL STATION, AND WORKSTATIONS THAT HAVE BEEN POWERED UP SHALL BE LOCKED AND SECURED WITH AN ACTIVATED BURGLAR ALARM AND ACCESS-CONTROL SYSTEM REPORTING TO A CENTRAL STATION.

3.12 DEMONSTRATION

(A) TRAIN OWNER'S MAINTENANCE PERSONNEL TO ADJUST, OPERATE, AND MAINTAIN SECURITY ACCESS SYSTEM. SEE SECTION 017900 "DEMONSTRATION AND TRAINING."

(B) DEVELOP SEPARATE TRAINING MODULES FOR THE FOLLOWING:

1. COMPUTER SYSTEM ADMINISTRATION PERSONNEL TO MANAGE AND REPAIR THE LAN AND DATABASES AND TO UPDATE AND MAINTAIN SOFTWARE.
2. OPERATORS WHO PREPARE AND INPUT CREDENTIALS TO MAN THE CONTROL STATION AND WORKSTATIONS AND TO ENROLL PERSONNEL.
3. SECURITY PERSONNEL.
4. HARDWARE MAINTENANCE PERSONNEL.
5. CORPORATE MANAGEMENT.

END OF SECTION 28 13 00 – ACCESS CONTROL

SECTION 28 20 00 – VIDEO SURVEILLANCE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 SUMMARY

- (A) SECTION INCLUDES A VIDEO SURVEILLANCE SYSTEM CONSISTING OF CAMERAS, DIGITAL VIDEO RECORDER, DATA TRANSMISSION WIRING, AND A CONTROL STATION WITH ITS ASSOCIATED EQUIPMENT.
- (B) THE VIDEO SURVEILLANCE SYSTEM SHALL GENERATE HIGH RESOLUTION VIDEO IMAGES. THE SYSTEM SHALL PROVIDE FOR SIMULTANEOUS RECORDING AND PLACK.
- (C) CONTRACTOR SHALL PROVIDE ALL REMAINING ACCESSORIES AND COMPONENTS FOR A COMPLETE OPERATING SYSTEM.
- (D) PROVIDE CAMERAS TO PROVIDE COMPLETE COVERAGE OF CORRIDORS, COMMON AREAS, ENTRANCE/EXITS AND PARKING LOTS.
- (E) RELATED REQUIREMENTS:
1. SECTION 28 13 00 "ACCESS CONTROL SYSTEM SOFTWARE AND DATABASE MANAGEMENT" TO INTEGRATE ACCESS CONTROL SYSTEM INTERFACE AND CONTROL.

1.03 DEFINITIONS

- (A) AGC: AUTOMATIC GAIN CONTROL.
- (B) BNC: BAYONET NEILL-CONCELMAN - TYPE OF CONNECTOR.
- (C) B/W: BLACK AND WHITE.
- (D) CCD: CHARGE-COUPLED DEVICE.
- (E) FTP: FILE TRANSFER PROTOCOL.
- (F) IP: INTERNET PROTOCOL.
- (G) LAN: LOCAL AREA NETWORK.
- (H) MPEG: MOVING PICTURE EXPERTS GROUP.
- (I) NTSC: NATIONAL TELEVISION SYSTEM COMMITTEE.
- (J) PC: PERSONAL COMPUTER.
- (K) PTZ: PAN-TILT-ZOOM.
- (L) RAID: REDUNDANT ARRAY OF INDEPENDENT DISKS.

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(M) TCP: TRANSMISSION CONTROL PROTOCOL - CONNECTS HOSTS ON THE INTERNET.

(N) UPS: UNINTERRUPTIBLE POWER SUPPLY.

(O) WAN: WIDE AREA NETWORK.

1.04 ACTION SUBMITTALS

(A) PRODUCT DATA: FOR EACH TYPE OF PRODUCT INDICATED. INCLUDE DIMENSIONS AND DATA ON FEATURES, PERFORMANCE, ELECTRICAL CHARACTERISTICS, RATINGS, AND FINISHES.

(B) SHOP DRAWINGS: FOR VIDEO SURVEILLANCE. INCLUDE PLANS, ELEVATIONS, SECTIONS, DETAILS, AND ATTACHMENTS TO OTHER WORK.

1. DETAIL EQUIPMENT ASSEMBLIES AND INDICATE DIMENSIONS, WEIGHTS, LOADS, REQUIRED CLEARANCES, METHOD OF FIELD ASSEMBLY, COMPONENTS, AND LOCATION AND SIZE OF EACH FIELD CONNECTION.

2. FUNCTIONAL BLOCK DIAGRAM: SHOW SINGLE-LINE INTERCONNECTIONS BETWEEN COMPONENTS FOR SIGNAL TRANSMISSION AND CONTROL. SHOW CABLE TYPES AND SIZES.

3. DIMENSIONED PLAN AND ELEVATIONS OF EQUIPMENT RACKS, CONTROL PANELS, AND CONSOLES. SHOW ACCESS AND WORKSPACE REQUIREMENTS.

4. UPS: SIZING CALCULATIONS.

5. WIRING DIAGRAMS: FOR POWER, SIGNAL, AND CONTROL WIRING.

(C) DESIGN DATA: INCLUDE AN EQUIPMENT LIST CONSISTING OF EVERY PIECE OF EQUIPMENT BY MODEL NUMBER, MANUFACTURER, SERIAL NUMBER, LOCATION, AND DATE OF ORIGINAL INSTALLATION. ADD PRETESTING RECORD OF EACH PIECE OF EQUIPMENT, LISTING NAME OF PERSON TESTING, DATE OF TEST, SET POINTS OF ADJUSTMENTS, NAME AND DESCRIPTION OF THE VIEW OF PRESET POSITIONS, DESCRIPTION OF ALARMS, AND DESCRIPTION OF UNIT OUTPUT RESPONSES TO AN ALARM.

1.05 CLOSEOUT SUBMITTALS

(A) OPERATION AND MAINTENANCE DATA: CAMERAS ARE TO BE INCLUDED IN OPERATION AND MAINTENANCE MANUALS. IN ADDITION TO ITEMS SPECIFIED IN SECTION 01 78 23 "OPERATION AND MAINTENANCE DATA," INCLUDE THE FOLLOWING:

1. LISTS OF SPARE PARTS AND REPLACEMENT COMPONENTS RECOMMENDED TO BE STORED AT THE SITE FOR READY ACCESS.

1.06 PROJECT CONDITIONS

(A) ENVIRONMENTAL CONDITIONS: CAPABLE OF WITHSTANDING THE FOLLOWING ENVIRONMENTAL CONDITIONS WITHOUT MECHANICAL OR ELECTRICAL DAMAGE OR DEGRADATION OF OPERATING CAPABILITY:

1. INTERIOR, CONTROLLED ENVIRONMENT: SYSTEM COMPONENTS INSTALLED IN TEMPERATURE-CONTROLLED INTERIOR ENVIRONMENTS SHALL BE RATED FOR CONTINUOUS OPERATION IN AMBIENT TEMPERATURES OF 36 TO 122 DEG F (2 TO 50 DEG C) DRY BULB AND 20 TO 90 PERCENT RELATIVE HUMIDITY, NONCONDENSING. USE NEMA 250, TYPE 1 ENCLOSURES.

2. EXTERIOR ENVIRONMENT: SYSTEM COMPONENTS INSTALLED IN LOCATIONS EXPOSED TO WEATHER SHALL BE RATED FOR CONTINUOUS OPERATION IN AMBIENT TEMPERATURES OF MINUS 30 TO PLUS 122 DEG F (MINUS 34 TO PLUS 50 DEG C) DRY BULB AND 20 TO 90 PERCENT RELATIVE HUMIDITY, CONDENSING. RATE FOR CONTINUOUS OPERATION WHEN EXPOSED TO RAIN AS SPECIFIED IN NEMA 250, WINDS UP TO 85 MPH (137 KM/H) AND SNOW COVER UP TO 24 INCHES (610 MM) THICK. USE NEMA 250, TYPE 3R ENCLOSURES.
3. SECURITY ENVIRONMENT: CAMERA HOUSING FOR USE IN HIGH-RISK AREAS WHERE SURVEILLANCE EQUIPMENT MAY BE SUBJECT TO PHYSICAL VIOLENCE.

1.07 WARRANTY

- (A) SPECIAL WARRANTY: MANUFACTURER'S STANDARD FORM IN WHICH MANUFACTURER AGREES TO REPAIR OR REPLACE COMPONENTS OF CAMERAS, EQUIPMENT RELATED TO CAMERA OPERATION, AND CONTROL-STATION EQUIPMENT THAT FAIL IN MATERIALS OR WORKMANSHIP WITHIN SPECIFIED WARRANTY PERIOD.

1. WARRANTY PERIOD: THREE YEARS FROM DATE OF SUBSTANTIAL COMPLETION.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- (A) VIDEO-SIGNAL FORMAT SHALL COMPLY WITH NTSC STANDARD, COMPOSITE INTERLACED VIDEO. COMPOSITE VIDEO-SIGNAL TERMINATION SHALL BE 75 OHMS.
- (B) SURGE PROTECTION: PROTECT COMPONENTS FROM VOLTAGE SURGES ORIGINATING EXTERNAL TO EQUIPMENT HOUSING AND ENTERING THROUGH POWER, COMMUNICATION, SIGNAL, CONTROL, OR SENSING LEADS. INCLUDE SURGE PROTECTION FOR EXTERNAL WIRING OF EACH CONDUCTOR'S ENTRY CONNECTION TO COMPONENTS.

2.2 PERFORMANCE REQUIREMENTS

- (A) ELECTRICAL COMPONENTS, DEVICES, AND ACCESSORIES: LISTED AND LABELED AS DEFINED IN NFPA 70, BY A QUALIFIED TESTING AGENCY, AND MARKED FOR INTENDED LOCATION AND APPLICATION.
- (B) COMPLY WITH NECA 1.
- (C) COMPLY WITH NFPA 70.
- (D) ELECTRONIC DATA EXCHANGE BETWEEN VIDEO SURVEILLANCE SYSTEM WITH AN ACCESS-CONTROL SYSTEM SHALL COMPLY WITH SIA TVAC.

2.3 STANDARD CAMERAS

- (A) B/W CAMERA:

1. COMPLY WITH UL 639.
2. PICKUP DEVICE: CCD INTERLINE TRANSFER, 252,000 512(H) BY 492(V) PIXELS.
3. HORIZONTAL RESOLUTION: 380 LINES.
4. SIGNAL-TO-NOISE RATIO: NOT LESS THAN 46 DB.

5. WITH AGC, MANUALLY SELECTABLE ON OR OFF.
6. SENSITIVITY: CAMERA SHALL DELIVER 1-V PEAK-TO-PEAK VIDEO SIGNAL AT THE MINIMUM SPECIFIED LIGHT LEVEL. ILLUMINATION FOR THE TEST SHALL BE WITH LAMPS RATED AT APPROXIMATELY 2200-K COLOR TEMPERATURE, AND WITH CAMERA AGC OFF.
7. MANUALLY SELECTABLE MODES FOR BACKLIGHT COMPENSATION OR NORMAL LIGHTING.
8. SCANNING SYNCHRONIZATION: DETERMINED BY EXTERNAL SYNCH OVER THE COAXIAL CABLE. CAMERA SHALL REVERT TO INTERNALLY GENERATED SYNCHRONIZATION ON LOSS OF EXTERNAL SYNCH SIGNAL.
9. MOTION DETECTOR: BUILT-IN DIGITAL.

2.4 LENSES

(A) DESCRIPTION: OPTICAL-QUALITY COATED LENS, DESIGNED SPECIFICALLY FOR VIDEO-SURVEILLANCE APPLICATIONS AND MATCHED TO SPECIFIED CAMERA. PROVIDE COLOR-CORRECTED LENSES WITH COLOR CAMERAS.

1. AUTO-IRIS LENS: ELECTRICALLY CONTROLLED IRIS WITH CIRCUIT SET TO MAINTAIN A CONSTANT VIDEO LEVEL IN VARYING LIGHTING CONDITIONS.
2. FIXED LENS: WITH CALIBRATED FOCUS RING.
3. ZOOM LENS: MOTORIZED, REMOTE-CONTROLLED UNIT, RATED AS "QUIET OPERATING." FEATURES INCLUDE THE FOLLOWING:
 - A. ELECTRICAL LEADS: FILTERED TO MINIMIZE VIDEO SIGNAL INTERFERENCE.
 - B. MOTOR SPEED: VARIABLE.
 - C. LENS SHALL BE AVAILABLE WITH PRESET POSITIONING CAPABILITY TO RECALL THE POSITION OF SPECIFIC SCENES.

2.5 POWER SUPPLIES

(A) LOW-VOLTAGE POWER SUPPLIES MATCHED FOR VOLTAGE AND CURRENT REQUIREMENTS OF CAMERAS AND ACCESSORIES, AND OF TYPE AS RECOMMENDED BY MANUFACTURER OF CAMERA AND LENS.

1. ENCLOSURE: NEMA 250, TYPE 1.

2.6 CAMERA-SUPPORTING EQUIPMENT

(A) MINIMUM LOAD RATING: RATED FOR LOAD IN EXCESS OF THE TOTAL WEIGHT SUPPORTED TIMES A MINIMUM SAFETY FACTOR OF TWO.

(B) PAN UNITS: MOTORIZED AUTOMATIC-SCANNING UNITS ARRANGED TO PROVIDE REMOTE-CONTROLLED MANUAL AND AUTOMATIC CAMERA PANNING ACTION AND EQUIPPED WITH MATCHING MOUNTING BRACKETS.

1. SCANNING OPERATION: SILENT, SMOOTH, AND POSITIVE.
2. STOPS: ADJUSTABLE WITHOUT DISASSEMBLY, TO LIMIT THE SCANNING ARC.

(C) PAN-AND-TILT UNITS: MOTORIZED UNITS ARRANGED TO PROVIDE REMOTE-CONTROLLED AIMING OF CAMERAS WITH SMOOTH AND SILENT OPERATION AND EQUIPPED WITH MATCHING MOUNTING BRACKETS.

1. PANNING ROTATION: 0 TO 355 DEGREES, WITH ADJUSTABLE STOPS.
2. TILT MOVEMENT: 90 DEGREES, PLUS OR MINUS 5 DEGREES, WITH ADJUSTABLE STOPS.
3. SPEED: 12 DEGREES PER SECOND IN BOTH HORIZONTAL AND VERTICAL PLANES.
4. WIRING: FACTORY PREWIRED FOR CAMERA AND ZOOM LENS FUNCTIONS AND PAN-AND-TILT POWER AND CONTROL.
5. BUILT-IN ENCODERS OR POTENTIOMETERS FOR POSITION FEEDBACK, AND THERMOSTAT-CONTROLLED HEATER.
6. PAN-AND-TILT UNIT SHALL BE AVAILABLE WITH PRESET POSITIONING CAPABILITY TO RECALL THE POSITION OF A SPECIFIC SCENE.

(D) MOUNTING BRACKETS FOR FIXED CAMERAS: TYPE MATCHED TO ITEMS SUPPORTED AND MOUNTING CONDITIONS. INCLUDE MANUAL PAN-AND-TILT ADJUSTMENT.

2.7 MONITORS

(A) MONOCHROME:

1. METAL CABINET UNITS DESIGNED FOR CONTINUOUS OPERATION.
2. HORIZONTAL RESOLUTION: 600 LINES, MINIMUM, AT CENTER.
3. MINIMUM FRONT PANEL DEVICES AND CONTROLS: POWER SWITCH; POWER-ON INDICATOR; AND BRIGHTNESS, HORIZONTAL-HOLD, VERTICAL-HOLD, AND CONTRAST CONTROLS.
4. MOUNTING: ADJUSTABLE TILTING AND TRAINING.
5. MOUNTING: SINGLE, 14-INCH (356-MM), VERTICAL, EIA 19-INCH (483-MM) ELECTRONIC EQUIPMENT RACK OR CABINET COMPLYING WITH CEA 310-E.
6. ELECTRICAL: 120-V AC, 60 HZ.

2.8 VIDEOTAPE RECORDERS

(A) DESCRIPTION: INDUSTRIAL, TIME-LAPSE TYPE RECORDER, DESIGNED FOR CONTINUOUS OPERATION. TAPE FORMAT IS 1/2 INCH (13 MM) USING INDUSTRIAL-GRADE, T-120 CASSETTES.

1. HORIZONTAL RESOLUTION: 400 LINES, MINIMUM.
2. RECORDING HEADS: ROTARY-SCAN TYPE.
3. INTEGRAL TIMER: PERMITS PROGRAMMING OF RECORDING OPERATION FOR ADJUSTABLE DAILY AND WEEKLY PERIODS.
4. TIME-LAPSE OPERATING MODES: MULTIPLE, COVERING 24 TO 240 HOURS, MINIMUM.
5. OTHER OPERATING MODES:

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- A. MANUAL PLAY AND RECORDING AT TWO- AND SIX-HOUR SPEEDS.
 - B. FORWARD AND REVERSE HIGH-SPEED SEARCH.
 - C. REVERSE, SLOW, AND SINGLE-FRAME PLAY.
- 6. ALARM RECORDING: OPERATING MODE IS AUTOMATICALLY SWITCHED FROM TIME-LAPSE TO TWO- OR SIX-HOUR RECORDING MODE WHEN AN EXTERNALLY GENERATED ALARM SIGNAL IS RECEIVED.
 - 7. AUDIO RECORDING: 70 TO 7000 HZ. PHONO AND MICROPHONE INPUT; PHONO OUTPUT.
 - 8. TIME AND DATE GENERATOR: RECORDS TIME AND DATE LEGEND IN CORNER OF RECORDED SCENES.
 - 9. TAPE COUNTER: DISPLAYS TAPE POSITION.
 - 10. MANUAL RECORDING LOCK: KEY OR KEYPAD OPERATED. PREVENTS UNAUTHORIZED TAMPERING OR CONTROL CHANGES DURING PRESET OPERATION.
 - 11. SIGNAL-TO-NOISE RATIO: 45 DB FOR VIDEO OUTPUT IN STANDARD PLAY MODE.
 - 12. MOUNTING: STANDARD 19-INCH (483-MM) RACK COMPLYING WITH CEA 310-E, OR FREESTANDING DESKTOP.

2.9 DIGITAL VIDEO RECORDERS

(A) DESCRIPTION: DIGITAL, TIME-LAPSE TYPE, FULL-FRAME AND MOTION RECORDER, WITH REMOVABLE HARD DRIVE.

- 1. RECORDING TIME: 400 HOURS MINIMUM.
- 2. RESOLUTION: 720 BY 480 LINES, MINIMUM.
- 3. PROGRAMMING SHALL BE FROM TRACKBALL AND PUSH BUTTONS ON FACE OF THE RECORDER, SETTINGS SHALL BE DISPLAYED ON ANY VIDEO MONITOR CONNECTED TO THE RECORDER. PROGRAMMING SHALL INCLUDE THE FOLLOWING:
 - A. MOTION ANALYSIS GRAPH.
 - B. PASSWORD PROTECTION.
 - C. ALARM AND TIMER CONTROLS.
 - D. CONTINUOUS RECORDING OPTION.
 - E. TIME-LAPSE OPERATING MODES.
 - F. SEARCH VIDEO BY TIME, EVENT, OR MOTION.
- 4. PROGRAMMING: SMARTMEDIA CARD FOR SOFTWARE UPDATING, IMAGE ARCHIVING, AND IMAGE TRANSFER TO A PC.
- 5. STORAGE: 80-GB, REMOVABLE HARD DRIVE. SOFTWARE SHALL PERMIT HOT-SWAPPING DRIVES.
- 6. COMPRESSION: MPEG-2.
- 7. TIME AND DATE GENERATOR: RECORDS TIME (HR:MIN:SEC) AND DATE LEGEND OF EACH FRAME.
- 8. AUDIO RECORDING: 70 TO 7000 HZ. PHONO AND MICROPHONE INPUT; PHONO OUTPUT.

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9. MOUNTING: STANDARD 19-INCH (483-MM) RACK COMPLYING WITH CEA 310-E, OR FREESTANDING DESKTOP.

2.10 DIGITAL SWITCHERS

(A) SEQUENTIAL SWITCHERS: AUTOMATICALLY SEQUENCE OUTPUTS OF MULTIPLE CAMERAS TO SINGLE MONITOR AND VIDEOTAPE RECORDER.

1. SWITCHING TIME INTERVAL: CONTINUOUSLY ADJUSTABLE, 5 TO 20 SECONDS MINIMUM, WITH MANUAL OVERRIDE.
2. SKIP-SEQUENTIAL-HOLD SWITCH: ONE FOR EACH CAMERA, WITH LED TO INDICATE ACTIVE CAMERA.
3. CAMERA IDENTIFICATION LEGEND: EITHER ON-SCREEN MESSAGE OR LABEL AT SKIP-SEQUENTIAL SWITCH.
4. ALARM SWITCHING: IN THE EVENT OF AN ALARM, ALARMING CHANNEL SHALL AUTOMATICALLY SWITCH THE MONITOR TO FULL SCREEN.
5. MOUNTING: STANDARD 19-INCH (483-MM) RACK COMPLYING WITH CEA 310-E.

(B) PTZ CONTROLS: ARRANGED FOR MULTIPLE-CAMERA CONTROL, WITH SWITCHES TO SELECT CAMERA TO BE CONTROLLED.

1. PAN-AND-TILT CONTROL: JOYSTICK TYPE.
2. ZOOM CONTROL: MOMENTARY-CONTACT, "IN-OUT" PUSH BUTTON.
3. AUTOMATIC-SCAN CONTROL: A PUSH BUTTON FOR EACH CAMERA WITH PAN CAPABILITY THAT PLACES CAMERA IN AUTOMATIC-SCANNING MODE.

2.11 IP VIDEO SYSTEMS

(A) DESCRIPTION:

1. SYSTEM SHALL PROVIDE HIGH-QUALITY DELIVERY AND PROCESSING OF IP-BASED VIDEO, AUDIO, AND CONTROL DATA USING STANDARD ETHERNET-BASED NETWORKS.
2. SYSTEM SHALL HAVE SEAMLESS INTEGRATION OF ALL VIDEO SURVEILLANCE AND CONTROL FUNCTIONS.
3. GRAPHICAL USER INTERFACE SOFTWARE SHALL MANAGE ALL IP-BASED VIDEO MATRIX SWITCHING AND CAMERA CONTROL FUNCTIONS, TWO-WAY AUDIO COMMUNICATION, ALARM MONITORING AND CONTROL, AND RECORDING AND ARCHIVE/RETRIEVAL MANAGEMENT. IP SYSTEM SHALL ALSO BE CAPABLE OF INTEGRATING INTO LARGER SYSTEM ENVIRONMENTS.
4. SYSTEM DESIGN SHALL INCLUDE ALL NECESSARY COMPRESSION SOFTWARE FOR HIGH-PERFORMANCE, DUAL-STREAM, MPEG-2/MPEG-4 VIDEO. UNIT SHALL PROVIDE CONNECTIONS FOR ALL VIDEO CAMERAS, CAMERA PTZ CONTROL DATA, BIDIRECTIONAL AUDIO, DISCREET SENSOR INPUTS, AND CONTROL SYSTEM OUTPUTS.
5. ALL CAMERA SIGNALS SHALL BE COMPRESSED, ENCODED, AND DELIVERED ONTO THE NETWORK FOR PROCESSING AND CONTROL BY THE IP VIDEO-MANAGEMENT SOFTWARE.

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6. CAMERA SYSTEM UNITS SHALL BE RUGGEDLY BUILT AND DESIGNED FOR EXTREME ADVERSE ENVIRONMENTS, COMPLYING WITH NEMA TYPE ENVIRONMENTAL STANDARDS.
7. ENCODER/DECODER COMBINATIONS SHALL PLACE VIDEO, AUDIO, AND DATA NETWORK STREAM THAT CAN BE MANAGED FROM MULTIPLE WORKSTATIONS ON THE USER'S LAN OR WAN.
8. ALL SYSTEM INTERCONNECT CABLES, WORKSTATION PCS, PTZ JOYSTICKS, AND NETWORK INTERMEDIATE DEVICES SHALL BE PROVIDED FOR FULL PERFORMANCE OF SPECIFIED SYSTEM.

2.12 CONTROL STATIONS

- (A) DESCRIPTION: HEAVY-DUTY, FREESTANDING, MODULAR, METAL FURNITURE UNITS ARRANGED TO HOUSE ELECTRONIC EQUIPMENT. COORDINATE COMPONENT ARRANGEMENT AND WIRING WITH COMPONENTS AND WIRING OF OTHER SYSTEMS.
- (B) EQUIPMENT MOUNTING: STANDARD 19-INCH (483-MM) RACK COMPLYING WITH CEA 310-E.
- (C) NORMAL SYSTEM POWER SUPPLY: 120 V, 60 HZ, THROUGH A LOCKED DISCONNECT DEVICE AND AN ISOLATION TRANSFORMER IN CENTRAL-STATION CONTROL UNIT. CENTRAL-STATION CONTROL UNIT SHALL SUPPLY POWER TO ALL COMPONENTS CONNECTED TO IT UNLESS OTHERWISE INDICATED.
- (D) POWER CONTINUITY FOR CONTROL STATION: BATTERIES IN POWER SUPPLIES OF CENTRAL-STATION CONTROL UNITS AND INDIVIDUAL SYSTEM COMPONENTS SHALL MAINTAIN CONTINUOUS SYSTEM OPERATION DURING OUTAGES OF BOTH NORMAL AND BACKUP AC SYSTEM SUPPLY.
 1. BATTERIES: RECHARGEABLE, VALVE-REGULATED, RECOMBINANT, SEALED, LEAD-ACID TYPE WITH NOMINAL 10-YEAR LIFE EXPECTANCY. CAPACITY ADEQUATE TO OPERATE PORTIONS OF SYSTEM SERVED INCLUDING AUDIBLE TROUBLE SIGNAL DEVICES FOR UP TO FOUR HOURS AND AUDIBLE AND VISUAL ALARM DEVICES UNDER ALARM CONDITIONS FOR AN ADDITIONAL 10 MINUTES.
 2. BATTERY CHARGER: SOLID-STATE, FULLY AUTOMATIC, VARIABLE-CHARGING-RATE TYPE. CHARGER SHALL RECHARGE FULLY DISCHARGED BATTERY WITHIN 24 HOURS.

2.13 SIGNAL TRANSMISSION COMPONENTS

- (A) VIDEO SURVEILLANCE CABLE CONNECTORS: BNC TYPE, 75 OHMS. COMPLY WITH REQUIREMENTS IN SECTION 27 10 10 "TELECOMMUNICATIONS CABLING SYSTEMS."

PART 3 - EXECUTION

3.01 EXAMINATION

- (A) EXAMINE PATHWAY ELEMENTS INTENDED FOR CABLES. CHECK RACEWAYS AND OTHER ELEMENTS FOR COMPLIANCE WITH SPACE ALLOCATIONS, INSTALLATION TOLERANCE, HAZARDS TO CAMERA INSTALLATION, AND OTHER CONDITIONS AFFECTING INSTALLATION.
- (B) EXAMINE ROUGHING-IN FOR LAN, WAN, AND IP NETWORK BEFORE DEVICE INSTALLATION.
- (C) PROCEED WITH INSTALLATION ONLY AFTER UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED.

3.02 WIRING

- (A) COMPLY WITH REQUIREMENTS IN SECTION 27 10 10 "TELECOMMUNICATIONS CABLING SYSTEMS."

- (B) WIRING METHOD: INSTALL CABLES IN RACEWAYS UNLESS OTHERWISE INDICATED.
 - 1. EXCEPT RACEWAYS ARE NOT REQUIRED IN ACCESSIBLE INDOOR CEILING SPACES AND ATTICS.
- (C) WIRING WITHIN ENCLOSURES: BUNDLE, LACE, AND TRAIL CONDUCTORS TO TERMINAL POINTS WITH NO EXCESS AND WITHOUT EXCEEDING MANUFACTURER'S LIMITATIONS ON BENDING RADII. PROVIDE AND USE LACING BARS AND DISTRIBUTION SPOOLS.
- (D) SPLICES, TAPS, AND TERMINATIONS: FOR POWER AND CONTROL WIRING, USE NUMBERED TERMINAL STRIPS IN JUNCTION, PULL, AND OUTLET BOXES; TERMINAL CABINETS; AND EQUIPMENT ENCLOSURES. TIGHTEN ELECTRICAL CONNECTORS AND TERMINALS ACCORDING TO MANUFACTURER'S PUBLISHED TORQUE-TIGHTENING VALUES. IF MANUFACTURER'S TORQUE VALUES ARE NOT INDICATED, USE THOSE SPECIFIED IN UL 486A-486B.
- (E) GROUNDING: PROVIDE INDEPENDENT-SIGNAL CIRCUIT GROUNDING RECOMMENDED IN WRITING BY MANUFACTURER.

3.03 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- (A) INSTALL CAMERAS AND INFRARED ILLUMINATORS LEVEL AND PLUMB.
- (B) INSTALL CAMERAS WITH 84-INCH- (2134-MM-) MINIMUM CLEAR SPACE BELOW CAMERAS AND THEIR MOUNTINGS. CHANGE TYPE OF MOUNTING TO ACHIEVE REQUIRED CLEARANCE.
- (C) SET PAN UNIT AND PAN-AND-TILT UNIT STOPS TO SUIT FINAL CAMERA POSITION AND TO OBTAIN THE FIELD OF VIEW REQUIRED FOR CAMERA. CONNECT ALL CONTROLS AND ALARMS, AND ADJUST.
- (D) INSTALL POWER SUPPLIES AND OTHER AUXILIARY COMPONENTS AT CONTROL STATIONS UNLESS OTHERWISE INDICATED.
- (E) AVOID GROUND LOOPS BY MAKING GROUND CONNECTIONS ONLY AT THE CONTROL STATION.
 - 1. FOR 12- AND 24-V DC CAMERAS, CONNECT THE COAXIAL CABLE SHIELDS ONLY AT THE MONITOR END.

3.04 FIELD QUALITY CONTROL

- (A) MANUFACTURER'S FIELD SERVICE: ENGAGE A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE TO INSPECT, TEST, AND ADJUST COMPONENTS, ASSEMBLIES, AND EQUIPMENT INSTALLATIONS, INCLUDING CONNECTIONS.
- (B) TESTS AND INSPECTIONS:
 - 1. INSPECTION: VERIFY THAT UNITS AND CONTROLS ARE PROPERLY INSTALLED, CONNECTED, AND LABELED, AND THAT INTERCONNECTING WIRES AND TERMINALS ARE IDENTIFIED.
 - 2. PRETESTING: ALIGN AND ADJUST SYSTEM AND PRETEST COMPONENTS, WIRING, AND FUNCTIONS TO VERIFY THAT THEY COMPLY WITH SPECIFIED REQUIREMENTS. CONDUCT TESTS AT VARYING LIGHTING LEVELS, INCLUDING DAY AND NIGHT SCENES AS APPLICABLE. PREPARE VIDEO-SURVEILLANCE EQUIPMENT FOR ACCEPTANCE AND OPERATIONAL TESTING AS FOLLOWS:
 - A. PREPARE EQUIPMENT LIST DESCRIBED IN "INFORMATIONAL SUBMITTALS" ARTICLE.
 - B. VERIFY OPERATION OF AUTO-IRIS LENSES.

- C. SET BACK-FOCUS OF FIXED FOCAL LENGTH LENSES. AT FOCUS SET TO INFINITY, SIMULATE NIGHTTIME LIGHTING CONDITIONS BY USING A DARK GLASS FILTER OF A DENSITY THAT PRODUCES A CLEAR IMAGE. ADJUST UNTIL IMAGE IS IN FOCUS WITH AND WITHOUT THE FILTER.
 - D. SET BACK-FOCUS OF ZOOM LENSES. AT FOCUS SET TO INFINITY, SIMULATE NIGHTTIME LIGHTING CONDITIONS BY USING A DARK GLASS FILTER OF A DENSITY THAT PRODUCES A CLEAR IMAGE. ADDITIONALLY, SET ZOOM TO FULL WIDE ANGLE AND AIM CAMERA AT AN OBJECT 50 TO 75 FEET (17 TO 23 M) AWAY. ADJUST UNTIL IMAGE IS IN FOCUS FROM FULL WIDE ANGLE TO FULL TELEPHOTO, WITH THE FILTER IN PLACE.
 - E. SET AND NAME ALL PRESET POSITIONS; CONSULT OWNER'S PERSONNEL.
 - F. SET SENSITIVITY OF MOTION DETECTION.
 - G. CONNECT AND VERIFY RESPONSES TO ALARMS.
 - H. VERIFY OPERATION OF CONTROL-STATION EQUIPMENT.
3. TEST SCHEDULE: SCHEDULE TESTS AFTER PRETESTING HAS BEEN SUCCESSFULLY COMPLETED AND SYSTEM HAS BEEN IN NORMAL FUNCTIONAL OPERATION FOR AT LEAST 14 DAYS. PROVIDE A MINIMUM OF 10 DAYS' NOTICE OF TEST SCHEDULE.
4. OPERATIONAL TESTS: PERFORM OPERATIONAL SYSTEM TESTS TO VERIFY THAT SYSTEM COMPLIES WITH SPECIFICATIONS. INCLUDE ALL MODES OF SYSTEM OPERATION. TEST EQUIPMENT FOR PROPER OPERATION IN ALL FUNCTIONAL MODES.
- (C) VIDEO SURVEILLANCE SYSTEM WILL BE CONSIDERED DEFECTIVE IF IT DOES NOT PASS TESTS AND INSPECTIONS.
- (D) PREPARE TEST AND INSPECTION REPORTS.
- 3.05** ADJUSTING
- (A) OCCUPANCY ADJUSTMENTS: WHEN REQUESTED WITHIN 12 MONTHS OF DATE OF SUBSTANTIAL COMPLETION, PROVIDE ON-SITE ASSISTANCE IN ADJUSTING SYSTEM TO SUIT ACTUAL OCCUPIED CONDITIONS. PROVIDE UP TO TWO VISITS TO PROJECT DURING OTHER-THAN-NORMAL OCCUPANCY HOURS FOR THIS PURPOSE. TASKS SHALL INCLUDE, BUT ARE NOT LIMITED TO, THE FOLLOWING:
- 1. CHECK CABLE CONNECTIONS.
 - 2. CHECK PROPER OPERATION OF CAMERAS AND LENSES. VERIFY OPERATION OF AUTO-IRIS LENSES AND ADJUST BACK-FOCUS AS NEEDED.
 - 3. ADJUST ALL PRESET POSITIONS; CONSULT OWNER'S PERSONNEL.
 - 4. RECOMMEND CHANGES TO CAMERAS, LENSES, AND ASSOCIATED EQUIPMENT TO IMPROVE OWNER'S USE OF VIDEO SURVEILLANCE SYSTEM.
 - 5. PROVIDE A WRITTEN REPORT OF ADJUSTMENTS AND RECOMMENDATIONS.
- 3.06** CLEANING
- (A) CLEAN INSTALLED ITEMS USING METHODS AND MATERIALS RECOMMENDED IN WRITING BY MANUFACTURER.

(B) CLEAN VIDEO-SURVEILLANCE-SYSTEM COMPONENTS, INCLUDING CAMERA-HOUSING WINDOWS, LENSES, AND MONITOR SCREENS.

3.07 DEMONSTRATION

(A) TRAIN OWNER'S MAINTENANCE PERSONNEL TO ADJUST, OPERATE, AND MAINTAIN VIDEO-SURVEILLANCE EQUIPMENT.

END OF SECTION 28 20 00 – VIDEO SURVEILLANCE

SECTION 28 31 12 - FIRE ALARM SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- (A) DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.02 WORK INCLUDED

- (A) THE WORK COVERED BY THIS SECTION OF THE SPECIFICATION INCLUDES THE FURNISHING OF ALL LABOR, EQUIPMENT, MATERIALS AND PERFORMANCE OF ALL OPERATIONS IN CONNECTION WITH THE INSTALLATION OF AN ELECTRICALLY SUPERVISED CLOSED LOOP AND ADDRESSABLE 24-VOLT DC FIRE ALARM SYSTEM AS SHOWN ON THE DRAWINGS AND AS HEREIN SPECIFIED. THE SYSTEM SHALL INCLUDE BUT NOT BE LIMITED TO ALL CONTROL PANELS, POWER SUPPLIES, ALARM INITIATING DEVICES, ALARM SIGNALING DEVICES, CONDUIT, WIRE, FITTINGS AND ALL AUXILIARY ACCESSORIES REQUIRED TO PROVIDE A COMPLETE AND OPERATING SYSTEM WHICH SHALL BE LEFT IN FIRST CLASS OPERATING CONDITION. THE SYSTEM SHALL BE APPROVED BY THE VARIOUS REGULATORY BODIES.
- (B) THE REQUIREMENTS OF THE CONDITIONS OF THE CONTRACT, SUPPLEMENTARY CONDITIONS AND GENERAL REQUIREMENTS, APPLY TO THE WORK SPECIFIED IN THIS SECTION.
- (C) THE ITEMS OF EQUIPMENT FURNISHED UNDER THIS SPECIFICATION SHALL BE LISTED AS A PRODUCT OF A SINGLE FIRE ALARM MANUFACTURER UNDER THE APPROPRIATE CATEGORY BY UNDERWRITERS LABORATORIES AND SHALL MEET THE APPLICABLE REQUIREMENTS OF NFPA STANDARDS, LIFE SAFETY CODE 101, NATIONAL ELECTRIC CODE ARTICLE 760 AS WELL AS THOSE STANDARDS SET BY THE AUTHORITIES HAVING JURISDICTION. THE SYSTEM CONTROLS SHALL BE LISTED UNDER UL STANDARD 864 (CONTROL UNITS). IN ADDITION, THE SYSTEM CONTROLS SHALL BE UL LISTED FOR POWER LIMITED APPLICATIONS PER NEC 760. ALL CIRCUITS MUST BE MARKED IN ACCORDANCE WITH NEC ARTICLE 760. THE FIRE ALARM AND DETECTION EQUIPMENT SHALL NOT BE MODIFIED OR INSTALLED TO ALTER OR VOID THE UNDERWRITERS LABORATORIES LABEL OR LISTING. FIRE ALARM CONTROL PANEL SHALL UL 9TH EDITION LISTED.
- (D) ALL CONTROL EQUIPMENT MUST HAVE TRANSIENT PROTECTION TO COMPLY WITH UL864 REQUIREMENTS. WHERE FIRE ALARM CIRCUITS LEAVE THE BUILDING, ADDITIONAL TRANSIENT PROTECTION MUST BE PROVIDED FOR EACH CIRCUIT. DEVICES MUST BE UL LISTED UNDER STANDARD #497B (ISOLATED LOOP CIRCUIT PROTECTORS).
- (E) PROVIDE POWER CONNECTIONS, DETECTION DEVICES, ETC., WHERE AUXILIARY EQUIPMENT IS REQUIRED, SUCH AS REMOTE POWER SUPPLIES, VOICE ANNUNCIATION PANELS, AND OTHER EQUIPMENT NECESSARY FOR A COMPLETE AND OPERATING SYSTEM. WHERE THE FIRE ALARM CONTROL PANEL IS SHOWN CONNECTED TO AN EMERGENCY POWER SYSTEM, ALL AUXILIARY EQUIPMENT SHALL ALSO BE CONNECTED TO THE EMERGENCY POWER SYSTEM.

1.03 QUALITY ASSURANCE

- (A) SUBMIT SHOP DRAWINGS AND PRODUCT DATA TO THE ARCHITECT-ENGINEER IN ACCORDANCE WITH THE GENERAL CONDITIONS AND GENERAL REQUIREMENTS. SHOP DRAWINGS SHALL INCLUDE THE FOLLOWING:
1. COMPLETE DESCRIPTIVE PRODUCT DATA INCLUDING UL LISTING FOR ALL SYSTEM COMPONENTS AND DETAILED MANUFACTURER'S DRAWINGS ON THE: FIRE ALARM CONTROL PANEL, REMOTE ANNUNCIATORS, MANUAL FIRE ALARM STATION, AUTOMATIC FIRE DETECTION DEVICES, ALARM SIGNALING DEVICES, WIRING AND CABLE.
 2. TERMINAL CONNECTION DIAGRAM OF THE FIRE ALARM CONTROL PANEL SHOWING ALL WIRING CONNECTION POINTS INCLUDING TYPICAL FIELD WIRING CIRCUIT DIAGRAMS.

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3. LAYOUT DRAWINGS SHOWING THE EXACT LOCATION OF ALL FIRE ALARM EQUIPMENT AND THE INTERCONNECTION BETWEEN THE DEVICES.
 4. A COMPLETE STEP-BY-STEP DESCRIPTION OF THE OPERATION OF THE SYSTEM.
 5. CERTIFICATION BY THE MANUFACTURER THAT THE BATTERY INSTALLATION MEETS THE OPERATING REQUIREMENTS SPECIFIED HEREIN.
- (B) ALL SUBMITTAL DATA ON THIS SYSTEM MUST BE APPROVED BY THE STATE FIRE MARSHALL AND/OR THE AUTHORITY HAVING JURISDICTION BEFORE IT IS SUBMITTED TO THE ARCHITECT FOR APPROVAL.
- (C) THE CONTRACTOR SHALL FURNISH TO THE OWNER, UPON FINAL ACCEPTANCE OF THE SYSTEM, FOUR (4) SETS OF WRITTEN OPERATING AND MAINTENANCE INSTRUCTIONS WHICH SHALL INCLUDE COPIES OF ALL DESIGNATED APPROVED SHOP DRAWINGS, WIRING DIAGRAMS, LAYOUT DRAWINGS AND INSTALLATION AND OPERATING INSTRUCTIONS. THE MANUAL SHALL CONTAIN PROCEDURES TO FOLLOW FOR DRILLS, TROUBLESHOOTING, RESETTING THE SYSTEM AND OTHER FUNCTIONS NORMAL TO, AND INHERENT IN, THE FIRE ALARM AND DETECTION SYSTEM.

1.04 SYSTEM OPERATION

- (A) ACTIVATION OF ANY MANUAL FIRE ALARM STATION, VERIFIED SMOKE DETECTOR, DUCT MOUNTED SMOKE DETECTOR, HEAT DETECTOR, SPRINKLER SYSTEM, WATERFLOW SWITCH OR ANY OTHER AUTOMATIC ALARM INITIATING DEVICE, SHALL PROVIDE THE FOLLOWING AUTOMATIC OPERATION:
1. AN ALARM SHALL BE DISPLAYED ON THE 80 CHARACTER LCD DISPLAY. THE TOP LINE OF 40 CHARACTERS SHALL BE THE CUSTOM POINT LABEL AND THE SECOND LINE SHALL BE THE DEVICE TYPE IDENTIFIER AND POINT STATUS INDICATOR. THE CUSTOM POINT LABEL SHALL IDENTIFY LOCATION OF THE DEVICE. THE NOMENCLATURE USED TO DESCRIBE THE DEVICE LOCATION SHALL BE COORDINATED WITH THE OWNER AND SHALL CORRESPOND TO ZONE INDICATION PLAQUE NOMENCLATURE. THE SYSTEM ALARM RED LED SHALL FLASH ON THE CONTROL PANEL AND REMOTE ANNUNCIATOR UNTIL THE ALARM HAS BEEN ACKNOWLEDGED AT THE CONTROL PANEL. ONCE ACKNOWLEDGED, THIS SAME LED SHALL LATCH ON. A SUBSEQUENT ALARM RECEIVED FROM ANOTHER ZONE SHALL FLASH THE SYSTEM ALARM LED ON THE CONTROL PANEL. THE LCD DISPLAY SHALL SHOW THE NEW ALARM INFORMATION.
 2. ALL AUDIBLE ALARM INDICATING DEVICES SHALL SOUND A UNIFORM CODE 3 TEMPORAL PATTERN AND ALL VISUAL DEVICES SHALL ACTIVATE AND HAVE THE FLASH RATE SYNCHRONIZED UNTIL SILENCED AT THE FIRE ALARM CONTROL PANEL OR REMOTE ANNUNCIATOR. THE SYSTEM WILL INCLUDE PROVISIONS FOR SILENCING THE SIGNALING DEVICES, ALLOWING FOR RE-INITIATION FOLLOWING A SUBSEQUENT ALARM, BUT ONLY AFTER THE SIGNALING DEVICES HAVE OPERATED INITIALLY FOR NOT LESS THAN THREE (3) MINUTES. (THE INHIBIT FEATURE SHALL BE ADJUSTABLE FROM 0-5 MINUTES). SYSTEMS THAT DO NOT HAVE RESOUND CAPABILITIES WILL NOT BE ACCEPTABLE.
 3. ALL CIRCUITS OF DOORS NORMALLY HELD OPEN BY DOOR CONTROL DEVICES SHALL RELEASE AFTER A FIVE (5) SECOND DELAY.
 4. A SUPERVISED SIGNAL TO NOTIFY THE LOCAL FIRE DEPARTMENT OR AN APPROVED CENTRAL STATION SHALL BE ACTIVATED.
 5. ALL AIR HANDLING UNITS OVER 2,000 CFM SHALL DEACTIVATE AND ALL SMOKE AND FIRE/SMOKE DAMPERS SHALL CLOSE.
 6. LIGHT AN ALARM INDICATOR LAMP ON SMOKE DETECTORS WHICH HAVE INITIATED AN ALARM.

7. THE ACTIVATION OF ANY ALARM INITIATING DEVICE SHALL, IN ADDITION TO THE OPERATIONS LISTED ABOVE, CAUSE THE ELEVATOR CABS TO BE RECALLED ACCORDING TO THE FOLLOWING SEQUENCE:
- A. IF THE ALARM DEVICE IS ON ANY FLOOR OTHER THAN THE MAIN LEVEL OF EGRESS, THE ELEVATOR CABS SHALL BE RECALLED TO THE MAIN LEVEL OF EGRESS.
 - B. IF THE ALARM DEVICE IS ON THE MAIN EGRESS LEVEL, THE ELEVATOR CABS SHALL BE RECALLED TO THE PREDETERMINED ALTERNATE RECALL LEVEL AS DETERMINED BY THE LOCAL AUTHORITY HAVING JURISDICTION.
- (B) THE ACTIVATION OF ANY (SYSTEM OPERATED) AREA SMOKE DETECTOR SHALL INITIATE AN ALARM VERIFICATION OPERATION WHEREBY THE PANEL WILL RESET THE ACTIVATED DETECTOR AND WAIT FOR A SECOND ALARM ACTIVATION. IF, WITHIN ONE (1) MINUTE AFTER RESETTING, A SECOND ALARM IS REPORTED FROM THE SAME OR ANY OTHER SMOKE DETECTOR, THE SYSTEM SHALL PROCESS THE ALARM AS DESCRIBED PREVIOUSLY. IF NO SECOND ALARM OCCURS WITHIN ONE (1) MINUTE THE SYSTEM SHALL RESUME NORMAL OPERATION. THE ALARM VERIFICATION SHALL OPERATE ONLY ON AREA SMOKE DETECTOR ALARMS. OTHER ACTIVATED INITIATING DEVICES SHALL BE PROCESSED IMMEDIATELY. THE ALARM VERIFICATION OPERATION SHALL BE SELECTABLE BY ZONE OR ADDRESSABLE DETECTOR AND SHALL ALLOW THE ZONES (DETECTORS) TO BE DIVIDED INTO SEVEN (7) DIFFERENT GROUPS WHEREBY ONLY TWO (2) ZONES FROM A GROUP WILL CONFIRM THE FIRST ACTIVATION AND CAUSE THE PANEL TO FOLLOW PROGRAMMED ALARM SEQUENCE. ALARM VERIFICATION SHALL NOT BE APPLIED TO DUCT SMOKE DETECTORS. THE CONTROL PANEL SHALL HAVE THE CAPABILITY TO DISPLAY THE NUMBER OF TIMES A ZONE OR ADDRESSABLE DETECTOR HAS GONE INTO A VERIFICATION MODE.
- (C) THE ACTIVATION OF ANY STANDPIPE OR SPRINKLER VALVE TAMPER SWITCH SHALL ACTIVATE A DISTINCTIVE SYSTEM SUPERVISORY AUDIBLE SIGNAL AND ILLUMINATE A DISTINCTIVE "SPRINKLER VALVE SUPERVISORY TAMPER" LED AT THE CONTROL PANEL AND THE REMOTE ANNUNCIATORS. DIFFERENTIATION BETWEEN VALVE TAMPER ACTIVATION OPENS AND/OR GROUNDS ON FIRE ALARM INITIATION CIRCUIT WIRING SHALL BE PROVIDED. ACTIVATING THE ALARM SILENCE SWITCH WILL SILENCE THE SUPERVISORY AUDIBLE SIGNAL WHILE MAINTAINING THE "SPRINKLER VALVE SUPERVISORY TAMPER" LED ON INDICATING THAT THE TAMPER CONTACT IS STILL IN THE OFF-NORMAL STATE. RESTORING THE VALVE TO THE NORMAL POSITION SHALL CAUSE THE "SPRINKLER SUPERVISORY TAMPER" LED TO EXTINGUISH THUS INDICATING RESTORATION TO NORMAL POSITION.
- (D) THE SYSTEM CONTROL PANEL MUST BE CAPABLE OF COMMUNICATING WITH THE TYPES OF ADDRESSABLE DEVICES SPECIFIED BELOW. THE LOCATION OF ADDRESSABLE DEVICES WILL BE SELECTED ALONG WITH CONVENTIONAL DEVICES TO OPTIMIZE THE SYSTEM LAYOUT IN ORDER TO PROVIDE THE LEVEL OF PROTECTION, ZONE IDENTIFICATION AND CONTROL AS SHOWN ON THE DRAWINGS.
- (E) THE SYSTEM SHALL HAVE PROVISIONS FOR DISABLING AND ENABLING ALL ADDRESSABLE DEVICES, MONITORING, SIGNALING AND CONTROL CIRCUITS INDIVIDUALLY FOR MAINTENANCE AND TESTING PURPOSES.
- (F) ALARM AND TROUBLE CONDITIONS SHALL BE IMMEDIATELY DISPLAYED ON THE CONTROL PANEL FROM ALPHANUMERIC LCD DISPLAY. IF MORE THAN ONE (1) ALARM OR TROUBLE IS IN THE SYSTEM, THE OPERATOR MAY SCROLL TO DISPLAY NEW ALARMS.
- (G) A MANUAL EVACUATION (DRILL) SWITCH SHALL BE PROVIDED TO OPERATE THE SYSTEMS ALARM INDICATING DEVICES. OTHER CONTROL CIRCUITS SHALL NOT BE ACTIVATED. HOWEVER, AN ALARM SHALL BE PROCESSED AS DESCRIBED PREVIOUSLY.
- (H) THE CONTROL PANEL SHALL INCLUDE A SYSTEM TESTING CAPABILITY TO HELP ENSURE THAT ZONING AND SUPERVISION HAVE BEEN MAINTAINED THROUGHOUT THE SYSTEM. THE ACTUATION OF THE ENABLE WALK TEST PROGRAM AT THE CONTROL PANEL SHALL ACTIVATE THE "WALK-TEST" MODE OF THE SYSTEM WHICH SHALL CAUSE THE FOLLOWING TO OCCUR:
- 1. THE CITY CONNECTION CIRCUIT SHALL BE DISCONNECTED.

2. CONTROL RELAY FUNCTIONS SHALL BE BYPASSED.
 3. THE CONTROL PANEL SHALL SHOW A TROUBLE CONDITION.
 4. THE ALARM ACTIVATION OF ANY INITIATION DEVICE SHALL CAUSE THE AUDIBLE SIGNALS TO CODE A NUMBER OF PULSES TO MATCH THE ZONE NUMBER.
 5. THE PANEL SHALL AUTOMATICALLY RESET ITSELF AFTER CODE IS COMPLETE.
 6. ANY MOMENTARY OPENING OF ALARM INITIATING OR ALARM INDICATING CIRCUIT WIRING SHALL CAUSE THE AUDIBLE SIGNALS TO SOUND CONTINUOUSLY FOR FOUR (4) SECONDS TO INDICATE THE TROUBLE CONDITION.
- (I) THE SYSTEM SHALL BE CAPABLE OF LOGGING AND STORING 300 EVENTS IN AN ALARM LOG AND 300 EVENTS IN A TROUBLE LOG. THESE EVENTS SHALL BE STORED IN A BATTERY PROTECTED RANDOM ACCESS MEMORY. EACH RECORDED EVENT SHALL INCLUDE THE TIME AND DATE OF THAT EVENT'S OCCURRENCE. THE SYSTEM SHALL HAVE THE CAPABILITY OF RECALLING ALARMS, TROUBLE CONDITIONS, ACKNOWLEDGEMENTS, SILENCING AND RESET ACTIVITIES IN CHRONOLOGICAL ORDER FOR THE PURPOSE OF RECREATING AN EVENT HISTORY.
- (J) THE TRUEALARM SMOKE SENSOR SHALL BE A SMOKE DENSITY MEASURING DEVICE HAVING NO SELF CONTAINED ALARM SET-POINT. THE ALARM DECISION FOR EACH SENSOR SHALL BE DETERMINED BY THE CONTROL PANEL. THE CONTROL PANEL SHALL DETERMINE THE CONDITION OF EACH SENSOR BY COMPARING THE SENSOR VALUE TO THE STORED VALUES. THE CONTROL PANEL SHALL MAINTAIN A MOVING AVERAGE OF THE SENSORS SMOKE CHAMBER VALUE. SYSTEMS THAT DO NOT AUTOMATICALLY MAINTAIN A CONSTANT SMOKE OBSCURATION SENSITIVITY FOR EACH DETECTOR BY COMPENSATING FOR ENVIRONMENTAL FACTORS ARE DEEMED NOT ACCEPTABLE.
- (K) AN OPERATOR AT THE CONTROL PANEL, HAVING A PROPER ACCESS LEVEL, SHALL HAVE THE CAPABILITY TO MANUALLY ACCESS THE FOLLOWING INFORMATION FOR EACH SENSOR:
1. PRIMARY STATUS.
 2. DEVICE TYPE.
 3. PRESENT AVERAGE VALUE.
 4. PRESENT SENSITIVITY SELECTED *
 5. PEAK DETECTION VALUES *
 6. SENSOR RANGE (NORMAL, DIRTY, ETC).
- (L) AN OPERATOR AT THE CONTROL PANEL, HAVING A PROPER ACCESS LEVEL, SHALL HAVE THE CAPABILITY TO MANUALLY CONTROL THE FOLLOWING FOR EACH SENSOR:
1. CLEAR PEAK DETECTION VALUES.
 2. ENABLE OR DISABLE THE POINT.
 3. CLEAR VERIFICATION TALLY.
 4. CONTROL A SENSOR'S RELAY DRIVER OUTPUT.
- (M) IT SHALL BE POSSIBLE TO PROGRAM THE CONTROL PANEL TO AUTOMATICALLY CHANGE THE SENSITIVITY SETTINGS OF EACH SENSOR BASED ON TIME-OF-DAY AND DAY-OF-WEEK. (FOR EXAMPLE, TO BE MORE SENSITIVE DURING UNOCCUPIED TIMES AND LESS SENSITIVE DURING OCCUPIED PERIODS.) THERE SHALL BE SEVEN (7) SENSITIVITY SETTINGS AVAILABLE FOR EACH SENSOR.
- (N) THE CONTROL PANEL SHALL HAVE THE CAPABILITY OF BEING PROGRAMMED FOR A PRE-ALARM OR TWO-STAGE FUNCTION. THIS FUNCTION ALLOWS AN INDICATION TO OCCUR WHEN, FOR EXAMPLE, A 3% SENSOR REACHES A THRESHOLD OF 1.5% SMOKE OBSCURATION.

1.05 SUPERVISION

- (A) WHEN A TROUBLE OF ANY NATURE IS DETECTED, AN AUDIBLE TROUBLE SIGNAL SHALL SOUND AT THE FIRE ALARM CONTROL PANEL UNTIL THE TROUBLE IS CORRECTED OR UNTIL IT IS MANUALLY SILENCED. IN ADDITION A "SYSTEM TROUBLE" LED SHALL BE ILLUMINATED AND SHALL REMAIN "ON" UNTIL THE TROUBLE CONDITION IS CORRECTED. A SUBSEQUENT TROUBLE CONDITION RECEIVED AFTER MANUALLY SILENCING SHALL CAUSE THE AUDIBLE TROUBLE SIGNAL TO "RESOUND". EACH INDEPENDENTLY SUPERVISED CIRCUIT SHALL INCLUDE A DISCREET LCD READOUT TO INDICATE DISARRANGEMENT CONDITION IN THAT CIRCUIT.
- (B) SHOULD A TROUBLE CONDITION BE PRESENT WITHIN THE SYSTEM AND THE AUDIBLE TROUBLE SIGNAL SILENCED, THE TROUBLE SIGNAL SHALL RESOUND AT PREPROGRAMMED TIME INTERVALS TO ACT AS REMINDER THAT THE FIRE ALARM SYSTEM IS NOT 100% OPERATIONAL. BOTH THE TIME INTERVAL AND THE TROUBLE REMINDER SIGNAL SHALL BE PROGRAMMABLE TO SUIT THE OWNER'S APPLICATION.
- (C) THE SYSTEM SHALL CONTAIN INDEPENDENTLY SUPERVISED INITIATING CIRCUITS SO THAT A FAULT IN ANY ONE (1) ZONE SHALL NOT AFFECT ANY OTHER ZONE. THE ALARM ACTIVATION OF ANY INITIATION CIRCUIT SHALL NOT PREVENT THE SUBSEQUENT ALARM OPERATION OF ANY OTHER INITIATION CIRCUIT.
- (D) THE ALARM INDICATING DEVICE CIRCUITS SHALL BE INDEPENDENTLY SUPERVISED AND FUSED SO THAT DISARRANGEMENT OF ANY CIRCUIT SHALL NOT AFFECT THE OPERATION OF THE OTHER CIRCUITS.
- (E) THE SYSTEM SHALL ANNUNCIATE, AT THE CONTROL PANEL, THE FOLLOWING TROUBLE CONDITIONS FOR EACH ADDRESSABLE POINT WITHIN THE SYSTEM: OPEN, SHORT AND DEVICE FAILED/MISSING. SHOULD A DEVICE FAIL IT WILL NOT HINDER THE OPERATION OF OTHER SYSTEM DEVICES.
- (F) ALL AUXILIARY MANUAL CONTROLS SHALL BE SUPERVISED SO THAT ALL SWITCHES MUST BE RETURNED TO THE NORMAL AUTOMATIC POSITION TO CLEAR SYSTEM TROUBLE.
- (G) THE POWER SUPPLY FOR THE SYSTEM SHALL BE SUPERVISED SO THAT LOSS OF THE INCOMING POWER, A LOW BATTERY VOLTAGE CONDITION OR A BATTERY DISCONNECTION WILL CAUSE A TROUBLE CONDITION IN THE SYSTEM. A GREEN "POWER ON" LED SHALL BE DISPLAYED CONTINUOUSLY WHILE INCOMING POWER IS PRESENT.
- (H) WIRING TO THE REMOTE ANNUNCIATOR(S) SHALL BE SUPERVISED FOR OPEN AND GROUND CONDITIONS.
- (I) THE SYSTEM SHALL AUTOMATICALLY INDICATE WHEN AN INDIVIDUAL SENSOR NEEDS CLEANING. WHEN A SENSOR'S AVERAGE VALUE REACHES A PREDETERMINED VALUE, A "DIRTY SENSOR" TROUBLE CONDITION SHALL BE AUDIBLY AND VISUALLY INDICATED AT THE CONTROL PANEL FOR THE INDIVIDUAL SENSOR. ADDITIONALLY, THE LED ON THE SENSOR BASE SHALL GLOW STEADY GIVING A VISIBLE INDICATION AT THE SENSOR LOCATION. IF A "DIRTY SENSOR" IS LEFT UNATTENDED AND ITS AVERAGE VALUE INCREASES TO A SECOND PREDETERMINED VALUE, AN "EXCESSIVELY DIRTY SENSOR" TROUBLE CONDITION SHALL BE INDICATED AT THE CONTROL PANEL FOR THE INDIVIDUAL SENSOR. IT SHALL BE POSSIBLE, AT THE CONTROL PANEL, TO DETERMINE IF ANY SENSORS ARE "ALMOST DIRTY" TO AID IN MAINTENANCE OF THE SYSTEM.
- (J) THE CONTROL PANEL SHALL AUTOMATICALLY PERFORM A DAILY SELF-TEST ON EACH SENSOR. CHECKING THE ELECTRONICS IN THE SENSOR'S BASE ENSURES THE ACCURACY OF THE VALUES BEING TRANSMITTED TO THE CONTROL PANEL. A SENSOR WHICH FAILS THE SELF-TEST WILL CAUSE A "SELF TEST ABNORMAL" TROUBLE CONDITION AT THE CONTROL PANEL. A SENSOR SELF-TEST WHICH MUST BE MANUALLY INITIATED BY THE OPERATOR SHALL NOT BE ACCEPTABLE.

1.06 POWER REQUIREMENTS

- (A) THE CONTROL PANEL SHALL RECEIVE 120 VAC POWER (AS NOTED ON THE PLANS) VIA A DEDICATED CIRCUIT. AN APPROVED EARTH GROUND CONNECTION TO THE CONTROL PANEL SHALL ALSO BE PROVIDED.

- (B) THE SYSTEM SHALL BE PROVIDED WITH SUFFICIENT BATTERY CAPACITY TO OPERATE THE ENTIRE SYSTEM UPON LOSS OF NORMAL 120 VAC POWER IN A NORMAL SUPERVISORY MODE FOR A PERIOD OF 24 HOURS WITH FIVE (5) MINUTES OF ALARM OPERATION AT THE END OF THIS PERIOD. THE SYSTEM SHALL AUTOMATICALLY TRANSFER TO THE STANDBY BATTERIES UPON POWER FAILURE. ALL BATTERY CHARGING AND RECHARGING OPERATIONS SHALL BE AUTOMATIC.
- (C) ALL CIRCUITS REQUIRING SYSTEM OPERATING POWER SHALL BE 24 VDC AND SHALL BE INDIVIDUALLY FUSED AT THE CONTROL PANEL.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- (A) THE EQUIPMENT FURNISHED UNDER THIS SPECIFICATION SHALL BE THE STANDARD PRODUCT OF SIEMENS OR EQUAL INTELLIGENT MICROPROCESSOR BASED ADDRESSABLE FIRE ALARM SYSTEM. THE MANUFACTURER'S SPECIFICATION SHEETS OF EACH ITEM SO LISTED SHALL BE CONSIDERED TO BE A PART OF THESE SPECIFICATIONS AND BINDING HEREIN. EACH COMPONENT OF THE SYSTEM SHALL DISPLAY THIS MANUFACTURER'S NAME AS WELL AS A UL LABEL.

2.02 FIRE ALARM CONTROL PANEL

- (A) WHERE SHOWN ON THE PLANS, PROVIDE AND INSTALL A SIEMENS FIRE FINDER XLS FIRE ALARM CONTROL PANEL. CONSTRUCTION SHALL BE MODULAR WITH SOLID-STATE, MICROPROCESSOR BASED ELECTRONICS. AN 80 CHARACTER LCD DISPLAY SHALL INDICATE ALARMS, SUPERVISORY SERVICE CONDITIONS AND ANY TROUBLES. KEYBOARDS OR KEYPADS SHALL NOT BE REQUIRED TO OPERATE THE SYSTEM DURING FIRE ALARM CONDITIONS. THE FIRE ALARM CONTROL PANEL SHALL BE IN AN ENCLOSED METAL SURFACE-MOUNTED CABINET SPECIFICALLY DESIGNED FOR PUBLIC AREAS. IT SHALL HAVE A LOCKED, HINGED FRONT DOOR WITH TWO (2) MASTER KEYS THAT ALSO FIT ALL OTHER FIRE ALARM APPARATUS UTILIZING KEYS FOR ACCESS.
- (B) THE CONTROL PANEL SHALL BE PROVIDED WITH ALARM INITIATING CIRCUITS AS REQUIRED. TROUBLE AND ALARM CONDITIONS SHALL BE INDICATED ON THE LCD DISPLAY.
- (C) ALL FIRE ALARM COMPONENTS AND WIRING SYSTEMS SHALL BE CLASS B. ALL CIRCUITS SHALL BE INSTALLED SUCH THAT THE OUTGOING AND RETURNING CONDUCTORS ARE ROUTED IN SEPARATE RACEWAYS IN ACCORDANCE WITH NFPA 72.
- (D) THE CONTROL PANEL SHALL PROVIDE COMMUNICATION WITH INDIVIDUALLY ADDRESSABLE INITIATING AND CONTROL DEVICES AS INDICATED ON THE DRAWINGS. ALL OF THESE DEVICES WILL BE INDIVIDUALLY ANNUNCIATED AT THE CONTROL PANEL. THERE SHALL BE NO LIMIT TO THE NUMBER OF DETECTORS, STATIONS OR ZONE ADAPTER MODULES, WHICH MAY BE ACTIVATED OR "IN ALARM" SIMULTANEOUSLY.
- (E) ALARM SIGNALING CIRCUITS SHALL BE PROVIDED AS REQUIRED. EACH CIRCUIT SHALL BE SEPARATELY FUSED AND INDICATED ON THE LCD DISPLAY. THE NUMBER OF CIRCUITS REQUIRED SHALL BE DETERMINED BY A METHOD WHICH ENSURES THAT THE END DEVICE RECEIVED NO LESS THAN 21 VDC OPERATING POWER AND IN NO CASE SHALL THE CIRCUIT BE INITIALLY LOADED IN EXCESS OF 80% OF IT'S RATED CAPACITY.
- (F) CONTROL PANEL SHALL HAVE DIGITAL ALARM COMMUNICATING TRANSMITTER FOR CENTRAL STATION MONITORING OF ALARMS, TROUBLES AND SUPERVISORY CONDITIONS WITH SPECIFIC POINT IDENTIFICATION. ALSO PROVIDE CONTACT CLOSURE DIGITAL COMMUNICATING TRANSMITTER FOR OFF-SITE MONITORING. PROVIDE WIRING TO CLOSEST TELEPHONE TERMINATION BOARD FOR OFF-SITE ANNUNCIATION. THE SELECTION OF A CENTRAL MONITORING AGENCY, ITS FEES AND THE FEES FOR THE LEASED LINES ARE THE RESPONSIBILITY OF THE OWNER.

- (G) THE FIRE ALARM CONTROL PANEL SHALL ALLOW FOR LOADING OR EDITING SPECIAL INSTRUCTIONS AND OPERATING SEQUENCES AS REQUIRED. THE SYSTEM SHALL BE CAPABLE OF ON SITE PROGRAMMING TO ACCOMMODATE AND FACILITATE EXPANSION, BUILDING PARAMETER CHANGES OR CHANGES AS REQUIRED BY LOCAL CODES. ALL SOFTWARE OPERATIONS SHALL BE STORED IN A NON-VOLATILE PROGRAMMABLE MEMORY WITHIN THE FIRE ALARM CONTROL PANEL. LOSS OF PRIMARY AND SECONDARY POWER SHALL NOT ERASE THE INSTRUCTIONS STORED IN MEMORY. SYSTEMS THAT REQUIRE FACTORY REPROGRAMMING TO ADD OR DELETE ADDRESSABLE DEVICES ARE UNACCEPTABLE.
- (H) THE FIRE ALARM CONTROL PANEL SHALL INCLUDE A MULTI-LEVEL PASSWORD PROTECTION CAPABILITY WHICH CAN BE APPLIED TO VARIOUS SYSTEM FUNCTIONS SUCH AS; ALARM SILENCE, ALARM RESET, MANUAL CONTROL, DISABLE/ENABLE AND WALK TEST. ACCESS TO A LEVEL WILL ONLY ALLOW THE OPERATOR TO PERFORM ALL ACTIONS WITHIN THAT LEVEL PLUS ALL ACTIONS OF LOWER LEVELS, NOT HIGHER LEVELS. THE ACCESS LEVEL SHALL BE IN EFFECT UNTIL THE OPERATOR MANUALLY LOGS OUT OR THE KEYPAD HAS BEEN INACTIVE FOR 10 MINUTES AT WHICH TIME THE ACCESS LEVEL RETURNS TO ITS LOWEST LEVEL.
- (I) THE "CONTROL" MODULE FOR THE FIRE ALARM SYSTEM SHALL INCLUDE ANNUNCIATOR SUPERVISION CIRCUITRY, EARTH GROUND DETECTION, LOW OR NO BATTERY VOLTAGE TROUBLE MONITORING AND REPORTING AND ADJUSTABLE ALARM SILENCE INHIBIT CAPABILITY AS WELL AS THE RESET, ALARM SILENCE, TROUBLE SILENCE SWITCHES AND AUDIBLE AND VISUAL TROUBLE INDICATORS. THE CONTROL PANEL SHALL ELECTRICALLY SUPERVISE FACILITIES FOR AUTOMATIC FIRE DEPARTMENT NOTIFICATION. RELAYS SHALL BE PROVIDED TO ACCOMPLISH THE VARIOUS CONTROL FUNCTIONS AS SPECIFIED IN THE SYSTEM OPERATION SECTION AND SHALL BE CAPABLE OF BEING BYPASSED FOR TESTING PURPOSE.
- (J) THE COMMUNICATION FORMAT TO THE ADDRESSABLE DEVICES MUST BE A COMPLETELY DIGITAL POLL-RESPONSE PROTOCOL TO ALLOW T-TAPPING OF THE CIRCUIT WIRING. EACH ADDRESSABLE DEVICE MUST BE UNIQUELY IDENTIFIED BY AN ADDRESS CODE ENTERED ON EACH DEVICE AT TIME OF INSTALLATION. THE SYSTEM MUST VERIFY THAT PROPER TYPE DEVICE IS IN PLACE AND MATCHES THE DESIRED SOFTWARE CONFIGURATION.
- (K) STANDBY POWER FOR THE SYSTEM SHALL BE PROVIDED BY LOW MAINTENANCE SEALED LEAD ACID BATTERIES SPECIFICALLY DESIGNED FOR FIRE ALARM USE AND SHALL BE KEPT FULLY CHARGED BY AN AUTOMATIC BATTERY CHARGER. AUTOMOTIVE TYPE CONSTRUCTION WET CELL STORAGE BATTERIES OR OTHER NON-FIRE ALARM TYPE BATTERIES WILL NOT BE ACCEPTABLE.

2.03 ALARM INITIATING DEVICES

- (A) MANUAL STATIONS SHALL BE DUAL-ACTION ADDRESSABLE STATIONS. MANUAL STATIONS SHALL BE CONSTRUCTED OF HIGH IMPACT, RED LEXAN WITH RAISED WHITE LETTERING AND A SMOOTH HIGH GLOSS FINISH. STATIONS SHALL BE KEYPED ALIKE WITH THE FIRE ALARM CONTROL PANEL. WHEN THE STATION IS OPERATED, THE HANDLE SHALL LOCK IN A PROTRUDING MANNER TO FACILITATE QUICK VISUAL IDENTIFICATION OF THE ACTIVATED STATION. ADDRESSABLE STATIONS SHALL CONTAIN ELECTRONICS THAT COMMUNICATE THE DEVICE STATUS TO THE CONTROL PANEL OVER TWO (2) WIRES WHICH ALSO PROVIDE POWER TO THE STATION. THE ADDRESS LOCATION OF THE STATION WILL BE FIELD PROGRAMMED AT THE STATION VIA A DIP SWITCH.
- (B) FURNISH AND INSTALL WHERE INDICATED ON THE PLANS, PHOTOELECTRIC SMOKE SENSOR WITH ADDRESSABLE SENSOR BASE. THE SENSORS SHALL COMMUNICATE THE ACTUAL SMOKE CHAMBER VALUES TO THE SYSTEM CONTROL PANEL. THE SENSORS SHALL BE LISTED TO UL STANDARD 268 FOR BOTH CEILING AND WALL MOUNT APPLICATIONS AND SHALL BE DOCUMENTED COMPATIBLE WITH THE CONTROL EQUIPMENT TO WHICH IT IS CONNECTED. EACH SENSOR BASE SHALL CONTAIN AN LED THAT WILL FLASH EACH TIME IT IS SCANNED BY THE CONTROL PANEL (ONCE EVERY FOUR (4) SECONDS). WHEN THE CONTROL PANEL DETERMINES THAT A SENSOR IS IN AN ALARM OR A TROUBLE CONDITION, THE CONTROL PANEL SHALL COMMAND THE LED ON THAT SENSOR'S BASE TO TURN ON STEADY INDICATING THE ABNORMAL CONDITION. SENSORS WHICH DO NOT PROVIDE A VISIBLE INDICATION OF AN ABNORMAL CONDITION AT THE SENSOR LOCATION SHALL NOT BE ACCEPTABLE. SENSOR BASES, AS SHOWN ON THE PLANS, SHALL BE PROVIDED WITH A RELAY DRIVER OUTPUT THAT IS TO BE CONTROLLED EITHER AUTOMATICALLY OR MANUALLY FROM THE CONTROL PANEL. EACH SENSOR SHALL CONTAIN A MAGNETICALLY ACTUATED TEST SWITCH TO PROVIDE FOR EASY ALARM TESTING AT THE SENSOR LOCATION. EACH SENSOR SHALL BE SCANNED BY THE CONTROL PANEL FOR ITS TYPE IDENTIFICATION TO PREVENT INADVERTENT

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SUBSTITUTION OF ANOTHER SENSOR TYPE. THE CONTROL PANEL SHALL OPERATE WITH THE INSTALLED DEVICE BUT SHALL INITIATE A "WRONG DEVICE" TROUBLE CONDITION UNTIL THE PROPER TYPE IS INSTALLED OR THE PROGRAMMED SENSOR TYPE IS CHANGED. THE SENSOR'S ELECTRONICS SHALL BE IMMUNE FROM FALSE ALARMS CAUSED BY EMI OR RFI.

(C) AUTOMATIC HEAT DETECTORS SHALL BE COMBINATION RATE-OF-RISE AND FIXED-TEMPERATURE TYPE. HEAT DETECTORS SHALL BE ADDRESSABLE DETECTORS. IN HIGH HAZARD AREAS WITH HIGH TEMPERATURE, FURNISH FIXED TEMPERATURE DETECTOR WITH THE APPROPRIATE ZONE ADAPTER MODULE. DETECTORS SHALL BE OF THE REPLACEABLE ELEMENT TYPE AND SHALL VISUALLY INDICATE AN ALARM CONDITION WHEN OPERATED.

(D) DUCT SMOKE DETECTORS SHALL BE PHOTOELECTRIC SMOKE SENSOR OPERATING ON THE LIGHT SCATTERING PHOTODIODE PRINCIPLE. NO RADIOACTIVE MATERIALS SHALL BE USED. DETECTOR CONSTRUCTION SHALL BE OF THE SPLIT TYPE THAT IS, MOUNTING BASE WITH TWIST-LOCK DETECTING SENSOR. CONTACTS BETWEEN THE BASE AND SENSOR SHALL BE OF THE BIFURCATED TYPE USING SPRING-TYPE, SELF-WIPING CONTACTS. THE SENSOR BASE SHALL CONTAIN AN LED THAT WILL FLASH EACH TIME IT IS SCANNED BY THE CONTROL PANEL (ONCE EVERY FOUR (4) SECONDS). WHEN THE CONTROL PANEL DETERMINES THAT A SENSOR IS IN AN ALARM OR A TROUBLE CONDITION, THE CONTROL PANEL SHALL COMMAND THE LED ON THAT SENSOR'S BASE TO TURN ON STEADY INDICATING THE ABNORMAL CONDITION. REMOVAL OF THE SENSOR SHALL CAUSE A TROUBLE SIGNAL AT THE CONTROL PANEL. DUCT HOUSING COUPLINGS SHALL BE SLOTTED TO INSURE PROPER ALIGNMENT OF THE SAMPLING AND EXHAUST TUBES. DETECTOR SHALL HAVE AN ALARM LED VISIBLE THROUGH THE FRONT COVER. INSTALLATION MUST COMPLY WITH NFPA-90A.

1. REMOTE ALARM LED INDICATORS SHALL BE PROVIDED FOR EACH DUCT SMOKE DETECTOR. INDICATORS SHALL BE MOUNTED IN AN EASILY ACCESSIBLE LOCATION SUCH AS NEAR THE DOORS OF MECHANICAL ROOMS OR FLUSH-MOUNTED IN THE CEILING LOCATED DIRECTLY BELOW THE UNIT WHEN THE DETECTOR IS ABOVE THE CEILING. EACH INDICATOR SHALL IDENTIFY THE UNIT IT SERVES AND ALSO INDICATE SUPPLY OR RETURN.

(E) RESIDENT SMOKE DETECTORS: SMOKE DETECTORS IN THE RESIDENT ROOMS SHALL BE A GENTEX PHOTOELECTRIC 9120 SERIES. SMOKE DETECTORS SHALL OPERATE ON 120 VAC AND BE PROVIDED WITH 9 VDC BATTERY BACKUP TO OPERATE THE DETECTOR IN THE CASE OF LOSS OF MAIN OPERATING POWER. SMOKE DETECTORS SHALL HAVE THE FOLLOWING FEATURES AND FUNCTIONS:

1. SUPERVISE BACKUP BATTERY AND PROVIDE INDICATION OF LOW BATTERY POWER OR MISSING BATTERY.
2. PROVIDE A SOLID STATE PIEZO ALARM RATED AT 90DB AT 10-FEET.
3. PROVIDE A VISUAL LED MONITOR THAT PULSES SLOW IN NORMAL OPERATION AND FAST IN ALARM CONDITION.
4. DETECTORS SHALL HAVE FORM A AND FORM C CONTACTS.
5. DETECTORS SHALL HAVE TANDEM INTERCONNECT CAPABILITY.
6. DETECTORS SHALL BE SELF-RESTORING WHEN CONDITIONS CAUSING THE ALARM CLEAR.

2.04 ALARM SIGNALING DEVICES

(A) ALARM HORNS SHALL BE SEMI-FLUSH. THE HORNS SHALL BE POLARIZED AND SHALL BE OPERATED BY 24 VDC. EACH HORN ASSEMBLY SHALL INCLUDE SEPARATE TERMINALS FOR IN/OUT WIRING FOR EACH LEG OF THE ASSOCIATED SIGNAL CIRCUIT. T-TAPPING OF SIGNAL DEVICE CONDUCTORS TO SIGNAL CIRCUIT CONDUCTORS SHALL NOT BE ACCEPTED.

1. ALARM ANNUNCIATION DB LEVELS SHALL MEET THE AMERICANS WITH DISABILITIES ACT (ADA), UL, NFPA AND LOCAL CODES.

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- (B) ALARM SPEAKERS SHALL BE SQUARE. COMBINATION ALARM SPEAKERS/VISUAL DEVICES SHALL BE ROUND. ALARM SPEAKERS SHALL PRODUCE A TEMPORAL PATTERN. COMBINATION SPEAKER/VISUAL DEVICES IN RESIDENT UNIT AREAS SHALL BE WHITE OR BEIGE.
1. ALARM ANNUNCIATION DB LEVELS SHALL MEET THE AMERICANS WITH DISABILITIES ACT (ADA), UL, NFPA AND LOCAL CODES.
- (C) VISIBLE ALARM INDICATING DEVICES SHALL BE ENTIRELY SOLID STATE AND COMPRISED OF XENON FLASHTUBE. VISUAL ALARM UNITS SHALL MEET THE PHOTOMETRIC REQUIREMENTS OF THE AMERICANS WITH DISABILITIES (ADA), UL, NFPA AND LOCAL CODES. THE UNIT SHALL BE COMPLETE WITH A TAMPER-RESISTANT LEXAN LENS AND THE WORD "FIRE" IN RED LETTERS.
1. THE DRAWINGS INDICATE AREAS REQUIRING VISUAL DEVICES. THE INTENSITY LEVEL OF EACH DEVICE, EXACT QUANTITY AND LOCATION PER AREA SHALL BE DETERMINED BY MANUFACTURER AND DEVICES PROVIDED ACCORDINGLY.

2.05 REMOTE ANNUNCIATOR

- (A) PROVIDE A SIEMENS FLUSH-MOUNTED REMOTE ANNUNCIATOR AT EACH LOCATION SHOWN ON THE DRAWINGS.
- (B) ANNUNCIATOR(S) SHALL HAVE 80 CHARACTER LCD DISPLAY (TWO (2) LINES, EACH LINE 40 CHARACTERS) WITH CONTROL SWITCHES FOR SYSTEM ACKNOWLEDGEMENTS, ALARM SILENCE AND SYSTEM RESET. THERE SHALL BE LAMP/LCD TEST AND FOUR (4) PROGRAMMABLE CONTROL SWITCHES WITH WINDOWS FOR "SLIP-IN" LABELS. MOUNTING SCREWS SHALL BE TAMPERPROOF.
- (C) A KEY SWITCH ACTIVATED "ENABLE" FEATURE SHALL BE PROVIDED. ALL SWITCHES ON THE ANNUNCIATOR SHALL BE INOPERABLE WITHOUT THE "ENABLE" SWITCH ACTIVATED. THE KEY SHALL BE REMOVABLE IN THE DISABLED POSITION ONLY.
- (D) THE DISPLAY SHALL PROVIDE CLEAR ENGLISH LANGUAGE INFORMATION TO INCLUDE POINT STATUS, TYPE OF ALARM (SMOKE DETECTOR, MANUAL STATION, ETC.), NUMBER OF ALARMS, SUPERVISORY CONDITIONS, TROUBLES IN THE SYSTEM AND A CUSTOM LOCATION LABEL.

2.06 AREA INDICATION PLAQUE

- (A) PROVIDE AN AREA INDICATION PLAQUE WALL MOUNTED ADJACENT TO EACH REMOTE ANNUNCIATOR AND ALSO AT THE FIRE ALARM CONTROL PANEL. THE DISPLAY SHALL BE A SCALED REPRESENTATION OF THE FACILITY WITH EACH AREA/ROOM IN THE FACILITY SHOWN ON THE PLAQUE AND LABELED ACCORDINGLY. COORDINATE SIZE AND NOMENCLATURE OF AREAS WITH OWNER AND PROGRAM CONTROL PANEL AND ANNUNCIATOR DISPLAYS TO CORRESPOND WITH NOMENCLATURE OF PLAQUE. THE PLAQUE SHALL BE APPROXIMATELY 18-INCH SQUARE (EXACT QUANTITY AND SIZE OF PLAQUE(S) SHALL BE DETERMINED BY SIZE OF PROJECT) WITH STAINLESS STEEL OR ANODIZED ALUMINUM FRAME AND PLEXIGLASS COVER OVER DISPLAY. THE PLAQUE ITSELF SHALL BE REVERSE-ENGRAVED SILK-SCREENED PLASTIC SHEET OF 3/16-INCH MINIMUM THICKNESS OR CADD GENERATED ON MYLAR.

2.07 MISCELLANEOUS DEVICES

- (A) DOOR HOLDERS SHALL BE PROVIDED AS WORK OF THIS SECTION. ELECTRICAL CONNECTIONS TO DOOR HOLDERS SHALL BE PROVIDED AS WORK OF THIS SECTION.
- (B) PROVIDE CONNECTION TO SMOKE AND COMBINATION FIRE/SMOKE DAMPERS.
- (C) FAN SHUTDOWN RELAYS SHALL BE PROVIDED AS REQUIRED AND SHALL BE COMPATIBLE WITH THE UNIT BEING CONTROLLED.
- (D) PROVIDE CONNECTION TO SPRINKLER SYSTEM FLOW AND TAMPER SWITCHES.

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- (E) ZONE ADAPTER MODULES SHALL BE USED FOR MONITORING OF WATERFLOW, VALVE TAMPER, NON-ADDRESSABLE DETECTORS AND DEVICES AND FOR CONTROL OF EVACUATION INDICATING APPLIANCES AND AHU SYSTEMS. ZAMS WILL BE CAPABLE OF MOUNTING IN A STANDARD ELECTRIC OUTLET BOX. ZAMS WILL INCLUDE COVER PLATES TO ALLOW SURFACE- OR FLUSH-MOUNTING. ZAMS WILL RECEIVE THEIR 24VDC POWER FROM A SEPARATE TWO (2) WIRE PAIR RUNNING FROM AN APPROPRIATE POWER SUPPLY. THE ZAM SHALL BE CAPABLE OF BEING PROGRAMMED FOR ITS "ADDRESS" LOCATION ON THE ADDRESSABLE DEVICE INITIATING CIRCUIT. THE ZAM SHALL BE COMPATIBLE WITH ADDRESSABLE MANUAL STATIONS AND ADDRESSABLE DETECTORS, ETC. ON THE SAME ADDRESSABLE INITIATING CIRCUIT.

2.08 WIRE

- (A) ALL WIRE AND WIRING SHALL BE IN STRICT COMPLIANCE WITH ALL OF THE PROVISIONS OF THE NATIONAL ELECTRICAL CODE, ARTICLE 760, THE MANUFACTURER'S RECOMMENDATIONS AND REQUIREMENTS:

PART 3 - EXECUTION

3.01 INSTALLATION

- (A) THE ENTIRE SYSTEM SHALL BE INSTALLED IN A WORKMANLIKE MANNER IN ACCORDANCE WITH APPROVED MANUFACTURER'S WIRING DIAGRAMS. THE CONTRACTOR SHALL FURNISH ALL CONDUIT, WIRING, OUTLET BOXES, JUNCTION BOXES, CABINETS AND SIMILAR DEVICES NECESSARY FOR A COMPLETE INSTALLATION. ALL WIRING SHALL BE OF THE TYPE RECOMMENDED BY THE MANUFACTURER AND APPROVED BY THE LOCAL AUTHORITY HAVING JURISDICTION AND SHALL BE INSTALLED IN RED CONDUIT THROUGHOUT. ALL JUNCTION BOXES SHALL BE SPRAYED RED AND LABELED "FIRE ALARM". WIRING COLOR CODE SHALL BE MAINTAINED THROUGHOUT THE INSTALLATION.
- (B) INSTALLATION OF EQUIPMENT AND DEVICES THAT PERTAIN TO OTHER WORK IN THE CONTRACT SHALL BE CLOSELY COORDINATED WITH THE APPROPRIATE SUBCONTRACTORS.
- (C) COVER ALL SMOKE DETECTION DEVICES WITH PLASTIC BAGS IMMEDIATELY AFTER INSTALLATION TO MAINTAIN CLEANLINESS, IF FIELD CONDITIONS SO REQUIRE.
- (D) THE CONTRACTOR SHALL CLEAN ALL DIRT AND DEBRIS FROM THE INSIDE AND THE OUTSIDE OF THE FIRE ALARM EQUIPMENT AFTER COMPLETION OF THE INSTALLATION.

3.02 FINAL CONNECTIONS, TESTING, INSPECTION AND ACCEPTANCE

- (A) THE CONTRACTOR SHALL, UNDER THIS CONTRACT, OBTAIN THE SERVICES OF A FACTORY TRAINED REPRESENTATIVE OF THE SYSTEM MANUFACTURER TO SUPERVISE THE INSTALLATION AND ITS PROGRESS, SUPERVISE FINAL CONNECTIONS TO THE EQUIPMENT AND PROVIDE TESTING TO ASSURE THAT THE SYSTEM IS IN PROPER OPERATING CONDITION AND IS IN COMPLIANCE WITH ALL APPLICABLE REGULATIONS. A COMPLETE FUNCTIONAL TEST OF THE SYSTEM IN ACCORDANCE WITH NFPA 72H SHALL BE PERFORMED AND A WRITTEN REPORT SHALL BE SUBMITTED TO THE CONTRACTOR ATTESTING TO THE PROPER OPERATION OF THE COMPLETED SYSTEM. THE CONTRACTOR SHALL HAVE PRESENT REPRESENTATIVES OF THE MANUFACTURER OF THE FIRE ALARM SYSTEM, AUTHORITIES HAVING JURISDICTION AND THE ARCHITECT DURING FINAL INSPECTION. THE CONTRACTOR SHALL DEMONSTRATE TO THE SATISFACTION OF ALL PARTIES THAT THE SYSTEM INSTALLED MEETS THE SPECIFICATION REQUIREMENTS. ALL CHANGES, MODIFICATIONS AND ADJUSTMENTS TO THE INSTALLED SYSTEM NEEDED TO MEET THE SPECIFICATION REQUIREMENTS WILL BE MADE AT NO ADDITIONAL COST TO THE OWNER.
- (B) UPON COMPLETION OF THE INSTALLATION, PRINTED SYSTEM OPERATING INSTRUCTIONS AND AS-BUILT WIRING AND LAYOUT DRAWINGS WILL BE FURNISHED TO THE OWNER.
- (C) THE MANUFACTURER WILL PROVIDE AN AUTHORIZED REPRESENTATIVE TO INSTRUCT AND TRAIN THE FIRE DEPARTMENT AND THE OWNER'S PERSONNEL IN THE OPERATION OF THE SYSTEM. THIS SERVICE WILL BE MADE AVAILABLE FOR TWO (2) ONE (1) HOUR SESSIONS AS SCHEDULED BY THE OWNER.

3.03 GUARANTEE AND AFTER SERVICE

- (A) THE CONTRACTOR SHALL WARRANT THE COMPLETED FIRE ALARM SYSTEM WIRING AND EQUIPMENT TO BE FREE FROM INHERENT MECHANICAL AND ELECTRICAL DEFECTS FOR A PERIOD OF ONE (1) YEAR FROM THE DATE OF THE COMPLETED AND CERTIFIED TEST OR FROM THE DATE OF FIRST BENEFICIAL USE.
- (B) UPON SATISFACTORY COMPLETION OF ALL TESTS, THE MANUFACTURER'S REPRESENTATIVE WILL PRESENT TO THE OWNER A PROPOSAL TO PROVIDE INSPECTIONS AND TESTING OF THE SYSTEM IN COMPLIANCE WITH THE REQUIREMENTS OF THE STATE AND LOCAL FIRE CODES.
- (C) THE SYSTEM'S VENDOR MUST EMPLOY FACTORY TRAINED TECHNICIANS AND MAINTAIN A SERVICE ORGANIZATION WITHIN 50 MILES OF THE JOB SITE. THIS ORGANIZATION MUST HAVE A MINIMUM OF 10 YEARS EXPERIENCE SERVICING FIRE ALARM SYSTEMS AND PROVIDE 24 HOUR EMERGENCY SERVICE.
- (D) THE VENDOR SHALL PROVIDE A MAXIMUM OF FOUR (4) HOUR RESPONSE TO THE OWNER'S REQUEST FOR SERVICE. THE VENDOR WILL DEMONSTRATE THIS CAPABILITY TO THE OWNER AND WILL PROVIDE THIS MINIMUM RESPONSE UNDER ALL REASONABLE CIRCUMSTANCES.

END OF SECTION 28 31 12 – FIRE ALARM SYSTEM

SECTION 32 31 23 - VINYL FENCING AND GATES

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PART 1 GENERAL

2.1 SECTION INCLUDES

- (A) PRIVACY FENCE
- (B) GATES
- (C) GATE HARDWARE

2.2 RELATED SECTIONS

- (A) SECTION 03 30 00 - CAST-IN-PLACE CONCRETE.

2.3 REFERENCES

- (A) ASTM D 1784 - STANDARD SPECIFICATION FOR RIGID POLY(VINYL CHLORIDE) (PVC) COMPOUNDS AND CHLORINATED POLY (VINYL CHLORIDE) (CPVC) COMPOUNDS.

2.4 SUBMITTALS

- (A) SUBMIT UNDER PROVISIONS OF SECTION 01 00 00 – GENERAL REQUIREMENTS.
- (B) PRODUCT DATA: MANUFACTURER'S DATA SHEETS ON EACH PRODUCT TO BE USED, INCLUDING:
 - 1. PREPARATION INSTRUCTIONS AND RECOMMENDATIONS.
 - 2. STORAGE AND HANDLING REQUIREMENTS AND RECOMMENDATIONS.
 - 3. INSTALLATION METHODS.
- (C) SHOP DRAWINGS: SUBMIT SHOP DRAWINGS FOR EACH PRODUCT AND ACCESSORY REQUIRED. INCLUDE INFORMATION NOT FULLY DETAILED IN MANUFACTURER'S STANDARD PRODUCT DATA.
- (D) SELECTION SAMPLES: FOR EACH FINISH PRODUCT SPECIFIED, TWO COMPLETE SETS OF COLOR CHIPS REPRESENTING MANUFACTURER'S FULL RANGE OF AVAILABLE COLORS AND PATTERNS.
- (E) VERIFICATION SAMPLES: FOR EACH FINISH PRODUCT SPECIFIED, TWO SAMPLES, MINIMUM SIZE 3 INCHES (76 MM) SQUARE, REPRESENTING ACTUAL PRODUCT, COLOR, AND PATTERNS.
- (F) MANUFACTURER'S CERTIFICATES: CERTIFY PRODUCTS MEET OR EXCEED SPECIFIED REQUIREMENTS.
- (G) CLOSEOUT SUBMITTALS: PROVIDE MANUFACTURER'S MAINTENANCE INSTRUCTIONS THAT INCLUDE RECOMMENDATIONS FOR PERIODIC CLEANING AND MAINTENANCE OF ALL COMPONENTS.

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VINYL FENCING AND GATES

2.5 QUALITY ASSURANCE

- (A) MANUFACTURER QUALIFICATIONS: A FIRM ENGAGED IN THE MANUFACTURE OF VINYL FENCE AND GATES OF TYPES AND SIZES SPECIFIED, AND WHOSE PRODUCTS HAVE BEEN IN SATISFACTORY USE IN SIMILAR SERVICE FOR A MINIMUM OF FIVE YEARS.
- (B) INSTALLER QUALIFICATIONS: A FIRM WITH A MINIMUM OF TWO YEARS OF SUCCESSFUL INSTALLATION EXPERIENCE WITH PROJECTS UTILIZING VINYL FENCE AND GATES SIMILAR IN TYPE AND SCOPE TO THAT REQUIRED FOR THIS PROJECT.
- (C) MOCK-UP: PROVIDE A MOCK-UP FOR EVALUATION OF SURFACE PREPARATION TECHNIQUES AND APPLICATION WORKMANSHIP.
 - 1. FINISH AREAS DESIGNATED BY ARCHITECT.
 - 2. DO NOT PROCEED WITH REMAINING WORK UNTIL WORKMANSHIP, COLOR, AND SHEEN ARE APPROVED BY ARCHITECT.
 - 3. REFINISH MOCK-UP AREA AS REQUIRED TO PRODUCE ACCEPTABLE WORK.
 - 4. ACCEPTED MOCK-UPS SHALL BE COMPARISON STANDARD FOR REMAINING WORK
- (D) PRE-INSTALLATION CONFERENCE: CONDUCT PRE-INSTALLATION CONFERENCE IN ACCORDANCE WITH SECTION 01 00 00 – GENERAL REQUIREMENTS. DATE AND TIME OF THE PRE-INSTALLATION CONFERENCE SHALL BE ACCEPTABLE TO THE OWNER AND THE ARCHITECT.
 - 1. PRIOR TO COMMENCING THE INSTALLATION, MEET AT THE PROJECT SITE TO REVIEW THE MATERIAL SELECTIONS, INSTALLATION PROCEDURES, AND COORDINATION WITH OTHER TRADES.
 - 2. MOCK-UPS SHALL BE REVIEWED DURING THE PRE-INSTALLATION CONFERENCE.
 - 3. PRE-INSTALLATION CONFERENCE SHALL INCLUDE THE CONTRACTOR, THE INSTALLER, AND ANY TRADE THAT REQUIRES COORDINATION WITH THE WORK.

2.6 DELIVERY, STORAGE, AND HANDLING

- (A) DELIVER MATERIALS TO THE PROJECT SITE IN MANUFACTURER'S ORIGINAL WRAPPINGS AND CONTAINERS, LABELED WITH SUPPLIER'S OR MANUFACTURER'S NAME, MATERIAL OR PRODUCT BRAND NAME, AND LOT NUMBER, IF ANY.
- (B) STORE MATERIALS IN THEIR ORIGINAL, UNDAMAGED PACKAGES AND CONTAINERS, INSIDE A WELL-VENTILATED AREA PROTECTED FROM WEATHER, MOISTURE, SOILING, EXTREME TEMPERATURES, AND HUMIDITY.

2.7 SEQUENCING

- (A) ENSURE THAT LOCATING TEMPLATES AND OTHER INFORMATION REQUIRED FOR INSTALLATION OF PRODUCTS OF THIS SECTION ARE FURNISHED TO AFFECTED TRADES IN TIME TO PREVENT INTERRUPTION OF CONSTRUCTION PROGRESS.
- (B) ENSURE THAT PRODUCTS OF THIS SECTION ARE SUPPLIED TO AFFECTED TRADES IN TIME TO PREVENT INTERRUPTION OF CONSTRUCTION PROGRESS.

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2.8 PROJECT CONDITIONS

- (A) MAINTAIN ENVIRONMENTAL CONDITIONS (TEMPERATURE, HUMIDITY, AND VENTILATION) WITHIN LIMITS RECOMMENDED BY MANUFACTURER FOR OPTIMUM RESULTS. DO NOT INSTALL PRODUCTS UNDER ENVIRONMENTAL CONDITIONS OUTSIDE MANUFACTURER'S ABSOLUTE LIMITS.

2.9 WARRANTY

- (A) LIFETIME LIMITED, NON-PRORATED WARRANTY ON MATERIAL AND 5 YEAR PRORATED LABOR WARRANTY.

PART 2 PRODUCTS

3.1 MANUFACTURERS

- (A) SUPERIOR PLASTIC PRODUCTS, INC., WHICH IS LOCATED AT: 260 JALYN DR.; NEW HOLLAND, PA 17557; TOLL FREE TEL: 800-633-7093; FAX: 717-355-7129; EMAIL: [REQUEST INFO \(TGIFFORD@SUPERIORPLASTIC.NET\)](mailto:REQUEST INFO (TGIFFORD@SUPERIORPLASTIC.NET)); WEB: [HTTPS://SUPERIORPLASTICPRODUCTS.COM](https://superiorplasticproducts.com) | [HTTP://WWW.KEYLINKONLINE.COM](http://www.keylinkonline.com)
- (B) SUBSTITUTIONS: OR APPROVED EQUAL
- (C) SUBSTITUTIONS: SEE SECTION 01 00 00 – GENERAL REQUIREMENTS.

3.2 MATERIALS

- (A) PVC: POLY VINYL CHLORIDE (PVC) FORMULATED TO RESIST IMPACT AND FOR ULTRA VIOLET (UV) STABILIZATION. EXTRUDED PRODUCTS MEETS OR EXCEEDS ASTM D 1784.
 - 1. 2
 - 2. 3
 - 3. 4
- (B) WIDTH: 8 FOOT WIDE SECTIONS
- (C) RAIL SIZE: 2 INCH BY 6 INCH BY 8 FOOT RAILS.
- (D) GATES AND POSTS:
 - 1. MATCHING FENCE STYLE.
- (E) COLORS:
 - 1. WHITE PINE.
 - 2. SEASONED PINE.

3.3 PRIVACY FENCE

- (A) STYLE: MANOR PRIVACY FENCE.

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1. HEIGHT:
 - a. 96 INCH
2. SECTION WIDTH:
 - a. 6 FOOT
3. DECO RAILS: 2 INCH BY 6-1/2
4. MIDRAIL: PROVIDE FOR 64 INCH, 84 INCH AND 72 INCH HIGH FENCE SECTIONS.
5. TONGUE AND GROOVE PANELS: 7/8 INCH BY 6.8 INCH.
6. POSTS: 5 INCH BY 5 INCH.
7. GATES AND POSTS:
 - a. MATCHING FENCE STYLE.
8. COLORS:
 - a. WHITE

3.4 GATE HARDWARE

(A) "SELECT" GATE HARDWARE:

1. LATCH: STAINLESS STEEL WITH ALUMINUM LATCH CLAPPER
2. ALUMINUM HANDLE
3. HINGE SET - SELECT
4. DROP PIN KIT - SELECT
5. 2 WAY LATCH SET
6. FINISH/COLOR: POWDER COATED
 - a. WHITE
 - b. BLACK

(B) GATE HARDWARE: STAINLESS STEEL WITH ALUMINUM LATCH CLAPPERS.

1. ALUMINUM GATE HANDLE.
2. GATE WHEEL.
3. ALUMINUM GATE BRACE.
4. HINGE SET

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5. RESIDENTIAL LATCH: STAINLESS STEEL WITH ALUMINUM LATCH CLAPPER.
 - a. DROP PIN KIT- RESIDENTIAL
6. COMMERCIAL LATCH: STAINLESS STEEL WITH ALUMINUM LATCH CLAPPER.
 - a. DROP PIN KIT - COMMERCIAL
 - b. SPRING SET - COMMERCIAL
7. FINISH/COLOR: POWDER COATED
 - a. BLACK

PART 3 EXECUTION

4.1 EXAMINATION

- (A) DO NOT BEGIN INSTALLATION UNTIL CONDITIONS HAVE BEEN PROPERLY PREPARED.
- (B) VERIFICATION OF CONDITIONS: EXAMINE LOCATIONS WHERE FENCING IS TO BE INSTALLED FOR ANY CONDITIONS DETRIMENTAL TO THE PROPER AND TIMELY COMPLETION OF THE WORK.
- (C) IF PREPARATION IS THE RESPONSIBILITY OF ANOTHER INSTALLER, NOTIFY ARCHITECT OF UNSATISFACTORY PREPARATION BEFORE PROCEEDING.

4.2 PREPARATION

- (A) CLEAN SURFACES THOROUGHLY PRIOR TO INSTALLATION.
- (B) PREPARE THE GRADE AND REMOVE SURFACE IRREGULARITIES, IF ANY, WHICH MAY CAUSE INTERFERENCE WITH THE INSTALLATION OF THE FENCE.
- (C) PREPARE SURFACES USING THE METHODS RECOMMENDED BY THE MANUFACTURER FOR ACHIEVING THE BEST RESULT FOR THE SUBSTRATE UNDER THE PROJECT CONDITIONS.

4.3 INSTALLATION

- (A) INSTALL IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.
- (B) SET POSTS AND GATE POSTS FOR GATE OPENINGS AS INDICATED ON THE DRAWINGS.
- (C) CENTER AND ALIGN POSTS, PLACE CONCRETE AROUND POSTS AND VIBRATE OR TAMP FOR CONSOLIDATION. RECHECK VERTICAL AND TOP ALIGNMENT OF POSTS, AND MAKE NECESSARY CORRECTIONS.
- (D) INSTALL GATES PLUMB, LEVEL, AND SECURE FOR FULL OPENING WITHOUT INTERFERENCE. FOR DOUBLE GATES, INSTALL DROP ROD. ADJUST HARDWARE FOR SMOOTH OPERATION.

4.4 CLEANING

- (A) TOUCH-UP, REPAIR, OR REPLACE DAMAGED PRODUCTS BEFORE SUBSTANTIAL COMPLETION.

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- (B) CLEAN THE WORK ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS. POST HOLE EXCAVATIONS SHALL BE SCATTERED UNIFORMLY AWAY FROM THE POSTS. CLEAN FENCE WITH MILD HOUSEHOLD DETERGENT AND RINSE WELL WITH CLEAN WATER. REMOVE MORTAR FROM EXPOSED POSTS USING A 10 PERCENT SOLUTION OF MURIATIC ACID FOLLOWED IMMEDIATELY BY SEVERAL RINSES WITH CLEAN WATER.

4.5 PROTECTION

- (A) PROTECT INSTALLED PRODUCTS UNTIL COMPLETION OF PROJECT.
- (B) TOUCH-UP, REPAIR OR REPLACE DAMAGED PRODUCTS BEFORE SUBSTANTIAL COMPLETION.

END OF SECTION 32 31 23

APPENDICES

DIVISION 2 – SITE WORK

SECTIONS 02100 - SITE PREPARATION
SECTION 02110 - GEOTEXTILES
SECTION 02112 - REMOVAL OF EXISTING PAVEMENT
SECTIONS 02200 – EARTHWORK
SECTION 02221 - TRENCH EXCAVATION AND BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES
SECTION 02225 - FLOWABLE FILL
SECTION 02234 - SUB BASE COURSE
SECTION 02235 - CRUSHED BASE COURSE
SECTIONS 02500 – PAVING AND SURFACING
SECTION 02502 - ASPHALT PRIME AND/OR TACK COAT
SECTION 02510 - ASPHALT CONCRETE PAVEMENT
SECTION 02515 PORTLAND CEMENT CONCRETE PAVEMENT
SECTION 02528 - CONCRETE CURB AND GUTTER
SECTION 02529 - CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND MISCELLANEOUS NEW CONCRETE CONSTRUCTION
SECTION 02581 - PAVEMENT MARKINGS AND MARKERS
SECTIONS 02600 – WATER DISTRIBUTION
SECTION 02660 - WATER DISTRIBUTION SYSTEMS
SECTIONS 02700 – SEWERAGE AND DRAINAGE
SECTION 02720 - STORM DRAIN SYSTEMS
SECTION 02730 - SANITARY SEWER COLLECTION SYSTEM
SECTIONS 02900 – LANDSCAPE
SECTION 02910 – SEEDING

DIVISION 3 – CONCRETE

SECTIONS 03200 – CONCRETE REINFORCEMENT
SECTION 03210 - REINFORCING STEEL
SECTION 03310 - STRUCTURAL CONCRETE

DIVISION 32

SECTION 32 93 00 – PLANTS SECTION 32 84 00 – PLANTING IRRIGATION

APPENICES

APPENDIX B

ALL REFERENCES TO MEASUREMENT OR PAYMENT SHALL BE DISREGARDED. THE PROJECT IS TO BE BID AS A LUMP SUM AND NO SEPARATE MEASUREMENT OR PAYMENT WILL BE MADE ON A UNIT COST BASIS.

PLEASE NOTIFY

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IF ANY PAGES ARE MISSING.

SECTION 02110 - GEOTEXTILES

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK CONSISTS OF FURNISHING, AND PLACING A GEOTEXTILE AS A SUBSURFACE DRAINAGE FABRIC PERMEABLE SEPARATOR BETWEEN DISSIMILAR MATERIALS (SUCH AS BETWEEN SUBGRADE AND SUB BASE/BASE), STABILIZATION FABRIC, TEMPORARY AND/OR PERMANENT EROSION CONTROL MEASURES OR AS WATERPROOFING/STRESS RELEASING MEMBRANE WITHIN PAVEMENT STRUCTURES.

1.2 REFERENCES

- A. THE CURRENT PUBLICATIONS LISTED BELOW FORM PART OF THIS SPECIFICATION.
- B. ASTM STANDARDS
- | | |
|---------------|--|
| D123 | STANDARD TERMINOLOGY RELATING TO TEXTILES |
| D276 | TEST METHODS FOR IDENTIFICATION OF FIBERS IN TEXTILES |
| D4354 | PRACTICE FOR SAMPLING OF GEOSYNTHETICS FOR TESTING |
| D4632 | BREAKING; LOAD AND ELONGATION OF GEOTEXTILES (GRAB |
| METHOD) D4533 | TRAPEZOID TEARING, STRENGTH OF GEOTEXTILES |
| D3786 | HYDRAULIC BURSTING, STRENGTH OF KNITTED GOODS AND NONWOVEN FABRICS DIAPHRAGM BURSTING STRENGTH TESTER METHODS |
| D4833 | INDEX PUNCTURE RESISTANCE OF GEOTEXTILES, GEOMEMBRANES, AND RELATED PRODUCTS |
| D4491 | WATER PERMEABILITY OF GEOTEXTILES BY PERMITTIVITY D4751 DETERMINING, APPARENT OPENING, SIZE OF A GEOTEXTILE |
| D4354 | SAMPLING, OF GEOTEXTILES FOR TESTING |
| D4759 | DETERMINING, THE SPECIFICATION CONFORMANCE OF GEOSYNTHETICS D276 IDENTIFICATION OF FIBERS IN TEXTILES |
| D4355 | DETERIORATION OF GEOTEXTILES FROM EXPOSURE TO ULTRAVIOLET LIGHT & WATER (XENON-ARC TYPE APPARATUS) |
| D4873 | GUIDE FOR IDENTIFICATION, STORAGE AND HANDLING OF GEOTEXTILES |
| D5141 | TEST METHOD FOR DETERMINING FILTER EFFICIENCY AND FLOW RATE FOR SILT FENCE APPLICATION OF A GEOTEXTILE USING SITE SPECIFIC SOILS |
| D5261 | TEST METHODS FOR MEASURING MASS PER UNIT AREA OF GEOTEXTILES |
| D422 & D1140 | PARTICLE SIZE ANALYSIS OF SOILS |
| D4318 | DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS |
| D698 | THE MOISTURE-DENSITY RELATIONS OF SOILS USING A 2.5-KG (5.5-LB) RAMMER AND A 305-MM (12-IN.) DROP |
- C. ASSHTO SPECIFICATIONS – M288 GEOTEXTILE SPECIFICATIONS FOR HIGHWAY APPLICATIONS
1. AUGMENTING AND PREVAILING OVER THIS SPECIFICATION SECTION.

PART 2: PRODUCTS

2.1 PHYSICAL AND CHEMICAL REQUIREMENTS

- A. ASSURE THAT FIBERS USED IN THE MANUFACTURE OF GEOTEXTILES, AND THE THREADS USED IN JOINING GEOTEXTILES BY SEWING, CONSIST OF LONG-CHAIN SYNTHETIC POLYMERS, COMPOSED OF AT LEAST 95% BY WEIGHT POLYOLEFINS OR POLYESTERS. THEY MUST BE FORMED INTO A NETWORK SO THE FILAMENTS ON YARNS RETAIN DIMENSIONAL STABILITY RELATIVE TO EACH OTHER, INCLUDING SELVEDGES. FURNISH MATERIALS MEETING THE PHYSICAL REQUIREMENTS FOR THE INDICATED APPLICATION AS DESCRIBED BY THE CORRESPONDING TABLE(S) OF PROPERTIES IN ASSHTO M288, GEOTEXTILE SPECIFICATIONS FOR HIGHWAY APPLICATIONS.

2.2 CERTIFICATION

- A. ASSURE THE MANUFACTURER FURNISHES THE PURCHASER A CERTIFICATE STATING: THE NAME OF THE MANUFACTURER, THE CHEMICAL COMPOSITION OF THE FILAMENTS OR YARNS, AND OTHER INFORMATION FULLY DESCRIBING THE GEOTEXTILE. THE MANUFACTURER MUST INCLUDE IN THE CERTIFICATE, A GUARANTEE STATING THAT THE GEOTEXTILE FURNISHED MEETS SPECIFICATIONS. THE CERTIFICATE MUST BE ATTESTED TO BY A PERSON HAVING A LEGAL AUTHORITY TO BIND THE COMPANY. MISMARKING, OR MISREPRESENTATION BY THE MANUFACTURER IS REASON TO REJECT THE GEOTEXTILE UNDER THESE SPECIFICATIONS. NOTICE SENT TO THE MANUFACTURER BY THE PURCHASER REGARDING REJECTION OF, WILL BE CONSIDERED TO BE NOTICE TO ALL WHOLESALERS, JOBBERS, DISTRIBUTORS, AGENTS AND OTHER INTERMEDIARIES HANDLING THE MANUFACTURER'S PRODUCT.
- B. LABEL THE FABRIC AND ITS CONTAINER WITH THE MANUFACTURER'S NAME AND FABRIC TYPE OR TRADE NAME, LOT NUMBER AND QUANTITY.

2.3 SHIPMENT AND STORAGE

- A. DURING SHIPMENT AND STORAGE, PROTECT THE FABRIC FROM DIRECT SUNLIGHT, ULTRA-VIOLET RAYS, TEMPERATURES EXCEEDING 160⁰F (71⁰C), MUD, DUST AND DEBRIS. KEEP THE FABRICS IN THE MANUFACTURER'S WRAPPING UNTIL JUST BEFORE USE. INCLUDE WITH EACH SHIPPING, A DOCUMENT, A CERTIFICATION SHOWING THAT THE GEOTEXTILE MEETS THE MANUFACTURER'S CERTIFICATE AND A GUARANTEE THAT HAS BEEN PREVIOUSLY FILED WITH THE PURCHASER.

PART 3: EXECUTION

3.1 GENERAL

- A. WHERE PLACING GEOTEXTILES ON NATIVE GROUND, CUT THE TREES AND SHRUBS FLUSH WITH THE GROUND SURFACE. DO NOT REMOVE THE TOPSOIL AND VEGETATION MAT. REMOVE ALL SHARP OBJECTS AND LARGE ROCKS. FILL DEPRESSIONS OR HOLES WITH A SUITABLE MATERIAL TO PROVIDE A FIRM FOUNDATION.
- B. REPLACE OR REPAIR ALL GEOTEXTILE THAT IS TORN, PUNCTURED, OR MUDDY. REMOVE THE DAMAGED AREA AND PLACE A PATCH OF THE SAME TYPE OF GEOTEXTILE OVERLAPPING 3 FEET, IN ALL DIRECTIONS, (0.9M) BEYOND THE DAMAGED AREA.

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3.2 DRAINAGE, SEPARATION AND STABILIZATION APPLICATIONS

- A. SHAPE THE SUBGRADE TO A SMOOTH SURFACE AND TO THE CROSS SECTION REQUIRED. SHAPE SLOPES TO GRADUALLY TRANSITION INTO SLOPE ADJUSTMENTS WITHOUT NOTICEABLE BREAKS. AT THE ENDS OF CUTS, THE INTERSECTION OF CUTS, AND EMBANKMENTS, ADJUST SLOPES IN THE HORIZONTAL AND VERTICAL PLANES TO BLEND INTO EACH OTHER OR INTO THE NATURAL GROUND.
- B. REMOVE ALL MATERIAL LARGER THAN 6 INCHES (15 CM) WITHIN THE TOP 6 INCHES (15CM) OF THE ROADBED. REMOVE UNSUITABLE MATERIAL FROM THE ROADBED AND REPLACE WITH SUITABLE MATERIAL. FINISH THE ROADBED AND DITCHES TO THE REQUIRED ELEVATION AND CROSS-SECTION.
- C. PLACE THE GEOTEXTILE SMOOTH AND FREE OF TENSION, STRESS, OR WRINKLES. FOLD AND CUT THE GEOTEXTILE TO CONFORM TO CURVES. OVERLAP IN THE DIRECTION OF CONSTRUCTION. OVERLAP THE GEOTEXTILE A MINIMUM OF 2 FEET (0.6M) AT THE ENDS AND SIDES OF ADJOINING SHEETS OR SEW THE GEOTEXTILE JOINTS ACCORDING TO THE MANUFACTURER'S RECOMMENDATIONS. DO NOT PLACE LONGITUDINAL OVERLAPS BELOW ANTICIPATED WHEEL LOADS. HOLD THE GEOTEXTILE IN PLACE WITH PINS, STAPLES, OR PILES OF COVER MATERIAL.
- D. END DUMP THE COVER MATERIAL ONTO THE GEOTEXTILE FROM THE EDGE OF THE GEOTEXTILE OR FROM PREVIOUSLY PLACED COVER MATERIAL. DO NOT OPERATE EQUIPMENT DIRECTLY ON THE GEOTEXTILE. SPREAD THE END-DUMPED PILE OF COVER MATERIAL MAINTAINING A MINIMUM LIFT THICKNESS OF 10 INCHES (250MM). COMPACT THE COVER MATERIAL WITH RUBBER-TIRED OR NONVIBRATORY SMOOTH DRUM ROLLERS. AVOID SUDDEN STOPS, STARTS, OR TURNS OF THE CONSTRUCTION EQUIPMENT. FILL ALL RUTS FROM CONSTRUCTION EQUIPMENT WITH ADDITIONAL COVER MATERIAL. DO NOT REGRADE RUTS WITH PLACEMENT EQUIPMENT.
- E. PLACE SUBSEQUENT LIFTS OF COVER MATERIAL IN THE SAME MANNER AS THE INITIAL LIFT. VIBRATORY COMPACTORS MAY BE USED FOR COMPACTING SUBSEQUENT LIFTS. IF FOUNDATION FAILURES OCCUR, REPAIR THE DAMAGED AREAS AND REVERT TO THE USE OF NONVIBRATORY COMPACTION EQUIPMENT.

3.3 TEMPORARY AND PERMANENT EROSION CONTROL APPLICATIONS

- A. PLACE AND ANCHOR THE GEOTEXTILE ON THE APPROVED SMOOTH-GRADED SURFACE. FOR SLOPE PROTECTION, PLACE THE LONG DIMENSION OF THE GEOTEXTILE DOWN THE SLOPE. FOR STREAM BANK PROTECTION, PLACE THE LONG DIMENSION OF THE GEOTEXTILE PARALLEL TO THE CENTERLINE OF THE CHANNEL.
- B. OVERLAP THE GEOTEXTILE A MINIMUM OF 12 INCHES (300MM) AT THE ENDS AND SIDES OF ADJOINING SHEETS OR SEW THE GEOTEXTILE JOINTS ACCORDING TO THE MANUFACTURER'S RECOMMENDATIONS. OVERLAP THE UPHILL OR UPSTREAM SHEET OVER THE DOWNHILL OR DOWNSTREAM SHEET. OFFSET END JOINTS OF ADJACENT SHEETS A MINIMUM OF 5 FEET (1.5M). PINS MAY BE USED TO HOLD THE GEOTEXTILE SHEETS IN PLACE. SPACE PINS ALONG THE OVERLAPS AT APPROXIMATELY 3 FOOT (1M) CENTERS.
- C. PLACE AGGREGATE, SLOPE PROTECTION, OR RIPRAP ON THE GEOTEXTILE STARTING AT THE TOE OF THE SLOPE AND PROCEED UPWARD. PLACE RIPRAP ONTO THE GEOTEXTILE FROM A HEIGHT OF LESS THAN 12 INCHES (300 MM). PLACE SLOPE PROTECTION ROCK OR AGGREGATE BACKFILL ONTO THE GEOTEXTILE FROM A HEIGHT LESS THAN 3 FEET (0.9M). IN UNDERWATER APPLICATIONS, PLACE THE GEOTEXTILE AND COVER MATERIAL IN THE SAME

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DAY.

3.4 PAVEMENT APPLICATIONS

- A. USE SS-1 CRACK FILLER MEETING THE APPLICABLE SECTION FOR CRACK FILLER FOR SURFACE PREPARATION OF CRACKS BETWEEN 1/8-INCH AND 1/4-INCH WIDE. FILL CRACKS EXCEEDING 1/4-INCH (6 MM) WIDTH WITH AN ASPHALT EMULSION SLURRY CONSISTING OF 20 PERCENT BY VOLUME OF SS-1, 2 PERCENT BY VOLUME PORTLAND CEMENT AND THE REMAINING PORTION FINE SAND.
- B. USE DISTRIBUTORS FOR SPRAYING A PERFORMANCE GRADED (PG) ASPHALTIC BINDER MEETING THE SPECIFICATIONS FOR THE ASPHALT CEMENT BEING USED IN THE ASPHALT CONCRETE OVERLAY.
- C. PLACE FABRIC USING MANUFACTURER RECOMMENDED EQUIPMENT.
- D. HANDLE AND PLACE ALL FABRIC FOLLOWING THE MANUFACTURER'S RECOMMENDATIONS.
- E. CLEAN PAVEMENT TO RECEIVE FABRIC OF DIRT, WATER AND VEGETATION. CLEAN ALL CRACKS BETWEEN 1/8-INCH (3 MM) AND 1/4-INCH (6 MM) WIDE AND FILL FLUSH TO THE SURFACE WITH SS-1 BITUMINOUS MATERIAL. TOP WITH SAND. REPAIR LARGER CRACKS OR HOLES USING THE ASPHALT EMULSION SLURRY. POUR THE MIXTURE INTO THE CRACKS UNTIL FULL. RE-FILL WITH SLURRY, THE FOLLOWING DAY, ANY CRACKS WHICH ARE NOT COMPLETELY FILLED INITIALLY. WHEN A LEVELING COURSE IS REQUIRED, PLACE IT BEFORE INSTALLING THE FABRIC. AREAS TO BE COVERED WITH A LEVELING COURSE DO NOT REQUIRE SURFACE PREPARATIONS FOR CRACKS UNLESS THE LEVELING COURSES WILL BE LESS THAN 0.3 FOOT (10CM).
- F. UNIFORMLY APPLY THE ASPHALTIC BINDER AT THE RATE DETERMINED BY THE ENGINEER. THE QUANTITY WILL VARY WITH PAVEMENT POROSITY. TAKE CARE TO PLACE SUFFICIENT BINDER TO SATISFY THE FABRIC AND MAKE THE MEMBRANE IMPERVIOUS TO WATER WITHOUT CAUSING A SLIPPAGE PLANE. THE APPLICATIONS RATES ARE TYPICALLY 0.25 TO 0.30 GALLON PER SQUARE YARD. APPLY BINDER USING A DISTRIBUTOR.
- G. HEAT THE ASPHALT BINDER HIGH ENOUGH TO PERMIT A UNIFORM SPRAY PATTERN. ENSURE AIR TEMPERATURE IS AT LEAST 50⁰ F AND RISING BEFORE APPLYING BINDER AND FABRIC.
- H. PLACE THE PAVING GEOTEXTILE ONTO THE ASPHALT SEALANT WITH MINIMAL WRINKLING. SLIT, LAY FLAT AND TACK ALL WRINKLES OR FOLDS HIGHER THAN 1 INCH (25 MM). BROOM AND/OR ROLL THE PAVING GEOTEXTILE TO MAXIMIZE FABRIC CONTACT WITH THE PAVEMENT SURFACE.
- I. AT GEOTEXTILE JOINTS, OVERLAP THE GEOTEXTILE 1 TO 3 INCHES (25 TO 75 MM) TO ENSURE FULL CLOSURE. OVERLAP TRANSVERSE JOINTS IN THE DIRECTION OF PAVING TO PREVENT EDGE PICKUP BY THE PAVER. APPLY ADDITIONAL ASPHALT SEALANT TO PAVING GEOTEXTILE OVERLAPS TO ENSURE PROPER BONDING OF THE DOUBLE FABRIC LAYER.
- J. IF ASPHALT SEALANT BLEEDS THROUGH THE FABRIC, TREAT THE AFFECTED AREAS WITH BLOTTER. MINIMIZE TRAFFIC ON THE GEOTEXTILE. IF CIRCUMSTANCES REQUIRE TRAFFIC ON THE FABRIC, APPLY BLOTTER AND PLACE "SLIPPERY WHEN WET" SIGNS.
- K. BROOM THE EXCESS BLOTTER FROM THE GEOTEXTILE SURFACES BEFORE PLACING THE OVERLAY. REPAIR ALL DAMAGED FABRIC BEFORE PLACING OVERLAY. APPLY A LIGHT TACK

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COAT BEFORE PLACING THE OVERLAY. TO AVOID DAMAGING THE GEOTEXTILE, DO NOT TURN EQUIPMENT ON THE GEOTEXTILE.

- L. PLACE A HOT ASPHALT CONCRETE OVERLAY WITHIN 48 HOURS AFTER PLACING THE PAVING GEOTEXTILE. LIMIT THE LAY-DOWN TEMPERATURE OF THE MIX TO A MAXIMUM OF 325⁰F (163⁰C) EXCEPT WHEN THE PAVING GEOTEXTILE IS COMPOSED OF POLYPROPYLENE FIBERS, LIMIT THE LAY-DOWN TEMPERATURE OF THE MIX TO A MAXIMUM OF 300⁰F (149⁰C).

PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. ALL GEOTEXTILES WILL BE MEASURED BY THE SQUARE YARD (SQUARE METER) ON A PLANE PARALLEL TO THE GROUND SURFACE, EXCLUDING OVERLAPS. THE ACCEPTED QUANTITIES, MEASURED AS PROVIDED ABOVE, WILL BE PAID AT THE CONTRACT PRICE PER UNIT OF MEASUREMENT FOR THE PAY ITEM THAT IS SHOWN IN THE BIDSCHEDULE.
- B. PAYMENT INDICATED TO INCLUDE COMPLETE COMPENSATION FOR ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED FOR THE COMPLETION OF THE WORK.

4.2 PAVING FABRICS

- A. FABRIC IS MEASURED AND PAID PER SQUARE YARD OF ROADWAY SURFACE COVERED, COMPLETE AND IN PLACE. NO ALLOWANCE IS MADE FOR ADDITIONAL FABRIC REQUIRED FOR OVERLAP JOINTS. NO ALLOWANCE IS MADE FOR BLOTTER SAND (IF OCCASIONALLY REQUIRED).
- B. CRACK FILLING IS MEASURED PER JOB AND PAYMENT IS AT CONTRACT LUMP SUM PRICE, COMPLETE IN PLACE.
- C. ASPHALT CEMENT BINDER IS MEASURED AND PAID BY THE TON, CORRECTED TO STANDARD TEMPERATURE, COMPLETE IN PLACE.

END OF SECTION 02110

SECTION 02112 – REMOVAL OF EXISTING PAVEMENT

REMOVAL OF EXISTING PAVEMENT, CONCRETE CURB, SIDEWALK, DRIVEWAY AND/OR STRUCTURES

PART 1: GENERAL

1.1 DESCRIPTION

- A. THE WORK CONSISTS OF REMOVING AND DISPOSING OF EXISTING PAVEMENT, CONCRETE CURB, COMBINED CURB AND GUTTER, SIDEWALK, PRIVATE DRIVEWAYS, AND CROSSWALKS, ALONG WITH ANY STRUCTURES DESIGNATED FOR REMOVAL IN THE CONTRACT DOCUMENTS. DETAILS OF REMOVALS ARE SPECIFIED IN THE CONTRACT DOCUMENTS.

PART 2: PRODUCTS - NOT USED PART 3:

EXECUTION

3.1 GENERAL

- A. DISPOSE OF ALL EXISTING PAVEMENT, CONCRETE CURB, CROSSWALK AND/OR COMBINED CURB AND GUTTER SPECIFIED FOR REMOVAL IN THE CONTRACT DOCUMENTS OR DIRECTED BY THE ENGINEER. EXERCISE CARE IN SUCH REMOVAL TO ASSURE THAT REMAINING NEARBY FACILITIES AND/OR STRUCTURES ARE NOT DISTURBED. RESTORE TO ORIGINAL CONDITION ANY SUCH EXISTING FACILITIES OR STRUCTURES DAMAGED BY CONSTRUCTION ACTIVITIES.
- B. CUT, REMOVE AND DISPOSE OF DESIGNATED EXISTING PAVEMENT TO THE LINES INDICATED ON THE CONTRACT DOCUMENTS, OR DIRECTED BY THE ENGINEER. MAKE STRAIGHT AND APPROXIMATELY VERTICAL CUTS OF EDGES ALONG WHICH NEW PAVEMENT IS TO BE PLACED.
- C. REMOVE AND DISPOSE OF EXISTING PRIVATE CONCRETE DRIVEWAYS AND/OR SIDEWALKS WHICH INTERFERE WITH CONSTRUCTION OF STREET IMPROVEMENTS OR WHICH DO NOT MATCH NEW GRADE AS SHOWN ON THE CONTRACT DOCUMENTS OR AS DIRECTED BY THE ENGINEER. REMOVE SUCH DRIVEWAYS AND/OR SIDEWALKS TO A DISTANCE OF 8 INCHES (20CM) BEHIND CURBS, OR TO GREATER DISTANCE IF REQUIRED TO PROPERLY MATCH THE NEW CURB AND GUTTER GRADE. REMOVE ALONG THE NEAT LINE PRODUCED BY A CONCRETE SAW CUT. MAKE CUTS TO DEPTHS OF AT LEAST 25 PERCENT OF THE CONCRETE THICKNESS AND TAKE CARE IN REMOVING THE CONCRETE ASSURING THE SLAB BREAKS ON THE SAWED NEATLINE.

PART 4: MEASUREMENT AND PAYMENT

4. 1 ASPHALTIC CONCRETE PAVEMENT REMOVAL

- A. REMOVAL AND DISPOSAL OF ASPHALT CONCRETE PAVEMENT IS PART OF SECTION 2230, STREET EXCAVATION, BACKFILL AND COMPACTION. NO SEPARATE PAYMENT WILL BE MADE FOR THIS ITEM.

4. 2 CONCRETE REMOVAL

- A. ALL CONCRETE REQUIRED TO BE REMOVED SHALL BE MEASURED BY THE LINEAL FOOT (METER),

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SQUARE YARD (SQUARE METER) OR CUBIC YARD (CUBIC METER) AS DESCRIBED BY THE CONTRACT DOCUMENTS.

- B. CONCRETE REMOVAL AND DISPOSAL SHALL BE PAID FOR AT THE CONTRACT UNIT PRICE BID, CONSTITUTING FULL COMPENSATION FOR ALL EQUIPMENT, TOOLS AND LABOR, INCLUDING THE PERFORMANCE OF ALL WORK TO PROVIDE INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- C. MEASUREMENT AND PAYMENT FOR CONCRETE REMOVAL AND DISPOSAL WILL BE MADE ONLY IF LISTED AS A SEPARATE PAY ITEM IN THE CONTRACT DOCUMENTS. IF NOT LISTED SEPARATELY IN THE CONTRACT AS A BID ITEM, CONCRETE REMOVAL AND DISPOSAL WILL BE INCLUDED AS PART OF SECTION 2230, STREET EXCAVATION, BACKFILLING AND COMPACTION.
- D. PAYMENT WILL BE MADE UNDER ONE OF THE FOLLOWING IF IDENTIFIED IN THE CONTRACT DOCUMENTS:
 - 1. CONCRETE REMOVAL - PER LINEAL FOOT (METER)
 - 2. CONCRETE REMOVAL - PER SQUARE YARD (SQUARE METER)
 - 3. CONCRETE REMOVAL - PER CUBIC YARD (CUBIC METER)

4. 3 CONCRETE SAW CUT

- A. FOR THOSE PROJECTS WHERE CONCRETE SAW CUTTING IS A SUBSTANTIAL ITEM OF WORK, THIS ITEM MAY BE MEASURED AND PAID FOR AT THE CONTRACT UNIT PRICE BID PER LINEAL FOOT (METER), CONSTITUTING FULL COMPENSATION FOR ALL EQUIPMENT, TOOLS AND LABOR, INCLUDING THE PERFORMANCE OF ALL WORK TO PROVIDE INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- B. PAYMENT WILL BE MADE UNDER THE FOLLOWING:
 - 1. SAW CUT FOR CONCRETE PAVEMENT, SIDEWALK, DRIVEWAY, AND CURB AND GUTTER – PER LINEAL FOOT (METER).
- C. MEASUREMENT AND PAYMENT FOR CONCRETE SAW CUTTINGS WILL BE MADE ONLY IF LISTED AS A SEPARATE ITEM IN THE BID DOCUMENTS. IF NOT LISTED IN THE CONTRACT AS A BID ITEM, SAW CUTTING SHALL BE PART OF THE CONCRETE REMOVAL IN SECTION 4.2 ABOVE, OR PART OF THE EXCAVATION ABOVE SUBGRADE ITEM IN SECTION 2230, STREET EXCAVATION, BACKFILL AND COMPACTION, EXCAVATION.

4. 4 PAYMENT INDICATED TO INCLUDE COMPLETE COMPENSATION FOR ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED FOR THE COMPLETION OF THE WORK.

END OF SECTION 02112

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**SECTION 02221 – TRENCH EXCAVATION AND BACKFILL
FOR PIPELINES AND APPURTENANT STRUCTURES**

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS THE EXCAVATION, TRENCHING AND BACKFILLING FOR PIPELINES AND APPURTENANCES. IT INCLUDES ALL CLEARING, GRUBBING, SITE PREPARATION, REMOVAL AND DISPOSAL OF DEBRIS FROM THE EXCAVATION, HANDLING AND STORING MATERIALS FOR FILL AND BACKFILL, ALL BRACING, SHORING AND TRENCH PROTECTION, CONSTRUCTION DEWATERING, ALL BACKFILL, SUBGRADE PREPARATION , FINAL GRADING, SITE DRESSING AND CLEANUP.

1.2 REFERENCES

- A. THE CURRENT PUBLICATIONS LISTED BELOW FORM A PART OF THIS SPECIFICATION.
- | | |
|--------------------------|--|
| AASHTO T99 | MOISTURE-DENSITY RELATIONS OF SOILS AND SOIL-AGGREGATE MIXTURES USING 5-LB (2.5KG) RAMMER AND 12-INCH (305MM) DROP |
| ASTM D698 | MOISTURE-DENSITY RELATIONS OF SOILS AND SOIL-AGGREGATE MIXTURES USING 5-LB (2.5KG) RAMMER AND 12-INCH (305MM) DROP |
| AASHTO T191 (ASTM D1556) | DENSITY OF SOIL IN-PLACE BY THE SAND-CONE METHOD |
| AASHTO T310 (ASTM D6938) | IN-PLACE DENSITY AND WATER CONTENT OF THE SOIL AND SOIL AGGREGATE BY NUCLEAR METHOD (SHALLOW DEPTH) |
| AASHTO T11 (ASTM C117) | MATERIALS FINER THAN 0.075MM (NO. 200) SIEVE IN MINERAL AGGREGATES BY WASHING |
| AASHTO T27 (ASTM C136) | SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE |
| AASHTO T89 | DETERMINING THE LIQUID LIMIT OF SOILS |
| AASHTO T90 | DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS |
| ASTM D4318 | TEST METHOD FOR LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS |

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1.3 STANDARD DRAWINGS

A. STANDARD DRAWINGS APPLICABLE TO THIS SECTION ARE AS FOLLOWS:

1. STANDARD DRAWING NO. 02221-1 - TYPICAL UTILITY TRENCH DETAIL

1.4 TESTING

A. FIELD DENSITY TESTING

1. MEET THE QUALITY CONTROL AND QUALITY ASSURANCE TESTING REQUIREMENTS IN SECTION 01400, CONTRACTOR QUALITY CONTROL AND OWNER QUALITY ASSURANCE.
2. IN-PLACE FIELD DENSITY TESTS FOR QUALITY ASSURANCE ARE AT OWNER EXPENSE MEETING AASHTO T191 (ASTM D1556), SAND CONE METHOD; OR BY AASHTO T310 (ASTM D6938) NUCLEAR DENSOMETER METHODS. QUALITY ASSURANCE FIELD DENSITY TESTING FREQUENCY IS AT THE ENGINEER'S DISCRETION.
3. RE-TESTING FAILING AREAS IS AT THE EXPENSE OF THE CONTRACTOR.
4. AT THE DIRECTION OF THE ENGINEER, PROVIDE NECESSARY EQUIPMENT AND LABOR TO EXCAVATE AND REPLACE MATERIALS FOR TEST HOLES UP TO 5 FEET DEEP INTO THE COMPACTED BACKFILL TO ALLOW TESTING BELOW THE SURFACE OF ANY LAYERS COVERED WITHOUT INSPECTION AND APPROVAL BY THE ENGINEER.

B. LABORATORY MAXIMUM DENSITY AND OPTIMUM MOISTURE

1. QUALITY ASSURANCE TESTS WILL BE MADE BY THE ENGINEER FOR EACH ON-SITE NATURAL SOIL OR EACH SOURCE OF OFF-SITE MATERIAL, INCLUDING BORROW MATERIAL, TO DETERMINE THE LABORATORY MAXIMUM DENSITY VALUES AND OPTIMUM COMPACTION MOISTURE CONTENT ACCORDING TO AASHTO T-99 OR ASTM D698.

C. MATERIAL SUBMITTALS

1. SUBMIT TO THE ENGINEER MATERIAL QUALITY TEST RESULTS INCLUDING TYPE 1 BEDDING GRADATION AND PLASTICITY INDEX; AND TYPE 2 BEDDING GRADATION.
2. SUBMIT TO THE ENGINEER SAMPLES OF ON-SITE AND OFF-SITE BORROW SOILS FOR LABORATORY MOISTURE-DENSITY RELATIONSHIP TESTING BY THE ENGINEER.
3. IF APPLICABLE, SUBMIT A BLASTING PLAN TO THE ENGINEER.

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PART 2: PRODUCTS

2.1 PIPE BEDDING MATERIALS

A. TYPE 1 PIPE BEDDING

1. TYPE 1 PIPE BEDDING INCLUDES THE MATERIAL PLACED FROM 4 INCHES (100MM) BELOW THE BOTTOM OF THE PIPE, AROUND THE PIPE, AND UP TO THE SPRINGLINE OF THE PIPE.
2. PROVIDE TYPE 1 BEDDING CONSISTING OF SAND, SANDY GRAVEL, OR GRAVEL HAVING A MAXIMUM 3/4 INCH SIZE (19MM) AND A MAXIMUM PLASTICITY INDEX OF 6, DETERMINED BY AASHTO T89 AND T90 OR BY ASTM D4318.
3. WHERE TRENCH EXCAVATION ENCOUNTERS WET OR UNSTABLE MATERIAL, TYPE 1 PIPE BEDDING MUST BE FREE DRAINING AND NON-PLASTIC
4. REFER TO STANDARD DRAWING 02221-1 AND SPECIAL PROVISIONS FOR OTHER REQUIREMENTS.

B. SELECT TYPE 1 BEDDING

1. SELECT TYPE 1 BEDDING INCLUDES THE MATERIAL PLACED FROM THE SPRINGLINE OF THE PIPE TO 6 INCHES (15CM) OVER THE PIPE.
2. SELECT TYPE 1 BEDDING SHALL CONSIST OF SOIL, SAND OR FINE GRAVEL, FREE FROM CLODS, LUMPS OF FROZEN MATERIAL, OR ROCK EXCEEDING 1-1/2 INCHES (38MM) IN ITS GREATEST DIMENSION.
3. EXCAVATED TRENCH MATERIAL MAY BE SCREENED OR SORTED FOR USE AS BACKFILL SUBJECT TO APPROVAL OF THE ENGINEER.
4. WHERE TRENCH EXCAVATION ENCOUNTERS WET OR UNSTABLE MATERIAL, SELECT TYPE 1 BEDDING MUST BE FREE DRAINING AND NON-PLASTIC.

C. TYPE 2 PIPE BEDDING

1. TYPE 2 PIPE BEDDING IS USED AS DIRECTED BY THE ENGINEER TO REPLACE UNSUITABLE MATERIAL ENCOUNTERED IN THE TRENCH BOTTOM.
2. PLACE TYPE 2 PIPE BEDDING FROM THE BOTTOM OF THE TYPE 1 BEDDING MATERIAL TO THE DEPTH REQUIRED TO ADEQUATELY SUPPORT THE PIPE.
3. TYPE 2 BEDDING SHALL CONSIST OF GRANULAR MATERIAL MEETING THE FOLLOWING GRADATION.

<u>SIEVE OPENING</u>	<u>% PASSING</u>
3 INCH	100
NO. 4	0 - 25
NO. 8	0 - 10

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D. SEPARATION GEOTEXTILE

1. THE PLANS MAY REQUIRE, OR THE ENGINEER MAY DIRECT, THE USE OF NON-WOVEN GEO-TEXTILE FABRIC INTENDED TO PROVIDE MATERIALS SEPARATION. THE FABRIC WILL WRAP ALL OR PART OF THE TYPE 1 PIPE BEDDING AND SELECT TYPE 1 PIPE BEDDING TO PREVENT MATERIALS MIGRATING INTO THE TRENCH BOTTOM AND TRENCH WALLS AS SHOWN ON THE PLANS OR AS DIRECTED BY THE ENGINEER. THE FABRIC SHALL BE AASHTO M288 CLASS 1, 2, OR 3 AS SPECIFIED OR DETERMINED BY THE ENGINEER AND SHALL FULLY COMPLY WITH MPW SECTION 2110.

2.2 TRENCH BACKFILL MATERIALS

A. MATERIALS FROM TRENCH EXCAVATION

1. BACKFILL MATERIAL OBTAINED FROM TRENCH EXCAVATIONS MUST BE FREE OF CINDERS, ASH, REFUSE, ORGANIC OR FROZEN MATERIAL, BOULDERS, OR OTHER DELETERIOUS MATERIALS. BACKFILL MATERIALS AND PLACEMENT ARE FURTHER DESCRIBED IN THE EXECUTION SECTION OF THIS SPECIFICATION.

B. IMPORTED BACKFILL MATERIAL

1. IMPORTED BACKFILL MATERIAL IS FROM BORROW SOURCE(S) OUTSIDE THE PROJECT LIMITS AND IS USED WHEN, IN THE OPINION OF THE ENGINEER, AN ADEQUATE VOLUME OF SUITABLE BACKFILL MATERIAL IS NOT AVAILABLE WITHIN THE PROJECT LIMITS. IMPORTED BACKFILL MATERIALS MUST COMPLY WITH THE REQUIREMENTS OF SECTION 2.2.A, MATERIALS FROM TRENCH EXCAVATION.

2.3 FLOWABLE FILL

- A. IF USED, FLOWABLE FILL IS TO MEET THE REQUIREMENTS OF SECTION 2225, FLOWABLE FILL.

2.4 DETECTABLE BURIED WARNING TAPE

- A. DETECTABLE BURIED WARNING TAPE IS TO HAVE A MINIMUM 6 INCH (15CM) WIDTH AND 5 MIL (0.12MM) THICKNESS AND A SOLID ALUMINUM CORE RUNNING THE FULL LENGTH AND WIDTH OF THE TAPE ENCLOSED IN A COLOR CODED INERT PLASTIC JACKET, IMPERVIOUS TO ALKALIS, CHEMICAL REAGENTS AND SOLVENTS IN THE SOIL. THE TAPE IS TO MEET APWA/ULCC COLOR CODE REQUIREMENTS AND IS TO HAVE A MAXIMUM 36 INCH (90CM) IMPRINT.

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PART 3: EXECUTION

3.1 PROTECTION OF EXISTING PROPERTIES

A. GENERAL

1. TAKE PRECAUTIONS TO PROTECT ALL ADJOINING PRIVATE AND PUBLIC PROPERTY AND FACILITIES, INCLUDING UNDERGROUND AND OVERHEAD UTILITIES, CURBS, SIDEWALKS, DRIVEWAYS, STRUCTURES, AND FENCES. RESTORE OR REPLACE ALL DISTURBED OR DAMAGED FACILITIES TO ITS ORIGINAL CONDITION AT CONTRACTOR'S EXPENSE.
2. CONTACT UTILITY OWNERS USING THE MONTANA ONE CALL SYSTEM IN ACCORDANCE WITH SECTION 01041, PROJECT COORDINATION, PARAGRAPH 1.2.B., FOR UTILITY LOCATES BEFORE STARTING WORK. PROTECT THE UTILITIES EXPOSED DURING THE WORK AND PREVENT DAMAGING UNDERGROUND UTILITIES ADJACENT TO EXCAVATIONS. IMMEDIATELY NOTIFY THE UTILITY OWNER OF ANY CONSTRUCTION DAMAGE. REPAIRS OF DAMAGE TO MARKED UTILITIES ARE AT THE EXPENSE OF THE CONTRACTOR.
3. RE-LOCATE EXISTING WATER MAINS, SANITARY SEWERS AND STORM DRAINS SHOWN ON THE PLANS, THAT CONFLICT WITH NEW PIPELINES OR STRUCTURES AS INDICATED IN THE CONTRACT DOCUMENTS. NO SEPARATE PAYMENT WILL BE MADE FOR THIS WORK UNLESS SHOWN AS A PAYMENT ITEM. IF THE OWNER AUTHORIZES THE RELOCATION OF MAINS OR SEWERS WHICH ARE NOT INDICATED IN THE BID DOCUMENTS, AND THE ENGINEER DETERMINES THE WORK WAS NOT INCLUDED IN THE ORIGINAL CONTRACT, PAYMENT WILL BE MADE UNDER THE APPLICABLE SECTIONS OF THE GENERAL CONDITIONS.
4. CUT AND REPLACE EXISTING SERVICE LINES INTERFERING WITH TRENCHING OPERATIONS ONLY WITH THE ENGINEER'S PERMISSION AND AT THE CONTRACTOR'S EXPENSE.
SHOW ALL REPAIRED AND/OR ADJUSTED WATER AND SEWER LINES ON THE AS-BUILT PLANS.
5. PROTECT EXISTING WATER AND SEWER MAINS AND WATER AND SEWER SERVICES FROM FREEZING AT ALL TIMES DURING CONSTRUCTION.

B. PRIVATELY OWNED UTILITIES

1. IF ANY EXISTING PRIVATE UTILITY INTERFERES WITH THE WORK IN EITHER ALIGNMENT OR GRADE, AND HAS TO BE MOVED, THE WORK WILL BE PERFORMED BY THE APPROPRIATE UTILITY OWNER, UNLESS OTHERWISE SPECIFIED IN THE CONTRACT DOCUMENTS. SUCH PRIVATE UTILITIES MAY INCLUDE GAS MAINS, UNDERGROUND ELECTRICAL AND TELEPHONE CABLES, TELEPHONE POLES, LIGHT POLES, ETC.

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2. IF, HOWEVER, SUCH PRIVATE UTILITY RELOCATION IS PERFORMED BY THE CONTRACTOR, AND THE RELOCATION IS NOT A SEPARATE PAYMENT ITEM, PAYMENT WILL BE MADE UNDER THE SECTION 02221 CONDITIONS COVERING SUCH CHANGES.
3. SUCH PAYMENT WILL BE MADE ONLY IF THE WORK IS DETERMINED BY THE ENGINEER TO BE A CHANGE FROM THE ORIGINAL CONTRACT WORK SCOPE.

C. EXISTING STRUCTURES

1. PREVENT DAMAGE TO EXISTING BUILDINGS OR STRUCTURES IN THE WORK AREA. REPAIR ALL CONSTRUCTION RELATED DAMAGE TO THE SATISFACTION OF THE OWNER.

D. EXISTING OVERHEAD UTILITIES

1. USE EXTREME CAUTION TO AVOID CONFLICT, CONTACT OR DAMAGE TO OVERHEAD UTILITIES DURING THE WORK.

E. EXPLORATORY EXCAVATION

1. THE LOCATION OF EXISTING BURIED PUBLIC UTILITIES MAY NEED TO BE VERIFIED BY EXPLORATORY EXCAVATION BEFORE CONSTRUCTION.
2. WHERE AUTHORIZED BY THE ENGINEER, THE CONTRACTOR WILL BE REIMBURSED FOR EXPLORATORY EXCAVATION WORK AT THE UNIT PRICE BID PER HOUR FOR A BACKHOE/EXCAVATOR WITH OPERATOR AND A LABORER TO ASSIST. USE A BACKHOE/EXCAVATOR HAVING AT LEAST 60 HORSEPOWER (45KW), AS RATED BY THE MANUFACTURER.
3. THE UNIT PRICE PER HOUR INCLUDES THE BACKHOE/EXCAVATOR, OPERATOR AND ONE LABORER BASED UPON THE ACTUAL TIME, TO THE NEAREST ONE-HALF HOUR, THAT THE EQUIPMENT AND PERSONNEL ARE USED IN ACTUAL EXCAVATING AND BACKFILLING OPERATIONS INCLUDING STANDBY TIME BETWEEN EXCAVATION AND BACKFILLING WHICH ALLOWS THE ENGINEER TO MAKE THE NECESSARY SURVEY OF THE UNDERGROUND UTILITIES.
4. EXERCISE CARE TO PREVENT DAMAGING ALL UTILITIES AND REPAIR ANY UTILITY DAMAGE CAUSED BY EXPLORATORY EXCAVATION.

F. PAVEMENT REMOVAL AND STRIPPING

1. WHERE TRENCH EXCAVATION OR APPURTENANT STRUCTURE EXCAVATION REQUIRES REMOVING CURB AND GUTTER, CONCRETE SIDEWALKS, ASPHALT CONCRETE PAVEMENT, OR PORTLAND CEMENT CONCRETE PAVEMENT, CUT THE CONCRETE OR PAVEMENT IN A STRAIGHT LINE PARALLEL TO THE EXCAVATIONS EDGE USING A SPADE-BITTED AIR HAMMER, CONCRETE SAW OR OTHER SUITABLE EQUIPMENT TO PRODUCE A STRAIGHT, SQUARE AND CLEAN BREAK. RE-CUT EDGES

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BROKEN DURING CONSTRUCTION, BEFORE CONCRETE OR PAVING OPERATIONS.

2. FOR TRENCHES PASSING THROUGH EXISTING PAVEMENT, CUT THE PAVEMENT ALONG A NEAT VERTICAL LINE AT LEAST 12 INCHES (30CM) FROM THE TRENCH EDGE. WHERE THE NEAT LINE CUT IS LESS THAN 3 FEET (0.9M) FROM THE EDGE OF THE EXISTING PAVEMENT, REMOVE AND REPLACE THE ENTIRE PAVEMENT SECTION BETWEEN TRENCH AND EDGE OF PAVEMENT.
 3. DISPOSE OF THE ASPHALT CONCRETE AND/OR PORTLAND CEMENT CONCRETE DEBRIS OFF-SITE ACCORDING TO APPLICABLE STATE AND LOCAL REGULATIONS.
- G. WHEN EXCAVATING ACROSS EXISTING GRAVEL STREETS OR OTHER DEVELOPED SURFACES, REMOVE THE SURFACING MATERIAL FULL DEPTH AND STOCKPILE FOR INCLUSION AS TRENCH BACKFILL OR LEGALLY DISPOSE OF THE SURFACING MATERIAL.
- H. WHEN EXCAVATING ACROSS CULTIVATED OR SODDED AREAS, REMOVE TOPSOIL FULL DEPTH OR TO A MAXIMUM 12 INCH (30CM) DEPTH, WHICHEVER IS LESS, AND STOCKPILE FOR POSSIBLE PROJECT USE.
- I. RE-SOD OR RESEED, AS SPECIFIED IN THE CONTRACT DOCUMENTS, ALL ESTABLISHED LAWN AREAS CUT BY TRENCHING OR DAMAGED DURING THE CONSTRUCTION, IN ACCORDANCE WITH SECTION 2910, AND/OR 2920, TO THE SATISFACTION OF THE ENGINEER.

3.2 MAINTENANCE OF FLOWS

- A. MAINTAIN THE FLOW OF SEWERS, DRAINS AND WATER COURSES ENCOUNTERED DURING CONSTRUCTION. RESTORE CULVERTS, DITCHES, FENCES, CROSSWALKS AND STRUCTURES DISTURBED BY CONSTRUCTION TO THEIR ORIGINAL CONDITION UPON COMPLETION OF THE WORK.

3.3 TRENCH EXCAVATION

A. GENERAL

1. MEET CURRENT OSHA SAFETY AND HEALTH STANDARDS FOR ALL EXCAVATION, TRENCHING, SHORING, AND RELATED WORK.
 2. EXCAVATE AT THE SPECIFIED LOCATIONS FOR PIPELINE INSTALLATIONS AND APPURTENANT STRUCTURES.
 3. CROSSINGS UNDER SIDEWALKS OR CURBS MAY BE MADE BY TUNNELING, IF APPROVED BY THE ENGINEER. IF A PORTION OF A SIDEWALK OR CURB IS REMOVED, USE A CONCRETE SAW TO MAKE JOINTS, COMPACT THE BACKFILL AS SPECIFIED, AND REPLACE THE REMOVED SECTION WITH NEW CONCRETE SIDEWALK OR CURB.
4. DURING EXCAVATION, STOCKPILE BACKFILL MATERIALS AWAY FROM THE

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TRENCH BANKS TO ASSURE TRENCH WALL STABILITY. STOCKPILE EXCAVATED MATERIALS ON ONLY ONE SIDE OF THE TRENCH WITHOUT OBSTRUCTING EXISTING FIRE HYDRANTS, VALVES, MANHOLES AND OTHER APPURTENANCES. ASSURE SURFACE DRAINAGE OF ADJOINING AREAS IS UNOBSTRUCTED.

5. REMOVE AND DISPOSE OF ALL EXCESS OR UNSUITABLE EXCAVATED MATERIALS.
6. PREVENT SURFACE WATER FROM FLOWING INTO EXCAVATIONS. PROMPTLY REMOVE ALL WATER ACCUMULATING IN TRENCH EXCAVATIONS. DO NOT PERMIT WATER TO ACCUMULATE IN ANY OPEN TRENCH. REMOVE AND RE-LAY ALL PIPE OUT OF ALIGNMENT OR GRADE CAUSED BY TRENCH FLOODING.
7. GRADE THE TRENCH BOTTOMS TO THE SPECIFIED LINES AND GRADES. ASSURE BEDDING MATERIAL PROVIDES UNIFORM BEARING AND SUPPORT FOR EACH PIPE SECTION ALONG ITS ENTIRE LENGTH. EXCAVATE FOR BELL AND JOINTS AFTER THE TRENCH BEDDING IS GRADED, LIMITING THE EXCAVATION TO THE REQUIRED LENGTH, DEPTH AND WIDTH FOR MAKING THE PARTICULAR TYPE OF JOINT USED. BACKFILL OVER- EXCAVATIONS WITH TYPE 2 BEDDING MATERIAL.
8. NO DIFFERENTIATION BETWEEN COMMON AND ROCK TRENCH EXCAVATION IS MADE, EXCEPT WHEN LISTED AS SEPARATE BID ITEMS ON THE BID PROPOSAL OR BID FORM. EXCAVATION INCLUDES REMOVING AND SUBSEQUENT HANDLING OF ALL EARTH, GRAVEL, BEDROCK OR OTHER MATERIAL ENCOUNTERED REGARDLESS OF THE TYPE, CHARACTER, COMPOSITION OR CONDITION OF THE MATERIAL.
9. THE USE OF TRENCH DIGGING MACHINERY IS PERMITTED, EXCEPT IN PLACES WHERE ITS OPERATION IS LIKELY TO CAUSE DAMAGE TO EXISTING STRUCTURES OR FEATURES, IN WHICH CASE HAND METHODS ARE TO BE EMPLOYED.

B. TRENCH DIMENSIONS

1. EXCAVATE TO THE TRENCH DIMENSIONS SPECIFIED BELOW.
2. WIDTH
 - A. EXCAVATE TO PROVIDE ROOM TO INSTALL AND JOIN THE PIPE AS SPECIFIED. THE MINIMUM TRENCH WIDTH IS 3'-6" (1.1M), FOR OUTSIDE PIPE DIAMETERS OF 18 INCHES (0.5M) OR LESS. THE MINIMUM TRENCH WIDTH IS 2'-0" (0.6M) PLUS THE OUTSIDE PIPE DIAMETER, FOR PIPE SIZES EXCEEDING 18 INCHES (0.5M). MAXIMUM TRENCH WIDTH MAY BE SPECIFIED IN THE CONTRACT DOCUMENTS.
3. DEPTH
 - A. EXCAVATE THE TRENCH AS REQUIRED FOR THE INVERT GRADE OR PIPE BURY AS SPECIFIED IN THE CONTRACT DOCUMENTS, PLUS 4 INCHES (10CM) FOR THE TYPE 1 PIPE BEDDING. IF BEDROCK, BOULDERS OR LARGE STONES ARE ENCOUNTERED AT THE BOTTOM OF THE TRENCH, EXCAVATE AT LEAST 6 INCHES (15CM) BELOW THE BOTTOM OF THE PIPE

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FOR BACKFILLING WITH TYPE 1 PIPE BEDDING.

C. SOFT OR UNSUITABLE TRENCH SUBGRADE

1. WHEN SOFT OR UNSTABLE MATERIAL IS ENCOUNTERED AT THE TRENCH SUBGRADE WHICH WILL NOT UNIFORMLY SUPPORT THE PIPE, EXCAVATE THE MATERIAL TO THE DEPTH DIRECTED BY THE ENGINEER AND BACKFILL TO TRENCH SUBGRADE ELEVATION WITH TYPE 2 PIPE BEDDING.

D. BLASTING

1. OBTAIN ENGINEER APPROVAL TO BLAST FOR EXCAVATION. IF APPROVED, THE ENGINEER WILL ESTABLISH THE TIME LIMITS BLASTING WILL BE PERMITTED.
2. USE UTMOST CARE TO PROTECT LIFE AND PROPERTY DURING BLASTING. USE ONLY A LICENSED BLASTER WITH EXPERIENCE IN THE TYPE OF BLASTING REQUIRED FOR THE WORK.
3. SAFELY AND SECURELY STORE ALL BLASTING MATERIALS MEETING LOCAL LAWS AND ORDINANCES AND CLEARLY MARK ALL STORAGE PLACES "DANGEROUS EXPLOSIVES". DO NOT LEAVE ANY EXPLOSIVES WHERE THEY COULD ENDANGER PERSONS OR PROPERTY.
4. BLASTING ROCK IN TRENCHES
 - A. WHEN BLASTING ROCK IN TRENCHES, COVER THE BLASTING AREA WITH EARTH BACKFILL OR APPROVED BLASTING MATS. BEFORE BLASTING, STATION WORKERS AND PROVIDE DANGER SIGNALS TO WARN PEOPLE AND STOP VEHICLES.
 - B. ASSUME RESPONSIBILITY FOR ALL DAMAGE TO PROPERTY AND INJURY TO PERSONS RESULTING FROM BLASTING OR ACCIDENTAL EXPLOSIONS DURING THE WORK.
 - C. FURNISH THE FOLLOWING INFORMATION TO THE OWNER AND ENGINEER AT LEAST 48 HOURS BEFORE THE COMMENCEMENT OF BLASTING OPERATIONS: NAME OF THE CONTRACTOR'S POWDER MAN, POWDER MAN'S EXPERIENCE, TYPE OF SHOT, TYPE OF EXPLOSIVES AND DETONATOR BEING USED, PROOF OF INSURANCE COVERING LIABILITY FOR SUCH OPERATION, TRAFFIC CONTROL PLANS AND PLANNED PROCEDURES FOR PROTECTING THE PUBLIC.
5. ASSURE BLASTING PLAN MEETS FEDERAL, STATE AND LOCAL ORDINANCES. OBTAIN ALL REQUIRED PERMITS BEFORE BLASTING STARTS.

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- E. PAVEMENT DAMAGE CAUSE BY EQUIPMENT
 - 1. EQUIP ALL TRACK MOUNTED EQUIPMENT OPERATED ON PAVEMENT SURFACING WITH PADS TO PREVENT PAVEMENT DAMAGE.
 - 2. RESTORE ALL PAVEMENT DAMAGED BY CONSTRUCTION TO ITS ORIGINAL CONDITION.
 - F. SHORING, BRACING AND SHEETING
 - 1. PROVIDE ALL SHORING, BRACING AND TIGHT SHEETING REQUIRED TO PREVENT CAVING AND PROTECT WORKERS, MEETING CURRENT OCCUPATIONAL SAFETY AND HEALTH ACT REQUIREMENTS, AND TO PROTECT ADJACENT PROPERTY AND STRUCTURES. THE COST OF THIS WORK IS INCLUDED IN THE COST FOR TRENCH EXCAVATION.
 - G. EXCAVATION FOR APPURTENANCES
 - 1. MAKE EXCAVATIONS FOR MANHOLES, HYDRANTS, STRUCTURES AND OTHER APPURTENANCES OF THE SIZE AND DEPTH TO PERMIT COMPACTING OF BACKFILL ON ALL SIDES TO THE SPECIFIED DENSITY. THE REQUIREMENTS FOR REMOVING WATER AND OTHER APPLICABLE PORTIONS OF THESE SPECIFICATIONS APPLY TO EXCAVATION FOR APPURTENANCES.
- 3.4 DEWATERING
- A. REMOVE ALL GROUND WATER ENCOUNTERED IN TRENCH EXCAVATIONS. DO NOT PLACE PIPE, BEDDING OR BACKFILL MATERIALS BELOW THE GROUNDWATER ELEVATION ESTABLISHED BY DEWATERING OPERATIONS. THE COST OF DEWATERING OPERATIONS IS CONSIDERED A PART OF THE EXCAVATION COST.
- 3.5 EXCAVATION STABILITY AND SAFETY
- A. THE STABILITY OF CONSTRUCTION EXCAVATIONS AND ASSOCIATED WORKER SAFETY, INCLUDING SLOPE GEOMETRY AND SHORING/BRACING CONSIDERATIONS, ARE THE RESPONSIBILITY OF THE CONTRACTOR. MEET CURRENT OSHA REGULATIONS. THIS MAY REQUIRE DESIGN OF TEMPORARY SLOPES AND/OR SHORING BY A LICENSED PROFESSIONAL ENGINEER.
- 3.6 TRENCH FILLING AND BACKFILLING
- A. GENERAL
 - 1. BACKFILL ALL TRENCHES AS SPECIFIED IMMEDIATELY AFTER GRADE, ALIGNMENT AND PIPE JOINTING HAS BEEN INSPECTED AND APPROVED BY THE ENGINEER. CONDUCT ANY PIPE TESTING AS SPECIFIED IN THE RESPECTIVE WATER DISTRIBUTION, SEWERAGE/DRAINAGE SECTIONS. CORRECT ALL DEFECTS DISCOVERED BY TESTS PRIOR TO BACKFILLING.

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B. PIPE BEDDING PLACEMENT

1. TYPE 1 BEDDING.

- A. PLACE TYPE 1 PIPE BEDDING MATERIAL 4 INCHES (10CM) UNDER THE PIPE, AROUND THE PIPE, AND UP TO THE SPRINGLINE OF THE PIPE. PLACE IN MAXIMUM LIFTS OF 6 INCHES (15CM), USING HAND OPERATED OR OTHER COMPACTION METHODS WITHOUT DAMAGING OR DISTURBING THE PIPE. THOROUGHLY COMPACT EACH LAYER. USE SPECIAL CARE TO ASSURE COMPACTION UNDER THE PIPE HAUNCHES.
- B. PLACE BACKFILL MATERIAL IN EQUAL LIFTS ON BOTH SIDES OF THE PIPE FOR THE FULL TRENCH WIDTH. TAKE CARE TO PREVENT MIGRATION OF TYPE 1 BEDDING INTO SURROUNDING SOILS DURING PLACEMENT AND COMPACTION

2. SELECT TYPE 1 BEDDING.

- A. PLACE SELECT TYPE 1 BEDDING MATERIAL FROM THE SPRINGLINE TO 6 INCHES (15CM) OVER THE PIPE. WHERE WET OR UNSTABLE MATERIAL EXISTS, ASSURE THE MATERIAL IS FREE DRAINING AND NON-PLASTIC.
- B. PLACE IN MAXIMUM LIFTS OF 6 INCHES (15CM) USING HAND OR OTHER COMPACTION METHODS WITHOUT DAMAGING OR DISTURBING THE PIPE. THOROUGHLY COMPACT EACH LAYER.
- C. PLACE BACKFILL IN EQUAL LIFTS ON BOTH SIDES OF THE PIPE FOR THE FULL TRENCH WIDTH. TAKE CARE TO PREVENT MIGRATION OF SELECT TYPE 1 BEDDING INTO SURROUNDING SOILS DURING PLACEMENT AND COMPACTION.

3. TYPE 2 PIPE BEDDING.

- A. USE TYPE 2 PIPE BEDDING DESCRIBED IN PRODUCTS SECTION AS SPECIFIED OR AS DIRECTED BY THE ENGINEER TO REPLACE UNSUITABLE MATERIAL ENCOUNTERED IN THE TRENCH BOTTOM, PLACING IT FROM THE BOTTOM OF THE TYPE 1 BEDDING MATERIAL TO THE DEPTH REQUIRED TO ADEQUATELY SUPPORT THE PIPE.

4. SEPARATION GEOTEXTILE

- A. PLACE SEPARATION GEOTEXTILE WHERE SHOWN ON THE PLANS OR WHERE DIRECTED BY THE ENGINEER.

C. TRENCH BACKFILL

- 1. AFTER THE PIPE BEDDING MATERIALS ARE PLACED AND COMPACTED AS SPECIFIED, BACKFILL THE TRENCH. USE BACKFILL MATERIAL FREE OF CINDERS, ASH, REFUSE,

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ORGANIC OR FROZEN MATERIAL, BOULDERS, OR OTHER DELETERIOUS MATERIALS. FROM THE TOP OF THE SELECT TYPE 1 PIPE BEDDING TO 6 INCHES (15CM) BELOW THE GROUND SURFACE, OR TO THE SUBGRADE ELEVATION, MATERIAL CONTAINING ROCK UP TO 8 INCHES (20CM) IN THE GREATEST DIMENSION MAY BE USED.

2. TRENCH BACKFILL FROM THE TOP OF THE PIPE BEDDING TO GROUND SURFACE OR TO THE STREET SUBGRADE IS SEPARATED INTO THREE CLASSIFICATIONS.
 - A. TYPE A TRENCH BACKFILL IS COMPACTED BACKFILL TYPICALLY USED IN STREETS OR PAVED AREAS.
 - B. TYPE B TRENCH BACKFILL IS TYPICALLY USED FOR UNPAVED ALLEYS, CULTIVATED AREAS, BORROW PITS, UNIMPROVED STREETS OR OTHER UNSURFACED AREAS, AND OTHER AREAS WHERE COMPACTION IS LESS CRITICAL.
 - C. TYPE C TRENCH BACKFILL IS TYPICALLY USED IN OPEN AND UNIMPROVED AREAS OUTSIDE OF THE PUBLIC RIGHT-OF-WAY.
3. MEET THE BACKFILL AND COMPACTION REQUIREMENTS FOR ALL OF THE BACKFILL TYPES DESCRIBED IN THE CONTRACT DOCUMENTS.
4. WATERING
 - A. APPLY UNCONTAMINATED WATER, WHEN REQUIRED, AT THE LOCATIONS AND IN THE AMOUNTS REQUIRED TO COMPACT THE BACKFILL MATERIAL TO THE SPECIFIED REQUIREMENTS. MAINTAIN AN ADEQUATE WATER SUPPLY DURING THE WORK. ASSURE THE EQUIPMENT USED FOR WATERING IS OF THE CAPACITY AND DESIGN TO PROVIDE UNIFORM WATER APPLICATION.
 - B. APPLY WATER DURING THE WORK TO CONTROL DUST AND TO MAINTAIN ALL EMBANKMENT AND BASE COURSES IN A DAMP CONDITION IN ACCORDANCE WITH THESE CONTRACT DOCUMENTS.
 - C. WATER REQUIRED FOR COMPACTING TRENCH BACKFILL MAY BE OBTAINED FROM THE MUNICIPAL SYSTEM IF APPROVED BY THE OWNER, OR FROM OTHER SOURCES.
5. REMOVE, REPLACE, AND RE-COMPACT BACKFILL IN TRENCHES WHERE SETTLEMENT HAS OCCURRED AS DIRECTED BY THE ENGINEER AT THE CONTRACTOR'S EXPENSE.
6. TRENCH BACKFILL TYPES ARE DESIGNATED AS FOLLOWS:
 - A. TYPE A TRENCH BACKFILL. PLACE TRENCH BACKFILL IN MAXIMUM 8 INCH COMPACTED LIFTS WITHIN 3 PERCENT OF OPTIMUM MOISTURE CONTENT, AND COMPACT TO AT LEAST 95 PERCENT OF MAXIMUM DRY DENSITY DETERMINED BY AASHTO T99 OR BY ASTM D698.

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- B. TYPE B TRENCH BACKFILL. PLACE BACKFILL IN MAXIMUM 8 INCH (205MM) LIFTS, WITHIN 3 PERCENT OF OPTIMUM MOISTURE CONTENT, AND COMPACT TO AT LEAST 90 PERCENT OF MAXIMUM DRY DENSITY, AS DETERMINED BY AASHTO T99 OR BY ASTM D698.
- C. TYPE C TRENCH BACKFILL. PLACE AND COMPACT TYPE C TRENCH BACKFILL IN MAXIMUM 12 INCH LIFTS AT DENSITIES EQUAL TO OR GREATER THAN THE DENSITIES OF ADJOINING UNDISTURBED SOIL. MOUND EARTH OVER THE TRENCH TOP, IF SO DIRECTED BY THE ENGINEER.
- D. FLOWABLE FILL. PLACE FLOWABLE FILL AS TRENCH BACKFILL AS SHOWN IN THE CONTRACT DOCUMENTS OR AS DIRECTED BY THE ENGINEER. FLOWABLE FILL MAY ALSO BE USED AS A CONSTRUCTION EXPEDIENT, SUBSTITUTING FOR ANY TYPE OF TRENCH BACKFILL, SUBJECT TO APPROVAL BY THE ENGINEER AND AT THE EXPENSE OF THE CONTRACTOR.
- D. REPLACEMENT OF UNSUITABLE BACKFILL MATERIAL
 - 1. REMOVE AND DISPOSE OF EXCAVATED SOILS THAT ARE SATURATED, CONTAIN DELETERIOUS MATERIALS OR HAVE CHARACTERISTICS THAT, IN THE OPINION OF THE ENGINEER, RENDER THE SOILS UNSUITABLE AS BACKFILL.
 - 2. REPLACE UNSUITABLE SOILS WITH MATERIAL OBTAINED FROM TRENCH EXCAVATIONS WITHIN THE PROJECT LIMITS AT THE EXPENSE OF THE CONTRACTOR. IF SUITABLE REPLACEMENT MATERIAL IS NOT AVAILABLE WITHIN PROJECT LIMITS, OBTAIN MATERIAL FROM AN APPROVED BORROW SOURCE, TO BE PAID FOR AS IMPORTED BACKFILL MATERIAL.
 - 3. PLACE AND COMPACT ALL IMPORTED MATERIAL ACCORDING TO THE APPLICABLE BACKFILL SPECIFICATION REQUIREMENTS.
- E. BACKFILL OF APPURTANCES
 - 1. PLACE AND COMPACT BACKFILL FOR APPURTENANCES TO FINISHED GRADE AROUND MANHOLES, INLETS, VALVE BOXES AND OTHER UNDERGROUND ITEMS WITHOUT DISTURBING APPURTENANCE ALIGNMENTS.
 - 2. MEET THE BACKFILL MATERIAL, PLACEMENT, AND COMPACTION REQUIREMENTS SPECIFIED FOR THE ADJOINING TRENCH.
- F. DETECTABLE BURIED WARNING TAPE
 - 1. THE USE OF WARNING TAPE IS OPTIONAL AND IF USED MUST NOT BE RELIED ON AS THE PRIMARY LOCATING DEVICE. PROVIDE WARNING TAPE AS DESCRIBED IN PRODUCTS SECTION 2.3. BURY TAPE A MAXIMUM 18 INCHES (45CM) BELOW FINISH SURFACE GRADE.

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3.7 SURVEY MARKERS AND MONUMENTS

- A. PROTECT ALL SURVEY MARKERS AND MONUMENTS. PROTECTION INCLUDES MARKING WITH FLAGGED HIGH LATH AND SUPERVISING WORK NEAR MARKERS AND MONUMENTS. DO NOT DISTURB MONUMENTS WITHOUT PRIOR APPROVAL FROM THE ENGINEER.
- B. REPLACE ALL CONTRACTOR DISTURBED OR DESTROYED SURVEY MARKERS OR MONUMENTS, NOT APPROVED DURING CONSTRUCTION, USING A LICENSED LAND SURVEYOR. SEE SECTION 01050 FOR DETAILS ON SURVEY MARKER PROTECTION/DISTURBANCE.

3.8 CLEANUP

- A. AS WORK PROGRESSES, REMOVE DEBRIS AND COMPLETE TO FINISH GRADE EACH PORTION OF THE WORK. ONCE THE WORK IS COMPLETE, CLEAR DEBRIS AND FINISH THE ENTIRE SITE TO SMOOTH, UNIFORM SLOPES PRESENTING A NEAT AND WORKMANLIKE APPEARANCE. REMOVE AND DISPOSE OF ALL ROCKS BROUGHT TO THE SURFACE DURING EXCAVATION OR BACKFILLING.

3.9 TIME AND DISTANCE OF OPEN TRENCHES

- A. PERFORM THE WORK SO THAT TRENCHES WILL REMAIN OPEN THE MINIMUM TIME REQUIRED TO ACCOMPLISH THE WORK.
- B. DO NOT BEGIN TRENCH EXCAVATING UNTIL APPROPRIATE COMPACTION EQUIPMENT IS AT THE EXCAVATION SITE.
- C. THE MAXIMUM PERMISSIBLE DISTANCE BETWEEN BACKFILLING/ COMPACTION OPERATIONS AND THE END OF NEWLY INSTALLED PIPE IS 200 FEET (60M) IN EXISTING STREETS (AND/OR ALLEYS) AND 500 FEET (150M) IN ALL OTHER AREAS.
- D. THE MAXIMUM DISTANCE BETWEEN THE NEWLY INSTALLED PIPE AND THE EXCAVATOR IS TO BE 100 FEET (30M) IN EXISTING STREETS (AND/OR ALLEYS) AND 200 FEET (60M) IN ALL OTHER AREAS.
- E. FOR EACH WORK GROUP CONSISTING OF A TRENCH EXCAVATOR, A PIPE LAYING CREW, AND A BACKFILLING/COMPACTING CREW, THE MAXIMUM ALLOWABLE OPEN DITCH AT ANY TIME IS 300 FEET (90M) IN EXISTING STREETS (AND/OR ALLEYS) AND 700 FEET (210M) IN ALL OTHER AREAS.
- F. THE MAXIMUM DISTANCE BEHIND THE END OF THE NEW PIPE IS 1,500 FEET (460M) FOR GRAVEL SURFACING REPLACEMENT, BASE PLACEMENT OR PAVEMENT REPLACEMENT.

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PART 4: MEASUREMENT AND PAYMENT

4. 1 GENERAL

- A. THE FOLLOWING ITEMS CONSTITUTE PAY ITEMS FOR THE WORK COVERED UNDER THIS SECTION. PAYMENT FOR THESE ITEMS IS FULL COMPENSATION FOR PROVIDING ALL MATERIALS, TOOLS, LABOR AND EQUIPMENT NECESSARY TO COMPLETE THE ITEM AND ALL INCIDENTAL WORK RELATED THERETO, WHETHER SPECIFICALLY MENTIONED HEREIN OR NOT.

4. 2 TRENCH EXCAVATION AND BACKFILL

- A. NO SEPARATE MEASUREMENT AND PAYMENT IS MADE FOR TRENCH EXCAVATION AND BACKFILL. INCLUDE ALL COSTS FOR THIS ITEM IN THE UNIT PRICE BID FOR PIPE, COMPLETE IN-PLACE.
- B. THE UPPER LIMIT OF THE TRENCH EXCAVATION AND BACKFILL ITEM IS DEFINED AS THE TOP OF SUBGRADE. DETAILS OF THE VARIOUS TYPES OF SURFACE RESTORATION ARE FOUND IN THE CONTRACT DOCUMENTS.

4. 3 TYPE 1 AND SELECT TYPE 1 PIPE BEDDING

- A. INCLUDE APPROVED MATERIAL FOR TYPE 1 AND SELECT TYPE 1 PIPE BEDDING IN THE PIPE INSTALLATION PRICE. NO MEASUREMENT OR ADDITIONAL PAYMENT IS MADE FOR FURNISHING OR PLACING TYPE 1 AND SELECT TYPE 1 PIPE BEDDING MATERIALS.

4. 4 TYPE 2 PIPE BEDDING

- A. APPROVED MATERIAL FOR TYPE 2 PIPE BEDDING TO REPLACE SOFT OR UNSUITABLE MATERIAL, IS MEASURED IN CUBIC YARDS (CUBIC METERS) OF MATERIAL FURNISHED, IN-PLACE, FOR THE DEPTH DIRECTED.
- B. PAYMENT FOR TYPE 2 PIPE BEDDING IS MADE AT THE CONTRACT UNIT PRICE BID PER CUBIC YARD (CUBIC METER), WHICH INCLUDES FURNISHING, PLACING AND COMPACTING THE TYPE 2 BEDDING MATERIAL AS SPECIFIED AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.
- C. PAYMENT QUANTITY IS BASED UPON AN EXCAVATION WIDTH OF 2.0 FEET (0.6M) PLUS THE OUTSIDE PIPE DIAMETER WITH A MINIMUM PAYMENT WIDTH OF 3.5 FEET (1.1M).
- D. IF TYPE 2 BEDDING IS PLACED WITHOUT THE ENGINEER'S AUTHORIZATION, THE TYPE 2 BEDDING IS A CONSTRUCTION EXPEDIENT SOLELY FOR THE CONTRACTOR'S CONVENIENCE AND NO PAYMENT FOR TYPE 2 BEDDING IS MADE.
- E. PAYMENT WILL BE MADE UNDER: TYPE 2 PIPE BEDDING - PER CUBIC YARD (CUBIC METER).

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4. 5 IMPORTED BACKFILL MATERIAL

- A. WHEN SATISFACTORY BACKFILL MATERIAL IS NOT AVAILABLE WITHIN THE PROJECT LIMITS, BACKFILL MATERIAL IMPORTED FROM BORROW SOURCES OUTSIDE THE LIMITS OF THE PROJECT SITE ARE MEASURED IN CUBIC YARDS OF MATERIAL FURNISHED, IN PLACE (COMPACTED), FOR THE DEPTH DIRECTED BY THE ENGINEER.
- B. THE TRENCH WIDTH FOR MEASUREMENT AND PAYMENT IS 2.0 FEET (0.6M) PLUS THE OUTSIDE PIPE DIAMETER, WITH A MINIMUM PAYMENT WIDTH OF 3.5 FEET (1.1M), MEASURED BETWEEN VERTICAL PLANES FOR THE DEPTH REQUIRED.
- C. PAYMENT FOR IMPORTED BACKFILL MATERIAL IS MADE AT THE CONTRACT UNIT PRICE BID PER CUBIC YARD, WHICH INCLUDES FURNISHING, PLACING, AND COMPACTING THE BACKFILL MATERIAL AS SPECIFIED AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.
- D. NO SEPARATE MEASUREMENT AND PAYMENT IS MADE FOR THIS ITEM WHEN, IN THE ENGINEER'S OPINION, SUITABLE SURPLUS MATERIAL IS AVAILABLE WITHIN THE PROJECT LIMITS, IN WHICH CASE ALL COSTS FOR THIS ITEM ARE TO BE INCLUDED IN THE UNIT PRICE BID FOR PIPE, COMPLETE IN-PLACE.
- E. PAYMENT FOR IMPORTED BACKFILL WILL BE MADE ONLY IF THE ENGINEER DETERMINES SURPLUS MATERIAL IS NOT AVAILABLE WITHIN THE PROJECT LIMITS.
- F. PAYMENT IS MADE UNDER: IMPORTED BACKFILL MATERIAL -PER CUBIC YARD (CUBIC METER).

4. 6 EXPLORATORY EXCAVATION

- A. MEASUREMENT OF THIS ITEM IS MADE FOR THE ACTUAL TIME, TO THE NEAREST ONE-HALF HOUR, FOR WHICH THE EQUIPMENT AND PERSONNEL ARE USED AND AUTHORIZED BY THE ENGINEER FOR ACTUAL EXPLORATORY EXCAVATION AND BACKFILLING OPERATIONS, INCLUDING STANDBY TIME BETWEEN EXCAVATION AND BACKFILLING, TO ALLOW THE ENGINEER TO SURVEY THE UNDERGROUND UTILITY.
- B. PAYMENT IS MADE AT THE CONTRACT UNIT PRICE BID PER HOUR, WHICH INCLUDES PROVIDING THE EQUIPMENT ON-SITE, WITH OPERATOR AND FUEL. WHERE EXPLORATORY EXCAVATION IS OUTSIDE OF PLANNED EXCAVATION LIMITS, PAYMENT ALSO INCLUDES ANY TIME REQUIRED FOR COMPACTION OF THE BACKFILL, IF NECESSARY.
- C. SURFACING REPAIR WILL BE PAID SEPARATELY, IF REQUIRED.
- D. PAYMENT WILL BE MADE UNDER: EXPLORATORY EXCAVATION - PER HOUR.

4. 7 GEOTEXTILE FABRIC

- A. MEASUREMENT AND PAYMENT FOR GEOTEXTILE FABRIC SHALL BE BY THE LINEAR FOOT OF TRENCH.

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- B. PAYMENT FOR THIS ITEM IS FULL COMPENSATION FOR PROVIDING ALL MATERIALS, TOOLS, LABOR AND EQUIPMENT NECESSARY TO COMPLETE THE ITEM AND ALL INCIDENTAL WORK RELATED THERETO, WHETHER SPECIFICALLY MENTIONED HEREIN OR NOT.

END OF SECTION 02221

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SECTION 02225 FLOWABLE FILL

PART I: GENERAL

1.1 DESCRIPTION

- A. THIS WORK CONSISTS OF FURNISHING AND PLACING FLOWABLE FILL TO THE LINES AND GRADES SHOWN ON THE PLANS AS BACKFILL IN TRENCHES AND/OR AT OTHER LOCATIONS. FLOWABLE FILL IS A SELF-COMPACTING CEMENTITIOUS MATERIAL USING MINERAL AGGREGATES (SAND AND/OR GRAVEL), NATIVE OR PROCESSED MATERIALS, FLY ASH/CEMENT, WATER, AIR ENTRAINING SOLUTION AND (OPTIONALLY) OTHER ADMIXTURES. FLOWABLE FILL IS ALSO KNOWN AS CONTROLLED LOW-STRENGTH MATERIAL (CLSM) AND CONTROLLED DENSITY FILL (CDF). FLOWABLE FILL IS ONLY PERMITTED WHEN SPECIFICALLY CALLED OUT IN THE CONTRACT DOCUMENTS OR APPROVED BY ENGINEER.

1.2 REFERENCES

- A. THE CURRENT PUBLICATIONS LISTED BELOW FORM A PART OF THE SPECIFICATION.

ASTM D4832	PREPARATION/TESTING OF SOIL-CEMENT SLURRY TEST CYLINDERS
ASTM C39	TEST METHOD FOR COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS
ASTM D6023	STANDARD TEST METHOD FOR UNIT WEIGHT
ASTM C150	SPECIFICATION FOR PORTLAND CEMENT
ASTM C618	SPECIFICATION FOR FLY ASH
ASTM C494	SPECIFICATION FOR CHEMICAL ADMIXTURE FOR CONCRETE
ASTM E329	PRACTICE FOR USE IN THE EVALUATION OF TESTING AND INSPECTION AGENCIES AS USED IN CONSTRUCTION
ASTM C1064	TEMPERATURE OF FRESHLY MIXED PORTLAND CEMENT CONCRETE
ASTM C117	MATERIALS FINER THAN 0.075 MM (NO. 200) SIEVE IN MINERAL AGGREGATES BY WASHING
ASTM C136	SIEVE ANALYSIS OF FINE & COARSE AGGREGATE
ASTM C117	MATERIALS FINER THAN NO. 200 (0.075 MM) SIEVE IN MINERAL AGGREGATES BY WASHING
ASTM D4318	TEST METHOD FOR LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS
ASTM C94	READY MIX CONCRETE
ACI 301	STANDARD SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS
ACI 304	GUIDE FOR MEASURING, MIXING, TRANSPORTING AND PLACING CONCRETE

1.3 TESTING

- A. THE ENGINEER MAY PERFORM OCCASIONAL QUALITY ASSURANCE TESTS ON THE FLOWABLE FILL CONSISTING OF SLUMP, AIR CONTENT MEASUREMENTS AND CASTING THREE CYLINDERS FOR COMPRESSIVE STRENGTH TEST. THE REQUIRED COMPRESSIVE STRENGTH TEST METHOD AND REQUIRED RANGE ARE DESCRIBED IN SECTION 2.4, COMPRESSIVE STRENGTH BELOW.

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- B. THE CONTRACTOR IS TO PROVIDE THE ENGINEER WITH A MIX DESIGN BY EITHER TRIAL BATCH OR FIELD EXPERIENCE METHODS TO VERIFY THE REQUIRED COMPRESSIVE STRENGTH OF THE FLOWABLE FILL AT THE 28 DAY AGE. MIX DESIGN REQUIREMENTS ARE DESCRIBED IN SECTION 2.3, PROPORTIONS; AND IN SECTION 2.4, COMPRESSIVE STRENGTH. PROPORTIONS SHALL BE SELECTED ON THE BASIS OF UNCONFINED, AIR CURED COMPRESSIVE STRENGTH TEST SPECIMENS.

PART 2: PRODUCTS

2.1 MIXTURE OF MATERIALS

- A. PROVIDE A MIXTURE OF THE MATERIALS DESCRIBED BELOW TO PRODUCE A SELF-COMPACTING CEMENTITIOUS MATERIAL BATCHED ON A PER CUBIC YARD BASIS.

2.2 MATERIALS

- A. PORTLAND CEMENT. PORTLAND CEMENT SHALL CONFORM TO THE REQUIREMENTS OF ASTM C150, TYPE 11.
- B. FLY ASH. FLY ASH SHALL CONFORM TO ASTM C618, CLASS C OR F.
- C. COARSE AGGREGATE, FINE AGGREGATE AND NATIVE MATERIALS. ANY AGGREGATE GRADATION WHICH PRODUCES PERFORMANCE CHARACTERISTICS OF THE FLOWABLE FILL SPECIFIED HEREIN WILL BE ACCEPTED, EXCEPT AS FOLLOWS: THE AMOUNT OF MATERIAL PASSING THE #200 SIEVE SHALL NOT EXCEED 20 PERCENT. ALSO, LIQUID LIMIT AND PLASTICITY INDEX SHALL NOT EXCEED 25 AND 5, RESPECTIVELY.
- D. WATER. WATER USED IN MIXING SHALL BE FREE OF OIL, SALT, ACID, ALKALI, SUGAR, VEGETABLE MATTER OR OTHER SUBSTANCES INJURIOUS TO THE FINISHED PRODUCT.
- E. CHEMICAL ADMIXTURES. CHEMICAL ADMIXTURES SHALL CONFORM TO THE REQUIREMENTS OF ASTM C494.

2.3 PROPORTIONS

- A. A VARIETY OF SAND/GRAVEL AGGREGATES, AND/OR NATIVE (OR PROCESSED) MATERIALS MEETING THE ABOVE REQUIREMENTS IN CONJUNCTION WITH APPROPRIATE AMOUNTS OF PORTLAND CEMENT AND FLYASH, AIR ENTRAINING SOLUTION, AND (OPTIONALLY) OTHER ADMIXTURES MAY BE USED TO PRODUCE THE REQUIRED MIX PROPERTIES DESCRIBED HEREIN.
- B. THE CONTRACTOR SHALL SUBMIT, TO THE ENGINEER, A MIX DESIGN BASED UPON A TRIAL BATCH OR FIELD EXPERIENCE, INCLUDING THE PROPORTIONS AND SOURCES OF ALL CONSTITUENT MATERIALS, AIR ENTRAINING AND (OPTIONALLY) OTHER ADMIXTURES, EXPRESSED AS CUBIC YARD BATCH WEIGHTS. THE MIX SHALL CONTAIN A MINIMUM OF 50 POUNDS (23 KG) OF CEMENT AND UP TO 250 POUNDS (114 KG) FLY ASH PER CUBIC YARD, WITH THE REMAINDER OF THE VOLUMES COMPOSED OF AGGREGATES, WATER, AND ANY APPROVED ADMIXTURES. MEASURED COMPRESSIVE STRENGTH, AIR CONTENT AND YIELD FOR THE MIX DESIGN TRIAL BATCH (OR FOR THE FIELD EXPERIENCE BASED MIX DESIGN) SHALL BE SUBMITTED.

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2.4 COMPRESSIVE STRENGTH

- A. FLOWABLE FILL SHALL BE DESIGNED TO ACHIEVE A 28 DAY COMPRESSIVE STRENGTH OF 30 TO 500 PSI (0.2 TO 3.4 MPA) WHEN TESTED IN ACCORDANCE WITH ASTM C39. EXCAVATABLE MIXES SHALL BE DESIGNED TO ATTAIN 28 DAY STRENGTHS IN THE RANGE OF 30 - 150 PSI (0.2 TO 1.0 MPA). TEST SPECIMENS SHALL BE MADE IN ACCORDANCE WITH ASTM D4832. COMPRESSIVE STRENGTH TESTS SHALL BE PERFORMED AT FREQUENCIES OF AT LEAST ONE TEST SET PER 150 YD³ (114M³) AND AT LEAST ONE TEST SET PER DAY OF PLACEMENT.

2.5 CONSISTENCY

- A. CONSISTENCY OF THE FRESH MIXTURE SHALL BE SUCH THAT THE MIXTURE MAY BE READILY PLACED WITHOUT SEGREGATION. HIGH FLOWABILITY MATERIAL GENERALLY HAS A SLUMP GREATER THAN 8 INCHES (20.3 CM). AS AN ALTERNATIVE TO SLUMP TESTING, DESIRED CONSISTENCY MAY BE APPROXIMATED BY FILLING AN OPEN-ENDED 3 INCH (76.2 MM) DIAMETER CYLINDER, 6 INCHES (15.2 CM) HIGH, WITH THE MIXTURE AND CYLINDER IMMEDIATELY PULLED STRAIGHT UP. THE CORRECT CONSISTENCY OF THE MIXTURE WILL PRODUCE AN APPROXIMATE 8 INCH (20.3 CM) DIAMETER CIRCULAR TYPE SPREAD WITHOUT SEGREGATION. ADJUSTMENTS OF THE PROPORTIONS OF CONSTITUENTS MAY BE MADE TO ACHIEVE PROPER SOLID SUSPENSION AND OPTIMUM FLOWABILITY. HOWEVER, STRENGTH REQUIREMENTS AND PROPER YIELD SHALL BE MAINTAINED FOR THE ACTUAL BATCH WEIGHTS.

PART 3: EXECUTION

3.1 CONSTRUCTION

- A. COMPLY WITH ACI 304 AND ASTM C94 FOR MEASURING, MIXING, TRANSPORTING, AND PLACING THE FLOWABLE FILL, AND AS HEREIN SPECIFIED.

3.2 LIMITATIONS OF PLACEMENT

- A. DO NOT PLACE CLSM ON FROZEN GROUND. MIX AND PLACE ONLY WHEN THE AIR TEMPERATURE IS AT LEAST 35 DEGREES F (2°C) AND RISING. AT THE TIME OF PLACEMENT, FLOWABLE FILL SHALL BE AT LEAST 40 DEGREES F (4°C). STOP MIXING AND PLACEMENT WHEN THE AIR TEMPERATURE IS 40 DEGREES F (4°C) AND FALLING.
- B. FLOWABLE BACKFILL SHALL BE PLACED BY METHODS THAT PRESERVE THE QUALITY OF THE MATERIAL IN TERMS OF COMPRESSIVE STRENGTH, FLOW, HOMOGENITY, PLASTICITY AND WORKABILITY. THE MATERIAL SHALL BE TRANSPORTED, PLACED, AND/OR CONSOLIDATED SO THAT IT FLOWS EASILY AROUND, ADJACENT TO AND UNDER STRUCTURES. IT SHALL HAVE THE FLOW, CONSISTENCY, AND WORKABILITY SUCH THAT THE MATERIAL IS SELF-COMPACTING.
- C. PROTECT FRESHLY PLACED FLOWABLE FILL FROM PREMATURE DRYING, EXCESSIVE COLD, OR HOT TEMPERATURES. THE AIR IN CONTACT WITH THE BACKFILL SURFACE SHALL BE MAINTAINED AT TEMPERATURES ABOVE FREEZING. BEGIN CURING, IMMEDIATELY FOLLOWING PLACEMENT BEFORE THE BACKFILL HAS DRIED. CONTINUE WITH CURING UNTIL THE BACKFILL HAS ATTAINED THE 28 DAY STRENGTH REQUIREMENT. THIS STRENGTH IS TO BE DETERMINED PRIOR TO ANY LOAD APPLICATIONS OR CONSTRUCTION ACTIVITY, UNLESS OTHERWISE DIRECTED BY AN ENGINEER.

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PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. PAYMENT IS MADE UNDER: FLOWABLE FILL – PER CUBIC YARD (CUBICMETERS).
- B. PAYMENT SHALL INCLUDE ALL LABOR, MATERIALS, EQUIPMENT AND INCIDENTALS NECESSARY TO PROVIDE, LOAD, HAUL, PLACE AND CONSOLIDATE THE FLOWABLE FILL.
- C. MEASUREMENT SHALL BE BASED UPON BATCH DELIVERY TICKETS PROVIDED TO THE ENGINEER AT THE TIME OF PLACEMENT.

END OF SECTION 02225

SECTION 02234 - SUB BASE COURSE

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS CONSTRUCTING A SUB-BASE COURSE OF EITHER CRUSHED OR UNCRUSHED MATERIALS MEETING THE SPECIFIED GRADATIONS AND OTHER QUALITY CRITERIA SPECIFIED HEREIN.

1.2 REFERENCES

AASHTO T11	AMOUNT OF MATERIAL FINER THAN NO. 200 (0.075 MM) SIEVE IN AGGREGATE
AASHTO T27	SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
AASHTO T89	DETERMINING LIQUID LIMIT OF SOILS
AASHTO T90	DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS
AASHTO T176	SAND EQUIVALENT VALUE OF SOILS AND FINE AGGREGATE
AASHTO T96	RESISTANCE TO DEGRADATION BY ABRASION AND IMPACT IN THE LOS ANGELES MACHINE
AASHTO T99 (ASTM D698)	MOISTURE-DENSITY RELATIONS OF SOILS AND SOIL-AGGREGATE MIXTURES USING 5-LB (2.5 KG) RAMMER AND 12-INCH (305 MM) DROP
ASTM D5821	DETERMINING THE PERCENTAGE OF FRACTURED PARTICLES IN COARSE AGGREGATE
AASHTO T191 (ASTM D1556)	DENSITY OF SOIL IN-PLACE BY SAND CONE METHOD
AASHTO T310 (ASTM D6938)	IN-PLACE DENSITY AND WATER CONTENT OF THE SOIL AND SOIL AGGREGATE BY NUCLEAR METHOD (SHALLOW DEPTH)

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1.3 DENSITY CONTROL TESTING

A. FIELD DENSITY TESTING

1. MEET THE QUALITY CONTROL AND QUALITY ASSURANCE TESTING REQUIREMENTS IN SECTION 01400, CONTRACTOR QUALITY CONTROL AND OWNER QUALITY ASSURANCE.
2. IN-PLACE FIELD DENSITY TESTS FOR QUALITY ASSURANCE ARE AT OWNER EXPENSE MEETING AASHTO T191 (ASTM D1556) SAND CONE METHOD OR AASHTOT310 (ASTM D 6938), NUCLEAR DENSOMETER METHOD. QUALITY ASSURANCE FIELD DENSITY TESTING FREQUENCY IS AT THE DISCRETION OF THE ENGINEER.
3. RETESTING OF FAILING AREAS IS AT THE EXPENSE OF THE CONTRACTOR.

B. LABORATORY MAXIMUM DENSITY AND OPTIMUM MOISTURE

1. MOISTURE DENSITY CURVES WILL BE PROVIDED BY THE CONTRACTOR FOR EACH BASE MATERIAL SUPPLIED. THESE WILL BE PROVIDED AT THE EXPENSE OF THE CONTRACTOR.

C. MATERIALS SUBMITTALS

1. SUBMIT TO THE ENGINEER GRADATIONS, MOISTURE DENSITY CURVES AND OTHER PRELIMINARY TEST RESULTS FOR SOURCES TO BE USED FOR BASE MATERIALS PRIOR TO DELIVERY TO THE SITE FOR APPROVAL BY THE ENGINEER. IF RECYCLED MATERIALS ARE PROPOSED, CBR TEST DATA MUST BE SUBMITTED TO THE ENGINEER TO ASSURE CONSISTENCY WITH DESIGN REQUIREMENTS.

PART 2: PRODUCTS

2.1 GENERAL

- A. FURNISH SELECT SUB-BASE MATERIAL MEETING THE APPLICABLE AGGREGATE QUALITY.

2.2 UNCRUSHED SUBBASE

- A. FURNISH MATERIAL CONSISTING OF HARD, DURABLE STONE, GRAVEL OR OTHER SIMILAR MATERIALS MIXED OR BLENDED WITH SAND, STONE DUST, RECYCLED CONCRETE AND/OR ASPHALT OR OTHER BINDING OR FILLER MATERIALS PRODUCED FROM APPROVED SOURCES, PROVIDING A UNIFORM MIXTURE MEETING THESE SPECIFICATIONS AND COMPACTED INTO A DENSE AND WELL- BONDED SUB BASE. OVERSIZE MATERIAL OF ACCEPTABLE QUALITY MAY BE CRUSHED AND USED IN THE BASE MATERIAL, IF THE BLEND MEETS THE SPECIFIED GRADATIONS.
- B. ASSURE THE MATERIAL RETAINED ON THE NO.4 SIEVE HAS A WEAR NOT EXCEEDING 50 PERCENT AT 500 REVOLUTIONS AS DETERMINED BY AASHTO T96.

2.3 CRUSHED SUBBASE

- A. FURNISH MATERIAL HAVING BOTH FINE AND COARSE CRUSHED STONE OR CRUSHED GRAVEL, AND/OR NATURAL GRAVEL, AND WHEN APPROVED, BLENDED WITH SOIL, SAND, SCREENINGS. RECYCLED CONCRETE AND/OR ASPHALT OR OTHER MATERIALS.

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- B. FURNISH CRUSHED GRAVEL OR STONE CONSISTING OF HARD, DURABLE PARTICLES, NOT CONTAINING EXCESSIVE FLAT, ELONGATED, SOFT OR DISINTEGRATED ROCK, DIRT, OR OTHER DELETERIOUS MATTER, AND HAVING A WEAR NOT EXCEEDING 50 PERCENT AT 500 REVOLUTIONS AS DETERMINED BY AASHTO T96.
- C. USE PRODUCTION METHODS THAT PRODUCE A PERCENT OF FRACTURED ROCK IN THE FINISHED PRODUCT THAT IS CONSTANT AND UNIFORM. CRUSH AGGREGATE SO THAT AT LEAST 25% OF THE MATERIAL IS RETAINED ON THE NO.4 SIEVE AND HAS ONE OR MORE MECHANICALLY FRACTURED FACES.

2.4 GRADATION

- A. PRODUCE MATERIAL, INCLUDING ANY ADDED BINDER OR FILLER, MEETING THE FOLLOWING TABLE OF GRADATIONS AS DETERMINED BY AASHTO METHODS T11 AND T27:

TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES

PASSING	4" MINUS	3" MINUS	2" MINUS	1 1/2" MINUS	1" MINUS
4 INCH	100				
3 INCH	---	100			
2 INCH	---	---	100		
1 1/2 INCH	---	---	---	100	
1 INCH	---	---	---	---	100
NO.4	25-60	25-60	25-60	25-60	25-70
NO.40	10-30	10-30	10-30	10-30	10-30
NO.200	2-10	2-10	2-10	2-10	2-10

- B. UP TO 5% "OVERSIZED" MATERIAL IS PERMITTED PROVIDED THAT THE "OVERSIZED" MATERIAL PASSES THE SCREEN SIZE IMMEDIATELY LARGER THAN THE TOP SIZE SPECIFIED. THE MATERIAL BETWEEN THE MAXIMUM SCREEN OPENING AND THE NO.4 SIEVE SHALL BE REASONABLY WELL GRADED.
- C. SUITABILITY OF THE AGGREGATE IS DETERMINED BY THE GRADATION TESTING OF MATERIAL PLACED IN THE PROJECT AS REQUIRED IN THE CONTRACT DOCUMENTS, WITHIN THE ALLOWABLE LIMITS DESCRIBED BY THE TABLE OF GRADATIONS FOR THE PARTICULAR GRADING SPECIFIED.
- D. ASSURE THE LIQUID LIMIT FOR THE AGGREGATE FRACTION PASSING A NO.40 SIEVE DOES NOT EXCEED 25, NOR THE PLASTICITY INDEX EXCEED 6, AS DETERMINED BY AASHTO T89 AND T90.

2.5 WATERING:

- A. USE UNCONTAMINATED WATER. PART 3: EXECUTION

3.1 PREPARATION

- A. IMMEDIATELY BEFORE PLACING THE BASE COURSE, BLADE SMOOTH AND SHAPE THE UNDERLYING SUBGRADE, SUB-BASE OR BASE COURSE TO THE PLAN CROSS SECTION BEFORE

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THE BASE COURSE IS PLACED ON THE STREET. DO NOT PLACE SUB-BASE COURSE ON WET OR MUDDY SUBGRADE OR SUB-BASE COURSE. MAINTAIN AT LEAST ONE COMPLETED AREA OF FINISHED AND ACCEPTED SUBGRADE OR SUB-BASE COURSE IN ADVANCE OF PLACING BASE COURSE.

3.2 PLACEMENT AND SPREADING

- A. MIX AND PLACE THE MATERIAL IN MAXIMUM 6-INCH (15 CM) HORIZONTAL LAYERS LOOSE THICKNESS. DEPOSIT AND SPREAD EACH LOAD OF MATERIAL ON THE PREPARED SUBGRADE, OR ON A COMPLETED SUB-BASE COURSE LAYER CONTINUOUSLY WITHOUT BREAKS. ASSURE HAULING OVER THE SUBGRADE OR OVER ANY COMPLETED SUB BASE COURSE DOES NOT DAMAGE THE SUBGRADE, SUB-BASE OR BASE COURSE.
- B. SPREAD USING DUMP BOARDS, SPREADER BOXES, OR MOVING VEHICLES EQUIPPED TO DISTRIBUTE THE MATERIAL IN A UNIFORM LAYER OR A WINDROW. PLACE AND SPREAD THE MATERIAL IN A UNIFORM LAYER TO THE SPECIFIED DEPTH WITHOUT CAUSING SEGREGATION. ONCE THE BASE COURSE IS SPREAD, BLADE-MIX IT THE FULL DEPTH BY ALTERNATELY BLADING THE ENTIRE LAYER TO THE CENTERLINE AND BACK TO THE ROADWAY EDGE.
- C. FOR MULTIPLE LAYERS, MIX EACH LAYER AS SPECIFIED ABOVE. BLADE SMOOTH AND COMPACT EACH LAYER BEFORE PLACING THE SUCCEEDING LAYER.
- D. UNIFORMLY ADD WATER, WHEN REQUIRED, ON SITE AND PLACE IN AMOUNTS REQUIRED TO COMPACT THE MATERIAL AS NECESSARY TO AID IN DENSIFICATION AND TO LIMIT SEGREGATION. MAINTAIN AN ADEQUATE WATER SUPPLY DURING THE WORK. ASSURE THE EQUIPMENT USED FOR WATERING IS OF THE CAPACITY AND DESIGN TO PROVIDE UNIFORM WATER APPLICATION.
- E. APPLY WATER DURING THE WORK TO CONTROL DUST AND TO MAINTAIN THE BASE COURSE IN A DAMP CONDITION.
- F. WHERE CRUSHED SUB-BASE IS SPECIFIED, PRODUCE A PRODUCT WITH AT LEAST 25% OF THE MATERIAL RETAINED ON THE NO.4 SIEVE HAVING ONE OR MORE FRACTURED FACES.
- G. WATER REQUIRED FOR COMPACTING BASE GRAVEL MAY BE OBTAINED FROM THE MUNICIPAL SYSTEM IF APPROVED BY THE OWNER, OR FROM OTHER SOURCES.
- H. COMPACT THE MATERIAL USING APPROPRIATE TAMPING EQUIPMENT OR POWER ROLLERS. CORRECT ALL IRREGULARITIES OR DEPRESSIONS THAT DEVELOP UNDER ROLLING BY SCARIFYING THE MATERIAL AND ADDING OR REMOVING MATERIAL, AS REQUIRED, UNTIL THE SURFACE MEETS SPECIFICATIONS.
- I. BLADE AND COMPACT ALTERNATELY, AS REQUIRED TO PRODUCE THE SPECIFIED SURFACE UNTIL FINAL INSPECTION. TAMP THE MATERIAL ALONG CURBS, HEADERS, MANHOLES, AND SIMILAR STRUCTURES AND ALL PLACES INACCESSIBLE TO ROLLERS USING APPROVED MECHANICAL TAMPERS OR HAND TAMPERS MEET FIELD DENSITY REQUIREMENTS.

3.3 FIELD DENSITY REQUIREMENTS

- A. FURNISH WATERING AND ROLLING TO OBTAIN A MINIMUM FIELD DENSITY OF 95 PERCENT OF THE MAXIMUM DRY DENSITY DETERMINED BY AASHTO T99. NO SEPARATE COMPENSATION IS ALLOWED FOR ROLLING AND WATERING THE SUB-BASE COURSE OTHER THAN THE SUB-BASE COURSE BID ITEM OR ITEMS LISTED ON THE CONTRACT DOCUMENTS.

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3.4 SURFACE TOLERANCES

- A. FINISH THE SUB-BASE COURSE SO THAT WHEN TESTED USING A 10-FOOT (3 M) STRAIGHT EDGE PLACED ON THE SURFACE WITH ITS CENTER LINE PARALLEL TO THE STREET CENTER, THE MAXIMUM SURFACE DEVIATION FROM THE STRAIGHT EDGE DOES NOT EXCEED 1/2-INCH (12.7 MM). ADDITIONALLY, THE FINISHED GRADE CANNOT DEVIATE MORE THAN 0.1 FOOT (30 MM) AT ANY POINT FROM THE STAKED ELEVATION AND THE SUM OF THE DEVIATIONS FROM TWO POINTS NOT MORE THAN 30 FEET (9.14 M) APART CANNOT EXCEED 0.1 FEET (30 MM).
- B. PERFORM ALL SUB BASE COURSE CORRECTIONS TO MEET THE ABOVE TOLERANCES USING APPROVED METHODS AND MATERIALS. PAYMENT FOR PATCHING AGGREGATE IS AT THE UNIT PRICE BID FOR THE SUB-BASE COURSE MATERIAL.

PART 4: MEASUREMENT AND PAYMENT

4. 1 CUBIC YARD BASIS: SUB-BASE COURSE

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE CUBIC YARDS (CUBIC METERS) OF UNCRUSHED OR CRUSHED, SUB-BASE COURSE OF THE SPECIFIED GRADATIONS, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR_"MINUS CRUSHED OR UNCRUSHED SUB BASE COURSE", WHICH CONSTITUTES FULL COMPENSATION FOR FURNISHING, LOADING, HAULING, SPREADING, BLENDING, SHAPING, WATERING, AND COMPACTING THE SUB-BASE COURSE MATERIAL, AND FOR ALL TOOLS, LABOR AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- B. PAYMENT IS MADE UNDER:
 - 1. _____" MINUS UNCRUSHED SUB BASE COURSE - PER CUBIC YARD.(CUBIC METER)
 - 2. _____" MINUS CRUSHED SUB BASE COURSE - PER CUBIC YARD. (CUBIC METER)

4. 2 SQUARE YARD BASIS: SUB BASE COURSE

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE SQUARE YARD (SQUARE METER) OF SUB BASE SURFACE AREA FOR FURNISHING CRUSHED OR UNCRUSHED, SUB-BASE COURSE OF THE THICKNESS AND GRADATIONS SPECIFIED, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR _____" THICKNESS OF _____" MINUS CRUSHED OR UNCRUSHED SUB BASE COURSE", WHICH CONSTITUTES FULL COMPENSATION FOR FURNISHING, LOADING, HAULING, SPREADING, SHAPING, BLENDING, WATERING AND COMPACTING THE SUB-BASE COURSE MATERIAL, AND FOR ALL TOOLS, LABOR AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- B. PAYMENT IS MADE UNDER:
 - 1. _____" THICKNESS OF _____" MINUS UN-CRUSHED SUB-BASE COURSE-PER SQUARE YARD (SQUARE METER).
 - 2. _____" THICKNESS OF _____" MINUS CRUSHED SUB-BASE COURSE-PER SQUARE YARD (SQUARE METER).

4. 3 LINEAR FOOT BASIS: SUB BASE COURSE

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE LINEAR FEET OF TRENCH RESTORED, MEASURED ALONG THE TRENCH CENTERLINE, WITH CRUSHED OR UNCRUSHED, SUB-BASE

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COURSE OF THE GRADATIONS SPECIFIED, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR _____" MINUS CRUSHED OR UNCRUSHED SUB-BASE COURSE", WHICH CONSTITUTES FULL COMPENSATION FOR FURNISHING, LOADING, HAULING, SPREADING, BLENDING, SHAPING, WATERING, AND COMPACTING THE SUB-BASE COURSE MATERIAL, AND FOR ALL TOOLS, LABOR AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

B. PAYMENT IS MADE UNDER:

1. _____" MINUS UNCRUSHED SUB-BASE COURSE - PER LINEAR FOOT (LINEAR METER).
2. _____" MINUS CRUSHED SUB-BASE COURSE - PER LINEAR FOOT (LINEAR METER).

END OF SECTION 02234

SECTION 02235 - CRUSHED BASE COURSE

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS THE PLACING OF ONE OR MORE BASE COURSES COMPOSED OF CRUSHED GRAVEL, STONE OR OTHER SIMILAR MATERIALS MEETING THE GRADATION AND OTHER QUALITY CRITERIA SPECIFIED HEREIN.

1.2 REFERENCES

AASHTO T11	AMOUNT FINER THAN NO. 200 (0.075 MM) SIEVE IN AGGREGATE
AASHTO T27	SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
AASHTO T89	DETERMINING LIQUID LIMIT OF SOILS
AASHTO T90	DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS
AASHTO T176	SAND EQUIVALENT VALUE OF SOILS AND FINE AGGREGATE AASHTO
T96	RESISTANCE TO DEGRADATION BY ABRASION AND IMPACT IN THE LOS ANGELES MACHINE
AASHTO T99 (ASTM D698)	MOISTURE-DENSITY RELATIONS OF SOILS AND SOIL-AGGREGATE MIXTURES USING 5-LB (2.5 KG) RAMMER AND 12-INCH (305 MM) DROP
ASTM D5821	DETERMINING THE PERCENTAGE OF FRACTURED PARTICLES IN COARSE AGGREGATE
AASHTO T191 (ASTM D1556)	DENSITY OF SOIL IN-PLACE BY SAND CONE METHOD
AASHTO T310 (ASTM D6938)	IN-PLACE DENSITY AND WATER CONTENT OF THE SOIL AND SOIL AGGREGATE BY NUCLEAR METHOD (SHALLOW DEPTH)

1.3 DENSITY CONTROL TESTING

A. FIELD DENSITY TESTING

1. MEET THE QUALITY CONTROL AND QUALITY ASSURANCE TESTING REQUIREMENTS IN SECTION 01400, CONTRACTOR QUALITY CONTROL AND OWNER QUALITY ASSURANCE.
2. IN-PLACE FIELD DENSITY TESTS FOR QUALITY ASSURANCE ARE AT OWNER EXPENSE MEETING AASHTO T191 (ASTM D1556) SAND CONE METHOD OR AASHTO T310 (ASTM D6938) NUCLEAR DENSOMETER METHOD. QUALITY

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ASSURANCE FIELD DENSITY TESTING FREQUENCY IS AT THE DISCRETION OF THE ENGINEER.

3. RETESTING OF FAILING AREAS IS AT THE EXPENSE OF THE CONTRACTOR.

B. LABORATORY MAXIMUM DENSITY AND OPTIMUM MOISTURE

1. MOISTURE DENSITY CURVES WILL BE PROVIDED BY THE CONTRACTOR FOR EACH BASE MATERIAL PROVIDED. THESE WILL BE PROVIDED AT THE EXPENSE OF THE CONTRACTOR.

1.4 MATERIALS SUBMITTALS

1. SUBMIT TO THE ENGINEER GRADATIONS, MOISTURE DENSITY CURVES AND OTHER TEST RESULTS FOR SOURCES TO BE USED FOR BASE MATERIALS PRIOR TO DELIVERY TO THE SITE FOR APPROVAL BY THE ENGINEER. IF RECYCLED MATERIALS ARE PROPOSED, CBR TEST DATA MUST BE SUBMITTED TO THE ENGINEER TO ASSURE CONSISTENCY WITH DESIGN REQUIREMENTS.

PART 2: PRODUCTS

2.1 GENERAL

A. FURNISH AGGREGATE BASE MATERIAL MEETING THE APPLICABLE AGGREGATE QUALITY REQUIREMENTS.

2.2 CRUSHED BASE MATERIAL

- A. CONSISTS OF BOTH FINE AND COARSE FRAGMENTS OF CRUSHED STONE OR CRUSHED GRAVEL, AND/OR NATURAL GRAVEL, AND WHEN APPROVED, BLENDED WITH SAND, FINELY CRUSHED STONE, CRUSHER SCREENINGS, RECYCLED CONCRETE AND/OR ASPHALT OR OTHER SIMILAR MATERIALS.
- B. USE CRUSHED STONE OR GRAVEL CONSISTING OF HARD, DURABLE PARTICLES OF FRAGMENTS OF STONE, FREE OF EXCESS OF FLAT, ELONGATED, SOFT OR DISINTEGRATED PIECES, DIRT, OR OTHER DELETERIOUS MATTER, AND HAVING A PERCENT OF WEAR OF NOT EXCEEDING 50 AT 500 REVOLUTIONS WHEN TESTED UNDER AASHTO T96.
- C. CRUSH MATERIAL SO THAT THE PERCENTAGE OF FRACTURED PARTICLES IN THE FINISHED PRODUCT IS AS CONSTANT AND UNIFORM AS PRACTICAL. CRUSH TO PRODUCE MATERIAL WHERE AT LEAST 35 PERCENT OF THE MATERIAL RETAINED ON THE NO. 4 SIEVE HAS AT LEAST ONE FRACTURED FACE.
- D. INCORPORATE ALL MATERIAL PRODUCED IN THE CRUSHING OPERATION AND PASSING THE NO. 4 MESH SIEVE INTO THE BASE MATERIAL NECESSARY TO MEET THE GRADATION REQUIREMENTS.

2.3 GRADATION

A. AS DETERMINED BY AASHTO METHODS T11 AND T27, FURNISH MATERIAL FOR THE GRADING SPECIFIED IN THE CONTRACT DOCUMENTS INCLUDING BINDER OR FILLER, WHICH MAY HAVE BEEN ADDED AT THE PLANT OR AT THE SITE, MEETING THE REQUIREMENTS OF THAT GRADING IN THE TABLE OF GRADATIONS BELOW:

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TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVE

PASSING	1 1/2" MINUS	1" MINUS	3/4" MINUS
1 1/2 INCH	100		
1 INCH	—	100	
3/4 INCH	—	—	100
1/2 INCH	—	—	—
NO. 4 SIEVE	25 - 60	40 - 70	40 - 70
NO. 10 SIEVE	—	25 - 55	25 - 55
NO. 200 SIEVE	0 - 8	2 - 10	2 - 10

- B. UP TO 5% "OVERSIZED" MATERIAL IS PERMITTED PROVIDED THAT THE "OVERSIZED" MATERIAL PASSES THE SCREEN SIZE IMMEDIATELY LARGER THAN THE TOP SIZE SPECIFIED. THE PRODUCED MATERIAL BETWEEN THE MAXIMUM SCREEN OPENING AND THE NO.4 SIEVE SHALL BE REASONABLY WELL GRADED.
- C. SUITABILITY OF THE AGGREGATE IS BASED ON SAMPLES OBTAINED DURING PLACEMENT IN THE PROJECT WITHIN LIMITS ALLOWED IN THE TABLE FOR THE PARTICULAR GRADING SPECIFIED.
- D. THAT PORTION OF THE FINE AGGREGATE PASSING THE NO. 200 SIEVE MUST BE LESS THAN 60 PERCENT OF THAT PORTION PASSING THE NO. 40 SIEVE.
- E. THE LIQUID LIMIT FOR THAT PORTION OF THE FINE AGGREGATE PASSING A NO. 40 SIEVE CANNOT EXCEED 25, NOR THE PLASTICITY INDEX EXCEED 6, AS DETERMINED BY AASHTO T89 AND T90.

2.4 WATERING:

- A. USE UNCONTAMINATED WATER.

PART 3: EXECUTION

3.1 GENERAL

- A. BEFORE PLACING THE BASE COURSE, SMOOTH AND SHAPE THE SURFACE OF THE UNDERLYING SUBGRADE, SUB-BASE OR BASE COURSE TO THE CROSS SECTION SHOWN ON THE PLANS BEFORE PLACING THE BASE COURSE.
- B. DO NOT PLACE BASE COURSE ON A WET OR MUDDY SUBGRADE OR SUB-BASE COURSE. COMPLETE AT LEAST ONE AREA OF FINISHED AND ACCEPTED SUBGRADE, SUB-BASE OR UNDERLYING BASE BEFORE THE PLACING OF ANY BASE COURSE.

3.2 PLACEMENT AND SPREADING

- A. MIX AND PLACE THE MATERIAL IN MAXIMUM 8 INCHES (20 CENTIMETERS) COMPACTED LAYERS UNLESS OTHERWISE APPROVED. DEPOSIT AND SPREAD EACH LOAD OF MATERIAL ON THE PREPARED SUBGRADE, OR ON A COMPLETED SUB-BASE OR BASE COURSE LAYER CONTINUOUSLY WITHOUT INTERRUPTION. DISCONTINUE OPERATING HAUL UNITS OVER SUBGRADE, OR OVER ANY SUB-BASE OR BASE COURSE COMPLETED IF THE HAUL UNITS

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DAMAGE THE SUBGRADE, SUB-BASE OR BASE COURSE.

- B. DEPOSIT AND SPREAD THE MATERIAL IN A UNIFORM LAYER, WITHOUT SEGREGATION, TO A LOOSE DEPTH SO THAT WHEN COMPACTED, AND MAKING ALLOWANCE FOR ANY FILLER TO BE BLENDED ON THE ROAD, THE LAYER HAS THE SPECIFIED THICKNESS.
- C. SPREAD MATERIAL USING DUMP BOARDS, SPREADER BOXES, OR VEHICLES EQUIPPED TO DISTRIBUTE THE MATERIAL IN A UNIFORM LAYER. THE MATERIAL MAY BE DEPOSITED IN WINDROWS MIXED AND SPREAD AS DESCRIBED BELOW.
- D. CONSTRUCT EACH LAYER MEETING THESE REQUIREMENTS. BLADE SMOOTH AND THOROUGHLY COMPACT EACH LAYER AS SPECIFIED BEFORE PLACING THE SUCCEEDING LAYER.
- E. IF SEGREGATION OR MOISTURE PROBLEMS EXIST, OR IF THE MATERIAL WAS PLACED ON THE ROAD IN WINDROWS, THOROUGHLY BLADE-MIX THE MATERIAL OF THE AFFECTED LAYER BY ALTERNATELY BLADING TO THE CENTER AND BACK TO THE EDGES OF THE STREET.
- F. UNIFORMLY ADD WATER, WHEN REQUIRED, ON SITE AND PLACE IN AMOUNTS REQUIRED TO COMPACT THE MATERIAL AS NECESSARY TO AID IN DENSIFICATION AND TO LIMIT SEGREGATION. MAINTAIN AN ADEQUATE WATER SUPPLY DURING THE WORK. ASSURE THE EQUIPMENT USED FOR WATERING IS OF THE CAPACITY AND DESIGN TO PROVIDE UNIFORM WATER APPLICATION.
- G. APPLY WATER DURING THE WORK TO CONTROL DUST AND TO MAINTAIN THE BASE COURSE IN A DAMP CONDITION IN ACCORDANCE WITH SECTION 01500 UNDER DUST CONTROL.
- H. WATER REQUIRED FOR COMPACTING BASE GRAVEL MAY BE OBTAINED FROM THE MUNICIPAL SYSTEM IF APPROVED BY THE OWNER, OR FROM OTHER SOURCES.

3.3 FIELD DENSITY REQUIREMENTS

- A. COMPACT PLACED MATERIAL THE FULL WIDTH BY ROLLING WITH SUITABLE TAMPING EQUIPMENT OR POWER ROLLERS. CORRECT ALL IRREGULARITIES OR DEPRESSIONS THAT DEVELOP DURING ROLLING BY LOOSENING THE MATERIAL IN THESE PLACES AND ADDING OR REMOVING MATERIAL, AS REQUIRED.
- B. PERFORM BLADING AND COMPACTING ALTERNATELY AS REQUIRED OR DIRECTED, TO MAINTAIN A SMOOTH, EVEN, UNIFORMLY COMPACTED SURFACE UNTIL THE FINAL INSPECTION. ALONG CURBS, HEADERS, MANHOLES, AND SIMILAR STRUCTURES, AND AT ALL PLACES NOT ACCESSIBLE TO THE ROLLER, COMPACT THE BASE COURSE MATERIAL WITH SUITABLE MECHANICAL TAMPERS OR HAND TAMPERS TO REACH THE COMPACTION REQUIREMENTS.
- C. PROVIDE THE WATERING AND ROLLING REQUIRED TO OBTAIN A MINIMUM FIELD DENSITY OF 95 PERCENT OF MAXIMUM DRY DENSITY AS DETERMINED BY AASHTO T99. NO SEPARATE COMPENSATION IS MADE FOR ROLLING AND WATERING THE BASE COURSE OTHER THAN THE BASE COURSE BID ITEM OR ITEMS LISTED ON THE CONTRACT DOCUMENTS.

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3.4 SURFACE TOLERANCES

- A. THE BASE COURSE SURFACE WHEN FINISHED AND TESTED WITH A 10-FOOT (3.0 METER) STRAIGHT EDGE PLACED ON THE SURFACE WITH ITS CENTER LINE PARALLEL TO THE CENTER LINE OF THE STREET, WILL NOT HAVE A SURFACE DEVIATION FROM THE STRAIGHT EDGE EXCEEDING 3/8- INCH (1.0 CENTIMETER). ADDITIONALLY, THE FINISHED GRADE CANNOT DEVIATE MORE THAN 0.05 FEET (1.5 CENTIMETERS) AT ANY POINT FROM THE STAKED ELEVATION, AND FURTHER, THE SUM OF THE DEVIATIONS FROM TWO POINTS NOT MORE THAN 30 FEET (9.0 METERS) APART CANNOT EXCEED 0.05 FEET (1.5 CENTIMETERS).
- B. FOR BASE COURSE RECEIVING ASPHALT CONCRETE SURFACING, THE FINISHED GRADE CANNOT DEVIATE MORE THAN 0.02 FEET (0.6 CENTIMETERS) AT ANY POINT FROM THE STAKED ELEVATIONS, AND THE SUM OF THE DEVIATIONS FROM TWO POINTS NOT MORE THAN 30 FEET (9.0 METERS) APART CANNOT EXCEED 0.02 FEET (0.6 CENTIMETERS).
- C. IF PATCHING OF THE BASE COURSE IS NECESSARY TO MEET THE TOLERANCES, PERFORM PATCHING USING METHODS AND AGGREGATES APPROVED BY THE ENGINEER. PAYMENT FOR PATCHING AGGREGATE IS AT THE UNIT PRICE BID FOR THE BASE COURSE MATERIAL.

PART 4: MEASUREMENT AND PAYMENT

4. 1 CUBIC YARD BASIS: CRUSHED BASE COURSE.

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE CUBIC YARDS (CUBIC METERS) OF CRUSHED BASE COURSE OF THE GRADATIONS SPECIFIED IN THE CONTRACT DOCUMENTS, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR ____ "MINUS CRUSHED BASE COURSE". PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, CRUSHING, LOADING, HAULING, SPREADING, SHAPING, WATERING AND COMPACTING THE BASE COURSE MATERIAL, AND FOR ALL TOOLS, LABOR AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- B. PAYMENT IS MADE UNDER:
 - 1. ____ " MINUS CRUSHED BASE COURSE - PER CUBIC YARD (CUBIC METERS).

4. 2 SQUARE YARD BASIS: CRUSHED BASE COURSE.

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE SQUARE YARDS (SQUARE METERS) OF CRUSHED BASE COURSE SURFACE AREA FOR FURNISHING CRUSHED BASE COURSE OF THE THICKNESS AND GRADATIONS SPECIFIED IN THE CONTRACT DOCUMENTS, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR ____ " THICKNESS OF ____ " MINUS CRUSHED BASE COURSE". PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, CRUSHING, LOADING, HAULING, SPREADING, SHAPING, WATERING AND COMPACTING THE BASE COURSE MATERIAL, AND FOR ALL TOOLS, LABOR AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- B. PAYMENT IS MADE UNDER:
 - 1. ____ " THICKNESS OF ____ " MINUS CRUSHED BASE COURSE - PER SQUARE YARD (SQUARE METER).

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CRUSHED BASE COURSE

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4. 3 LINEAR FOOT BASIS: CRUSHED BASE COURSE.

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE LINEAR FEET (LINEAR METERS) OF TRENCH RESTORED, MEASURED ALONG THE TRENCH CENTERLINE, WITH CRUSHED BASE COURSE OF THE GRADATIONS SPECIFIED IN THE CONTRACT DOCUMENTS, COMPLETED IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR _____" MINUS CRUSHED BASE COURSE". PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, CRUSHING, LOADING, HAULING, SPREADING, SHAPING, BLENDING, WATERING AND COMPACTING THE BASE COURSE MATERIAL, AND FOR ALL TOOLS, LABOR AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- B. PAYMENT IS MADE UNDER:
1. _____" MINUS CRUSHED BASE COURSE - PER LINEAR FOOT (LINEAR METER).

END OF SECTION 02235

SECTION 02502 - ASPHALT PRIME AND/OR TACK COAT

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS THE SINGLE APPLICATION OF ASPHALT MATERIAL AS SPECIFIED IN THE CONTRACT DOCUMENTS ON A PREPARED SUB-GRADE, SUB-BASE, BASE OR ASPHALT SURFACE MEETING THE PLANS AND SPECIFICATIONS.

PART 2: PRODUCTS

2.1 GENERAL

- A. FURNISH ASPHALT MATERIAL GRADE AND TYPE AS SPECIFIED BELOW MEETING THE REQUIREMENTS OF TABLE 1 AND TABLE 2 IN THIS SECTION.

TYPE AND GRADE

USE

LIQUID ASPHALT, MC-70
COAT EMULSIFIED ASPHALT, CRS-1 OR CRS-2

ASPHALT PRIME COAT EMULSIFIED ASPHALT, SS-1 OR SS-1
ASPHALT TACK ASPHALT TACK COAT

- B. FURNISH BLOTTER SAND AS SPECIFIED BELOW MEETING THE REQUIREMENTS OF MDT 407.02.2.

1. BLOTTER MATERIAL SHALL BE 100% PASSING THE ½-INCH (12.5 MM) SCREEN HAVING A PI OF 6 OR LESS.

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ASPHALT PRIME AND/OR TACK COAT

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**TABLE 1
SPECIFICATIONS FOR ANIONIC EMULSIFIED ASPHALTS**

TYPE	RAPID SETTING				MEDIUM SETTING						SLOW SETTING			
GRADE	RS-1		RS-2		MS-1		MS-2		MS-2H		SS-1		SS-1H	
TEST OF EMULSIONS:	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
VISCOSITY, SAYBOLT-FUROL AT 77°F (25°C)	20	100	...	...	20	100	100	...	100	...	20	100	20	100
VISCOSITY, SAYBOLT-FUROL AT 122°F (50°C)	...	...	75	400	...	...	...	...	...	...	...	...	...	...
DEMULSIBILITY*, 35ML, 0.02N CaCl ₂ , PERCENT	60	...	60	...	...	...	...	...	...	...	...	...	...	...
RESIDUE BY DISTILLATION, PERCENT	55	...	63	...	55	...	65	...	65	...	57	...	57	...
TEST ON RESIDUE FROM DISTILLATION TESTS														
PENETRATION, 77°F (25°C), 100G, 5S	100	200	100	200	100	200	100	20	40	90	100	200	40	90
DUCTILITY, 77°F (25°C), 5CM/MIN, CM.	40	...	40	...	40	...	40	...	40	...	40	...	40	...
SOLUBILITY IN TRICHLOROETHYLENE	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...
SUGGESTED USES:	SURFACE TREATMENT PENETRATION MACADAM AND TACK COAT		SURFACE TREATMENT AND PENETRATION MACADAM		PLANT OR ROAD MIXTURE WITH COURSE AGGREGATE, SUBSTANTIALLY ALL OF WHICH IS RETAINED ON A NO. 8 (2.36 MM) SIEVE AND PRACTICALLY NONE OF WHICH PASSES A NO. 200 (0.075 MM) SIEVE, TACK		PLANT OR ROAD MIXTURE WITH COURSE AGGREGATE, SUBSTANTIALLY ALL OF WHICH IS RETAINED ON A NO. 8 (2.36 MM) SIEVE AND PRACTICALLY NONE OF WHICH PASSES A NO. 200 (0.075 MM) SIEVE.		PLANT OR ROAD MIXTURE WITH COURSE AGGREGATE, SUBSTANTIALLY ALL OF WHICH IS RETAINED ON A NO. 8 (2.36 MM) SIEVE AND PRACTICALLY NONE OF WHICH PASSES A NO. 200 (0.075 MM) SIEVE.		PLANT OR ROAD MIXTURE WITH GRADED AND FINE AGGREGATES, SUBSTANTIALLY QUANTITY OF WHICH PASSES A NO. 8 (2.36 MM) SIEVE AND A PORTION OF WHICH MAY PASS A NO. 200 (0.075 MM) SIEVE. SLURRY SEAL TREATMENT.			
* THE DEMULSIBILITY TEST SHALL BE MADE WITHIN 30 DAYS FROM THE DATE OF SHIPMENT.														

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**TABLE 2
SPECIFICATIONS FOR CATIONIC EMULSIFIED ASPHALTS ASSHTO M208**

TYPE	RAPID SETTING				MEDIUM SETTING						SLOW SETTING		
GRADE	CRS-1		CRS-2		CMS-1		CMS-2H		CSS-1		CSS-1H		
TEST OF EMULSIONS:	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
VISCOSITY, SAYBOLT-FUROL AT 77°F (25°C)	...	...	...	...	...	...	...	...	...	20	100	20	100
VISCOSITY, SAYBOLT-FUROL AT 122°F (50°C)	...	20	100	100	400	50	450	50	450	...	...	...	...
DEMULSIBILITY ^A 35ML, 0.08% SODIUM DIOCTYL SULTROSUCCINATE, %	40	...	40	...	...	...	...	...	...	...	...	...	...
PARTICLE CHARGE TEST	POS	...	POS	...	POS	...	POS	...	POS ^B	...	...	...	POS ^B
DISTILLATION: OIL DISTILLATION BY VOLUME OF EMULSION, PERCENT	...	...	3	...	3	...	12	...	12	...	...	...	...
RESIDUE, PERCENT	60	...	...	65	...	65	...	65	...	...	57	...	57
TEST ON RESIDUE FROM DISTILLATION TESTS													
PENETRATION, 77°F (25°C), 100G, 5S	100	250	100	250	100	250	40	90	100	250	40	90	...
DUCTILITY, 77°F (25°C), 5CM/MIN, CM.		40	...	40	...	40	...	...	40	...	40	...	40
SOLUBILITY IN TRICHLOROETHYLENE	97.5	...	...	97.5	...	97.5	...	97.5	...	...	97.5	...	97.5
SUGGESTED USES:	SURFACE TREATMENT		SURFACE TREATMENT		PLANT OR ROAD MIXTURE WITH COURSE AGGREGATE,				PLANT OR ROAD MIXTURE WITH GRADED AND FINE AGGREGATES, A				
^A THE DEMULSIBILITY TEST SHALL BE MADE WITHIN 30 DAYS FROM THE DATE OF SHIPMENT. ^B IF THE PARTICLE CHARGE TEST RESULT IS INCONCLUSIVE, MATERIAL HAVING A MAXIMUM PH VALUE OF 6.7 WILL BE ACCEPTABLE.													

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ASPHALT PRIME AND/OR TACK COAT

PART 3: EXECUTION

3.1 DISTRIBUTORS.

- A. USE A PRESSURE DISTRIBUTOR FOR PRIME AND TACK COATS THAT DISTRIBUTES THE REQUIRED AMOUNT OF ASPHALTIC MATERIAL AT THE SPECIFIED TEMPERATURE IN A UNIFORM SPRAY, WITHOUT ATOMIZATION. ASSURE THE DISTRIBUTOR IS PNEUMATIC TIRED AND DOES NOT RUT OR OTHERWISE DAMAGE THE SURFACE BEING SPRAYED. EQUIP IT WITH A BITUMETER HAVING A DIAL VISIBLE TO THE TRUCK DRIVER FOR MAINTAINING THE CONSTANT SPEED REQUIRED FOR APPLICATION AT THE SPECIFIED RATE.
- B. ASSURE THE PUMP IS OPERATED BY A SEPARATE POWER UNIT OR BY THE TRUCK POWER UNIT. EQUIP THE PUMP WITH A TACHOMETER HAVING A DIAL READILY VISIBLE TO THE OPERATOR, REGISTERING GALLONS PER MINUTE PASSING THROUGH THE NOZZLES.
- C. THE DISTRIBUTOR SHALL BE DESIGNED SO THAT THE NORMAL WIDTH OF APPLICATION SHALL BE NOT LESS THAN 12 FEET (3.66 M), WITH PROVISION FOR THE APPLICATION OF LESSER OR GREATER WIDTH WHEN NECESSARY. THE DISTRIBUTOR SHALL BE DESIGNED OR EQUIPPED SO THAT THE HEIGHT OF THE SPRAY BAR ABOVE THE SURFACE TO BE SPRAYED, MAY BE SET AND MAINTAINED WITHIN A TOLERANCE OF 1/2 INCH (13 MM) (PLUS OR MINUS) OF THE HEIGHT REQUIRED TO PROVIDE A UNIFORM APPLICATION.
- D. ASSURE THE DISTRIBUTOR IS EQUIPPED AND OPERATED SO THAT THE ASPHALTIC MATERIAL IS CIRCULATED OR AGITATED THROUGHOUT THE ENTIRE HEATING SYSTEM. PROVIDE A MEANS FOR CONSTANT, ACCURATE TEMPERATURE INDICATION OF THE ASPHALTIC MATERIAL IS PROVIDED. ASSURE THE THERMOMETER WELL IS PLACED WITHOUT CONTACTING THE HEATING TUBE.

3.2 ASPHALT PRIME COAT.

- A. ASPHALT PRIME COAT WILL BE APPLIED ONLY IF SPECIFIED IN THE PLANS OR SPECIAL PROVISIONS. SEE SECTION 02502.4.
- B. SPRAY THE ASPHALT PRIME COAT, UNDER AVERAGE CONDITIONS, FROM 0.20 TO 0.50 GALLONS PER SQUARE YARD (0.9 TO 8.2 LITERS PER SQUARE METER) OF LOW VISCOSITY MC-70 ASPHALT ON THE PREPARED SURFACE OF A NON-ASPHALTIC BASE COURSE.
- C. IMMEDIATELY BEFORE APPLYING THE PRIME COAT, CLEAN THE SURFACE TO BE PRIMED OF ALL DIRT AND LOOSE MATERIALS USING BLOWERS OR A POWER BROOM, SUPPLEMENTED BY HAND BROOMING IF NECESSARY. FINISH THE SURFACE TO RECEIVE THE ASPHALT MATERIAL TO THE SPECIFIED REQUIREMENTS FOR SMOOTHNESS, COMPACTION, AND GRADE. APPLY PRIME COAT WHEN THE SURFACE IS DRY OR SLIGHTLY DAMP AND WHEN THE AIR TEMPERATURE IN THE SHADE IS NOT LESS THAN 50° F (10° C).
- D. APPLY ASPHALT MATERIAL USING A PRESSURE DISTRIBUTOR AT THE RATE OR RATES DIRECTED BY THE ENGINEER.
- E. BEFORE SPRAYING, SPREAD BUILDING PAPER OVER THE SURFACE FROM THE JOINT BACK, FOR THE DISTANCE REQUIRED FOR THE SPRAY BAR TO BEGIN SPRAYING AND OPERATING AT FULL FORCE WHEN THE SURFACE TO BE TREATED IS REACHED. ONCE THE ASPHALT IS APPLIED, REMOVE AND DISPOSE OF THE BUILDING PAPER. ASSURE THE SPRAY BAR IS SHUT OFF INSTANTANEOUSLY AT EACH CONSTRUCTION JOINT TO ASSURE A STRAIGHT LINE AND FULL APPLICATION OF ASPHALT PRIME UP TO THE JOINT. IF REQUIRED TO PREVENT DRIPPING, INSERT A DRIP PAN UNDER THE NOZZLE WHERE THE APPLICATION ENDS. USE A HAND SPRAYER TO APPLY PRIMER MATERIAL TO TOUCH UP ALL SPOTS MISSED BY THE DISTRIBUTOR.

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- F. PROTECT THE SURFACES OF STRUCTURES AND TREES ADJACENT TO THE AREA BEING TREATED FROM BEING SPATTERED OR MARRED. DO NOT DISCHARGE ASPHALT MATERIAL INTO BORROW PITS OR GUTTERS.
- G. AFTER THE PRIME COAT HAS BEEN APPLIED, ASSURE IT IS LEFT UNDISTURBED FOR AT LEAST 24 HOURS OR UNTIL IT IS CURED OR BLOTTED. BLOT ALL EXCESS ASPHALT MATERIAL REMAINING ON THE SURFACE AFTER 24 HOURS WITH SAND BEFORE OPENING THE SURFACE TO TRAFFIC. MAINTAIN THE PRIMED OR TACKED SURFACE UNTIL THE SURFACING HAS BEEN PLACED. MAINTENANCE INCLUDES SPREADING ANY ADDITIONAL SAND REQUIRED TO PREVENT ASPHALT MATERIAL ADHERING TO THE TIRES OF VEHICLES USING THE SURFACE AND PATCHING ALL BREAKS IN THE SURFACE WITH ADDITIONAL BITUMINOUS MATERIAL. ANY AREA OF SURFACE DISTURBED BY TRAFFIC OR OTHERWISE, IS TO BE CLEANED BEFORE THE NEXT COURSE IS PLACED. BEFORE PLACING THE SURFACE COURSE, SWEEP ALL EXCESS AND/OR LOOSE SAND USED FOR BLOTTER FROM THE SURFACE.

3.3 ASPHALT TACK COAT.

- A. THE ASPHALT TACK COAT IS THE APPLICATION OF A DILUTED, SLOW-BREAKING, SS-1 OR SS-1H ASPHALT EMULSION TO INSURE BOND BETWEEN THE SURFACE BEING PAVED AND THE OVERLYING COURSE. IMMEDIATELY BEFORE APPLYING THE TACK COAT, CLEAN THE SURFACE TO BE TACKED OF ALL DIRT AND LOOSE MATERIALS USING BLOWERS OR POWER BROOMS, SUPPLEMENTED BY HAND BROOMING IF NECESSARY.
- B. APPLY TACK COAT WHEN THE SURFACE IS DRY OR SLIGHTLY DAMP, AND WHEN THE AIR TEMPERATURE IN THE SHADE IS AT LEAST 50° F (10° C).
- C. DILUTE THE ASPHALT EMULSION, SS-1 OR S-1H, WITH WATER AT ONE PART EMULSION TO ONE PART WATER. APPLY THE DILUTED EMULSION USING A PRESSURE DISTRIBUTOR AT THE RATE OF 0.1 GALLON PER SQUARE YARD (4.5 LITERS PER SQUARE METER).
- D. BEFORE APPLICATION, SPREAD BUILDING PAPER OVER THE SURFACE, FROM THE JOINT BACK, FOR THE REQUIRED DISTANCE FOR THE SPRAY BAR TO BEGIN SPRAYING AND OPERATING AT FULL FORCE WHEN THE SURFACE TO BE TREATED IS REACHED. ONCE THE ASPHALT IS APPLIED, REMOVE AND DISPOSE OF THE BUILDING PAPER. SHUT OFF THE SPRAY BAR SHALL INSTANTANEOUSLY AT EACH CONSTRUCTION JOINT TO ASSURE A STRAIGHT LINE AND FULL APPLICATION OF ASPHALT PRIME UP TO THE JOINT. IF REQUIRED TO PREVENT DRIPPING, INSERT A DRIP PAN UNDER THE NOZZLE WHERE THE APPLICATION IS STOPPED. USE A HAND SPRAYER TO APPLY PRIMER MATERIAL FOR TOUCHING UP ALL SPOTS MISSED BY THE DISTRIBUTOR.
- E. AFTER THE TACK COAT HAS BEEN APPLIED, ASSURE IT IS UNDISTURBED UNTIL THE ASPHALT EMULSION HAS "BROKEN", GENERALLY WITHIN 30 MINUTES OF APPLICATION. PLACE THE NEXT PAVING COURSE AFTER THE EMULSION HAS BROKEN.
- F. SCHEDULE OPERATIONS SO THAT ALL TACK COATS ARE PLACED WITH THE ASPHALT-PAVING COURSE IN THE SAME DAY.

PART 4: MEASUREMENT AND PAYMENT:

4. 1 ASPHALT PRIME COAT

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE SQUARE YARD (METER) OR TON (METRIC TON) ASPHALT PRIME COAT MATERIAL, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR "MC-70 ASPHALT PRIME COAT".

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- B. PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL DEMURRAGE, STORAGE, HANDLING, AND OTHER CHARGES; ALL MATERIAL (INCLUDING THE ASPHALT PRIME COAT MATERIAL), TOOLS, EQUIPMENT, LABOR AND PERFORMANCE OF ALL WORK NECESSARY TO THE FURNISHING, TESTING, DELIVERY, UNLOADING, HEATING, HAULING AND SPREADING OF THE ASPHALT PRIME COAT, CLEANING THE SURFACE TO BE PRIMED, BLOTTING EXCESS PRIME MATERIAL, MAINTAINING THE PRIMED SURFACE, AND ALL INCIDENTALS NECESSARY TO COMPLETE THE ITEM.
- C. PAYMENT IS MADE ONLY FOR THE ASPHALT PRIME COAT MATERIAL REQUIRED AND ACTUALLY USED IN THE WORK. THE OWNER ACCEPTS NO RESPONSIBILITY FOR ANY MATERIAL SHIPPED ONTO THE PROJECT IN EXCESS OF REQUIREMENTS BECAUSE OF TANK-TRUCK OR TANK-CAR CAPACITIES OR FOR OTHER REASONS.
- D. PAYMENT IS MADE UNDER:
 - 1. MC-70 ASPHALT PRIME COAT:
 - A. PER SQUARE YARD (SQUARE METER)
 - B. PER TON (METRIC TON)

4. 2 ASPHALT TACK COAT.

- A. THIS IS MEASURED AND PAID FOR BY THE GALLON (LITER) OF UNDILUTED, ASPHALT TACK COAT MATERIAL, COMPLETE IN-PLACE, AT THE CONTRACT UNIT PRICE BID FOR "SS-1 OR SS-1H ASPHALT TACK COAT".
- B. PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL DEMURRAGE, STORAGE, HANDLING, AND OTHER CHARGES; ALL MATERIAL (INCLUDING THE ASPHALT TACK COAT MATERIAL AND WATER FOR DILUTING), TOOLS, EQUIPMENT, LABOR AND PERFORMANCE OF ALL WORK NECESSARY TO THE FURNISHING, TESTING, DELIVERY, UNLOADING, HEATING, DILUTING, HAULING AND SPREADING OF THE ASPHALT TACK COAT, CLEANING THE SURFACE TO BE TACKED, MAINTAINING THE TACKED SURFACE, AND ALL INCIDENTALS NECESSARY TO COMPLETE THE ITEM.
- C. PAYMENT IS MADE ONLY FOR THE ASPHALT TACK COAT MATERIAL REQUIRED AND ACTUALLY USED IN THE WORK. THE OWNER ACCEPTS NO RESPONSIBILITY FOR ANY MATERIAL SHIPPED ONTO THE PROJECT IN EXCESS OF REQUIREMENTS BECAUSE OF TANK-TRUCK OR TANK-CAR CAPACITIES OR FOR OTHER REASONS.
- D. PAYMENT IS MADE UNDER:
 - 1. SS-1 OR SS-1H ASPHALT TACK COAT
 - A. PER GALLON (LITER)
 - B. PER SQUARE YARD (SQUARE METER)

4. 3 TONNAGE BASIS: BLOTTER – SAND.

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE TON OF 2,000 POUNDS (900 KG) FOR THE ITEM IN THE CONTRACT DOCUMENTS AT THE CONTRACT UNIT PRICE BID FOR BLOTTER - SAND.
- B. PRICE AND PAYMENT IS FULL COMPENSATION FOR THE FURNISHING, DELIVERING, AND PLACING OF THE MATERIAL; FOR BROOMING, FOR CLEANING THE EXISTING SURFACE, FOR REMOVAL OF THE EXCESS AGGREGATE AND CLEANING GUTTERS, AND FOR ALL LABOR, EQUIPMENT, TOOLS, AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

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ASPHALT PRIME AND/OR TACK COAT

- C. PAYMENT IS MADE UNDER:
 - 1. BLOTTER – SAND
 - A. PER TON (METRIC TON)

END OF SECTION 02502

SECTION 02510 - ASPHALT CONCRETE PAVEMENT

PART 1: GENERAL

1.1 DESCRIPTION:

- A. THIS WORK IS THE PRODUCTION AND PLACEMENT OF PLANT MIX ASPHALT CONCRETE PAVEMENT.
- B. HOT PLANT MIX ASPHALT CONCRETE IS A MINERAL AGGREGATE AND ASPHALT MATERIAL MIXED AT A CENTRAL HOT PLANT MEETING THESE SPECIFICATIONS AND PLACED IN ONE OR MORE COURSES ON A NEWLY PREPARED OR EXISTING STREET ROADWAY IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.

1.2 REFERENCES:

AASHTO T11 (ASTM D1140) ASTM D5361	AMOUNT OF MATERIAL FINER THAN NO. 200 (0.075 MM) SIEVE IN AGGREGATE STANDARD PRACTICE FOR SAMPLING COMPACTED BITUMINOUS MIXTURES FOR LABORATORY TESTING SIEVE ANALYSIS OF FINE AND COARSE
AASHTO T27 (ASTM C136) AASHTO T89 (ASTM D4318) AASHTO T90 (ASTM D4318) AASHTO T283 (ASTM D4867) AASHTO T176 (ASTM D2419) AASHTO T245 (ASTM D6926, D6927) AASHTO T96 (ASTM C131) ASTM D2041	AGGREGATE DETERMINING LIQUID LIMIT OF SOILS DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS RESISTANCE OF COMPACTED ASPHALT MIXTURES TO MOISTURE-INDUCED DAMAGE SAND EQUIVALENT VALUE OF SOILS AND FINE AGGREGATE RESISTANCE TO PLASTIC FLOW OF BITUMINOUS MIXTURES USING MARSHALL APPARATUS RESISTANCE TO DEGRADATION OF SMALL-SIZE COARSE AGGREGATE BY ABRASION AND IMPACT IN THE LOS ANGELES MACHINE THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF BITUMINOUS MIXTURES
ASTM C1097 D3666 INSPECTING ASTM D5821 COARSE	HYDRATED LIME FOR USE IN ASPHALTIC CONCRETE MIXTURES ASTM EVALUATING AND QUALIFYING AGENCIES TESTING AND DETERMINING THE PERCENTAGE OF FRACTURED PARTICLES IN AGGREGATE LIGHTWEIGHT PARTICLES IN
ASTM C123 AGGREGATE ASTM D6307 STM C142 MS-2	ASPHALT CONTENT OF HOT MIX ASPHALT BY IGNITION METHOD CLAY LUMPS AND FRIABLE PARTICLES IN AGGREGATES ASPHALT INSTITUTE – MIX DESIGN METHODS

PART 2: PRODUCTS

2.1 GENERAL:

- A. THE ASPHALT CONCRETE SURFACE COURSE MUST HAVE AT LEAST A 3-BIN SEPARATION, WHEN CONTINUOUS FLOW MIXING TYPES OF PLANTS ARE USED. WHEN A DRUM DRYER IS USED WITH A WEIGHT BATCHING SYSTEM FROM DRY BINS, SEPARATE AND STOCKPILE THE CRUSHED AGGREGATE INTO TWO SIZES.
- B. THE SPECIFIC TYPE AND GRADING OF AGGREGATE SHALL BE AS INDICATED ON THE PLANS OR IN THE CONTRACT DOCUMENTS. THE TYPES AND GRADES ARE DESCRIBED IN THIS SPECIFICATION.
- C. THE FURNISHING OF ASPHALT MATERIALS FOR USE IN ASPHALTIC CONCRETE MIXES SHALL MEET THE REQUIREMENTS FOR THE PARTICULAR GRADE SPECIFIED IN THE CONTRACT DOCUMENTS. THE TYPES AND GRADES ARE DESCRIBED IN THIS SPECIFICATION.
- D. PREPARE PAVEMENT COURSE TO CONFORM TO THE LINES, GRADES, THICKNESS AND TYPICAL CROSS SECTIONS SHOWN IN PROJECT DOCUMENTS AND PLANS, AND SHALL BE ROLLED, FINISHED, AND APPROVED BY THE ENGINEER BEFORE THE PLACEMENT OF THE NEXT COURSE.

2.2 PLANT MIX AGGREGATES

- A. FURNISH AGGREGATES FROM ACCEPTABLE SOURCES APPROVED BY THE ENGINEER.
- B. FURNISH TEST DATA AS OUTLINED IN THIS SECTION ON EACH SOURCE TO BE USED FOR ACCEPTANCE BY THE ENGINEER.
- C. DESIGNATION OF THE SOURCE OF SUPPLY AND THE ACCEPTABILITY OF THE MATERIAL THERE FROM, DOES NOT EXTEND TO THE GRADING OF THE MATERIAL AS IT MAY NATURALLY COME FROM THE PIT OR CRUSHER. ADJUST THE CRUSHER AND SCREENS TO REMOVE CERTAIN PORTIONS OF THE MATERIAL AS MAY BE NECESSARY TO FURNISH GRAVEL THAT WILL COMPLY WITH THE SPECIFICATIONS IN THE CONTRACT. NO ADDITIONAL COMPENSATION WILL BE ALLOWED FOR SUCH ADJUSTMENT OF THE EQUIPMENT OR THE REJECTION OF WASTE. IT IS UNDERSTOOD THAT THE ENGINEER MAY ORDER PROCUREMENT OF MATERIAL FROM ANY PORTION OF ANY AREA DESIGNATED AS A PIT SITE AND MAY REJECT PORTIONS OF THE DEPOSIT AS UNACCEPTABLE.
- D. AGGREGATE MATERIALS SHALL NOT CONTAIN MORE THAN 1.5% BY WEIGHT OF CLAY LUMPS, SHALE, OR COAL, NOR SHALL LIGHT WEIGHT PARTICLES EXCEED 3.5% BY WEIGHT. NO COMBINATION OF CLAY, SHALE, COAL, OR LIGHTWEIGHT PARTICLES SHALL EXCEED 3.5% BY WEIGHT. DO NOT USE SCORIA (FIRED CLAY). AGGREGATE MATERIALS SHALL CONFORM TO THE GRADING STIPULATED IN THE CONTRACT DOCUMENTS. USE REASONABLE CARE IN THE SELECTION OF MATERIAL IN A PIT SO THAT UNIFORM PRODUCT WILL BE PRODUCED AT ALL TIMES. NO COMPENSATION WILL BE ALLOWED FOR SUCH STRIPPING OF THE PIT AS MAY BE REQUIRED IN ORDER THAT SATISFACTORY MATERIAL MAY BE SECURED.

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- E. AGGREGATE USED SHALL CONSIST OF GRAVEL, CRUSHED TO THE SPECIFIED SIZE, CRUSHED STONE, COMPOSED OF HARD DURABLE PEBBLES OR STONE FRAGMENTS, RECLAIMED ASPHALT PAVEMENT, AND FINELY CRUSHED STONE FILLER, SAND OR NATURAL CLEAN MATERIAL, OR OTHER FINE MINERAL MATERIAL. THE PORTION OF THE MATERIAL RETAINED ON THE NO. 4 SIEVE (4.74 MM) WILL BE CALLED COARSE AGGREGATE AND THAT PASSING THE NO. 4 SIEVE (4.74 MM) AND RETAINED ON THE #200 SIEVE (0.075 MM) WILL BE CALL FINE AGGREGATE. THE MATERIAL PASSING THE #200 (0.075 MM) WILL BE CALLED MINERAL FILLER. THE RECLAIMED ASPHALT PAVEMENT SHALL BE REMOVED FROM ITS ORIGINAL LOCATION AND REDUCED BY SUITABLE MEANS TO SUCH PARTICLE SIZE AS MAY BE REQUIRED FOR USE IN HOT PLANT MIX ASPHALT CONCRETE.
- F. FOR ALL GRADINGS OF FINE AGGREGATE, INCLUDING ANY BLENDED FINE AGGREGATE AND MINERAL FILLER, PASSING A NO 40 SIEVE (0.425 MM), SHALL HAVE A LIQUID LIMIT NOT EXCEEDING 25 AND A PLASTICITY INDEX OF NOT MORE THAN 6.
- G. PRODUCE COARSE AGGREGATE RETAINED ON THE NO. 4 SIEVE (4.75 MM) HAVING A MINIMUM OF 50% BY WEIGHT OF PARTICLES WITH AT LEAST ONE MECHANICALLY FRACTURED FACE. THE COARSE AGGREGATE SHALL NOT EXCEED 40% WEAR AT 500 REVOLUTIONS.
- H. PRELIMINARY ACCEPTANCE OF AGGREGATES PROPOSED FOR USE MAY BE MADE AT THE POINT OF PRODUCTION. FINAL ACCEPTANCE WILL BE MADE ONLY AFTER TESTS OF THE AGGREGATES ARE COMPLETE AND IN PLACE.
- I. SURFACE COURSE ASPHALT PLANT MIX AGGREGATE:

TABLE 1

REQUIREMENTS FOR GRADING OF SURFACE COURSE AGGREGATE

PERCENTAGE BY WEIGHT PASSING JOB MIX TARGET BANDS						
SIEVE SIZE	TYPE A	TYPE B		TYPE C		JOB MIX TOLERANCE
1" (25.0 MM)	100	---		---		---
¾" (19.0 MM)	91-93	100		---		+/- 7
½" (12.5 MM)	76-89	83-93		100		+/- 7
3/8" (9.5 MM)	61-79	73-87		91-93		+/- 7
NO 4 (4.75 MM)	41-54	47-63		51-71		+/- 6
NO 10 (2.00 MM)	31-39	32-43		34-46		+/- 6
NO 40 (0.425 MM)	16-27	15-25		16-26		+/- 5
NO 200 (0.075 MM)	4-7	5-7		5-9		+/- 2

1. THE ABOVE GRADATION BANDS REPRESENT THE JOB MIX TARGET LIMITS, WHICH DETERMINE THE SUITABILITY OF AGGREGATE FOR USE. THE FINAL JOB MIX TARGET

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ASPHALT CONCRETE PAVEMENT

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GRADATION MUST BE WITHIN THE SPECIFIED BANDS AND UNIFORMLY GRADED FROM COARSE TO FINE AND NOT VARY FROM THE LOW LIMITS ON ONE SCREEN TO THE HIGH LIMITS ON THE ADJACENT SCREEN, OR VICE VERSA. THE FINAL JOB MIX GRADATION LIMITS ARE ESTABLISHED BY APPLYING THE JOB MIX TOLERANCES TO THE JOB MIX TARGETS.

2. THE JOB MIX FORMULA ESTABLISHES TARGET VALUES. DURING PRODUCTION OF THE MIX, THE GRADATIONS SHALL LIE WITHIN THE JOB MIX GRADATION LIMITS SPECIFIED IN TABLE 1. FOR EXAMPLE, "TYPE A, NO. 200" BAND IS "4-7". QA JOB MIX TARGET OF 5 HAS BEEN SELECTED FOR THE FINAL MIX. THE JOB MIX GRADATION LIMITS IS 5, PLUS AND MINUS 2. THEREFORE, THE JOB MIX GRADATION LIMITS FOR PRODUCTION IS 3-7.

2.3 ASPHALT BINDER MATERIAL

- A. FURNISH ASPHALT BINDER MATERIAL TO BE USED AS SPECIFIED IN THE CONTRACT DOCUMENTS THAT MEET THE TYPE AND GRADE SPECIFIED REQUIREMENTS IN THIS SECTION IN TABLE 3.
 1. GRADES:
 - A. (PGAB) PG 58-22
 - B. (PGAB) PG 58-28
 - C. (PGAB) PG 64-22
 - D. (PGAB) PG 64-28 (POLYMER MODIFIED)
- B. THE PERCENTAGE OF ASPHALT BY WEIGHT, TO BE ADDED TO THE AGGREGATE WILL BE, GENERALLY, BETWEEN 4 AND 8 PERCENT OF THE WEIGHT OF THE TOTAL MIX. THE MIX DESIGN WILL ESTABLISH THE EXACT PERCENTAGE OF ASPHALT IN THE MIX, BASED UPON PRELIMINARY LABORATORY TESTS, SIEVE ANALYSIS AND GRADING AND CHARACTER OF THE AGGREGATE FURNISHED WITHIN THE SPECIFICATION LIMITS. NO CLAIM IS ALLOWED FOR THE PAYMENT FOR REJECTING ANY BATCH OR LOAD OF MIXTURE CONTAINING AN EXCESS OR DEFICIENT AMOUNT OF ASPHALT BINDER VARYING MORE THAN 0.4 OF A PERCENT FROM THE FIXED MIX DESIGN PERCENTAGE.
- C. OBTAIN ENGINEER APPROVAL OF THE ASPHALT MATERIAL SOURCE BEFORE SHIPMENTS ARE MADE TO ANY PROJECT. THE SOURCE OF SUPPLY CANNOT CHANGE AFTER WORK IS STARTED UNLESS APPROVED IN WRITING BY THE ENGINEER. THE ENGINEER IS NOT LIABLE FOR THE QUANTITY SHIPPED.
- D. SAMPLES OF ASPHALT BINDER MATERIAL MAY BE TAKEN, AS DIRECTED BY THE ENGINEER, AND PLACED IN UNCONTAMINATED ONE-QUART CONTAINERS. WHEN SAMPLED, THESE SHALL BE TAKEN FROM THE TANKER CAR OR TRUCK AT THE POINT OF DELIVERY ON THE PROJECT AND SUBMITTED TO THE ENGINEER.
- E. ALL TRANSPORT VEHICLES MUST BE EQUIPPED WITH A SPIGOT OR GATE VALVE INSTALLED IN EITHER: (1) THE UNLOADING LINE, (2) IN THE TANKER AT THE CENTERLINE ON THE TANK, (3) IN THE PRESSURE LINE FROM THE UNLOADING PUMP, OR OTHER LOCATIONS APPROVED BY THE ENGINEER. ASSURE THE SPIGOT OR GATE VALVE HAS A DIAMETER OF BETWEEN 3/8 INCH (1 CM) AND 3/4 INCH (2.5 CM). THE SPIGOT VALVE MUST BE LOCATED TO PREVENT CONTAMINATION FROM PLANT DUST OR OTHER CONTAMINANTS.
- F. THE SUPPLIER FURNISHING THE ASPHALT BINDER MATERIAL SHALL INSPECT EACH TANKER CAR OR TRUCK BEFORE IT IS LOADED AND SHIP ONLY IN CLEAN, UNCONTAMINATED, FULLY INSULATED CARS OR TRUCKS, SEALED AFTER LOADING BY THE SUPPLIER.

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- G. THE MATERIAL SUPPLIER SHALL ISSUE, IN DUPLICATE, A CERTIFICATE SHOWING FULL COMPLIANCE WITH THE SPECIFICATIONS FOR THE DESIGNATED GRADE OF MATERIAL, TOGETHER WITH THE FOLLOWING INFORMATION. PROJECT NUMBER, DATE OF SHIPMENT, SOURCE OF THE MATERIAL, CAR OR TRUCK INITIAL AND NUMBER, DESTINATION, GROSS QUANTITY LOADED, LOADING TEMPERATURE, AND NET QUANTITY IN GALLONS AT 60° F (15.5° C) OR TONS, WHICHEVER UNIT OF MEASUREMENT IS STIPULATED. ASSURE THE CERTIFICATE OF COMPLIANCE ACCOMPANIES THE SHIPMENT AND IS FURNISHED TO THE ENGINEER. THE CERTIFICATE, SIGNED BY THE SUPPLIER REPRESENTATIVE, MUST ALSO CERTIFY THAT THE CONVEYANCE VESSEL WAS INSPECTED AND FOUND TO BE FREE OF CONTAMINATING MATERIAL.
- H. THE CERTIFICATE OF COMPLIANCE IS THE BASIS FOR TENTATIVE ACCEPTANCE AND USE OF THE MATERIAL. SAMPLES TAKEN ACCORDING TO APPLICABLE SAMPLING METHODS AND RETAINED BY THE ENGINEER MAY BE TESTED AT THE ENGINEER'S DISCRETION. FAILURE OF THE ASPHALT MATERIAL TO MEET THESE SPECIFICATIONS MAY RESULT IN REJECTION OF THE ENTIRE, ASSOCIATED WORK. IF REJECTED, REMOVED AND REPLACE REJECTED WORK.
- I. APPLY ASPHALT MATERIAL AT TEMPERATURES THAT ASSURE UNIFORM MIXING OR SPREADING. APPLICATION TEMPERATURE RANGES FOR EACH GRADE OF MATERIAL SHOULD BE ACCOMPANIED WITH THE MIX DESIGN. APPLICATION TEMPERATURE FOR MIXING APPLICATIONS WILL BE IN ACCORDANCE WITH THE MIX DESIGN.
- J. UPON REQUEST BY THE ENGINEER, FURNISH THE ENGINEER AND/OR LABORATORY (RESPONSIBLE FOR COMPLETING THE MIX DESIGN) WITH DATA OR A REPORT SHOWING THE TEMPERATURE- VISCOSITY RELATIONSHIP OF EACH ASPHALT BINDER USED ON THE PROJECT. ASSURE THIS DATA COVERS THE RANGE OF TEMPERATURES USED FOR MIXING AND COMPACTION. IN ADDITION, THE ENGINEER MAY REQUEST A COMPLETE SET OF TEST RESULTS FROM TABLE 3 FOR EACH GRADE USED ON THE PROJECT.

TABLE 3

PERFORMANCE GRADED ASPHALT BINDER (PGAB)

PERFORMANCE GRADE	PG 58		PG 64		TEST
	-22	-28	-22	-28	METHOD
AVERAGE 7-DAY MAXIMUM PAVEMENT DESIGN TEMPERATURE, °C	<58		<64		
MINIMUM PAVEMENT DESIGN TEMPERATURE, °C	>-22	>-28	>-22	>-28	
ORIGINAL BINDER					
FLASH POINT TEMP.: MINIMUM °C	230				AASHTO T48
VISCOSITY: MAXIMUM, 3 PA · S (3000 CP), TEST TEMP, °C	135				ASTM D4402
DYNAMIC SHEAR: G* / SIN DELTA, MINIMUM, 1.00 KPA TEST TEMP @ 10 RAD / S, °C	58		64		AASHTO TP5
ROLLING THIN FILM OVEN (AASHTO T240) OR THIN FILM OVEN (T179) RESIDUE					
MASS LOSS, MAXIMUM, %	1.0				AASHTO T240
DYNAMIC SHEAR: G* / SIN DELTA, MINIMUM, 2.20 KPA TEST TEMP @ 10 RAD / S, °C	58		64		AASHTO TP5
PRESSURE AGING VESSEL RESIDUE (AASHTO PP1)					
PAV AGING TEMP, °C	100		100		AASHTO PP1
DYNAMIC SHEAR: G* / SIN DELTA, MAXIMUM, 5000 KPA TEST TEMP @ 10 RAD / S, °C	22	19	25	22	AASHTO TP5
CREEP STIFFNESS °: S, MINIMUM, 300 MPA M-VALUE, MINIMUM, 0.300 TEST TEMP, @ 60 SEC, °C	-12	-18	-12	-18	AASHTO TP1
DIRECT TENSION °: FAILURE STRAIN, MINIMUM, 1.0%, TEST TEMP @ 1.0 MM/MIN. °C	-12	-18	-12	-18	AASHTO TP3

- A. IF CREEP STIFFNESS IS BELOW 300 MPA, THE DIRECT TENSION TEST IS NOT REQUIRED. IF THE CREEP STIFFNESS IS BETWEEN 300 AND 600 MPA THE DIRECT TENSION FAILURE STRAIN REQUIREMENT CAN BE USED IN LIEU OF THE CREEP STIFFNESS REQUIREMENT. THE M-VALUE REQUIREMENT MUST BE SATISFIED IN BOTH CASES.

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2.4 HYDRATED LIME FOR ASPHALT CONCRETE.

- A. MINERAL FILLER MAY BE INCORPORATED IN THE ASPHALT CONCRETE MIXTURE. FURNISH HYDRATED LIME AS FILLER WHEN SPECIFIED. ASSURE IT IS FREE OF LUMPS AND EXTRANEOUS MATERIAL AND MEETS THE FOLLOWING GRADATION REQUIREMENTS AS PER ASTM D242:

<u>SIEVE</u>	<u>PERCENT</u>
NO. 30 (0.60 MM) SIEVE	100
NO. 80 (0.180 MM) SIEVE	95-100
NO. 200 (0.075 MM) SIEVE	70-100

- B. ASSURE THE HYDRATED LIME MEETS PARAGRAPH 2 (CHEMICAL COMPOSITION) AND PARAGRAPH 7 (A) REQUIREMENTS (CHEMICAL ANALYSIS) OF ASTM C1097.
- C. WHERE REQUIRED, THE MINERAL FILLER WILL BE EFFECTIVELY MIXED WITH THE HOT PLANT MIX ASPHALTIC CONCRETE.

2.5 COMPOSITION OF MIXES:

A. GENERAL

1. SUBMIT TO THE ENGINEER FOR APPROVAL A MIX DESIGN FOR EACH MIX REQUIRED ON THE PROJECT. ASSURE THE JOB-MIX FORMULA IS WITHIN THE GRADATION LIMITS IN PART 2 PRODUCTS IN THIS SECTION.
2. HAVE THE JOB-MIX FORMULA PREPARED BY AN INDEPENDENT TESTING LABORATORY APPROVED BY THE ENGINEER. THE REQUIREMENTS OF ASTM D-3666 ARE THE GUIDELINES FOR TESTING LABORATORY APPROVAL. THE COST OF THE JOB-MIX FORMULA(S) IS AT CONTRACTOR EXPENSE.
3. KEEP THE JOB MIX FORMULA CURRENT AND CONTAIN THE FOLLOWING MINIMUM INFORMATION:
 - A. GRADATION OF ALL CONSTITUENT AGGREGATES.
 - B. SPECIFIC GRAVITY OF CONSTITUENT AGGREGATES AND ASPHALT CEMENT.
 - C. SOURCE OF SUPPLY OF ALL MATERIALS AND GRADE OF ASPHALT CEMENT.
 - D. MARSHALL DESIGN CURVES FOR STABILITY, UNIT WEIGHT, FLOW AND VOLUMETRIC REQUIREMENTS (VMA AND TOTAL VOIDS) AT ASPHALT CONTENTS BELOW AND ABOVE OPTIMUM (FOUR POINTS MINIMUM).
 - E. MEASURED VOIDLESS (RICE'S) SPECIFIC GRAVITY USED IN VOIDS COMPUTATIONS.
 - F. COMPOSITE AGGREGATE GRADING.
 - G. RECOMMENDED ASPHALT CEMENT CONTENT.
 - H. MARSHALL COMPACTIVE EFFORT (50 BLOWS).
 - I. DATE OF MIX DESIGN (JOB MIX FORMULA).
 - J. INDEX OF RETAINED STRENGTH.
4. IN ADDITION TO THE JOB MIX FORMULA, ALL ASPHALT CONCRETE SURFACING MIX SUBMITTALS WILL HAVE LABORATORY TESTS INDICATING THAT THE TENSILE STRENGTH

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RATIO (TSR) AS DETERMINED BY AASHTO T-283,, IS AT LEAST 70%. TEST SHALL BE PERFORMED AT 7.0 +/- 1% AIR VOIDS AND SHALL INCLUDE THE FREEZE CYCLE.

B. ASPHALT CONCRETE SURFACE COURSE

1. THE MAXIMUM PERMISSIBLE VARIATION FROM THE JOB-MIX FORMULA WITHIN THE SPECIFICATION LIMITS IS AS FOLLOWS:

- A. AGGREGATE GRADATION WITHIN JOB MIX TOLERANCES
B. ASPHALT ± 0.4 PERCENT* C.
TEMPERATURE OF MIX ± 20 ° F.

* THIS TOLERANCE WILL BE PERMITTED ONLY IF THE JOB MIX PARAMETER CURVES INDICATE THAT THE CORRESPONDING MARSHALL DESIGN LIMITS ARE NOT EXCEEDED.

2. PRODUCE HOT PLANT MIX ASPHALT CONCRETE SURFACE COURSES HAVING THE FOLLOWING CHARACTERISTICS AS MEASURED BY AASHTO T245, ASTM D6726 & D6927 "RESISTANCE TO PLASTIC FLOW OF BITUMINOUS MIXTURES BY MEANS OF THE MARSHALL APPARATUS":

- A. NUMBER OF COMPACTION BLOWS, EACH END OF SPECIMEN..... 50.
B. STABILITY, MINIMUM..... 1200.
C. FLOW 8 – 18.
D. AIR VOIDS, PERCENT 3-5.
E. PERCENT VOIDS IN MINERAL AGGREGATE (MINIMUM). . . . SEE TABLE 4.

TABLE 4	
REQUIRED VOIDS IN MINERAL AGGREGATE (VMA)	
NOMINAL PARTICLE SIZE (TABLE 2)	VOIDS IN MINERAL AGGREGATE, MIN.
3/8 – INCH (9.5 MM)	14
1/2 – INCH (12.5 MM)	13
3/4 – INCH (19.0 MM)	12
1 – INCH (25.0 MM)	11
1 1/2 – INCH (37.5 MM)	10
NOMINAL MAXIMUM PARTICLE SIZE IS ONE SIZE LARGER THAN THE FIRST SIEVE TO RETAIN MORE THAN 10 PERCENT.	

PART 3: EXECUTION

3.1 CRUSHING:

A. CRUSHING EQUIPMENT

1. FIT CRUSHING PLANT-SCREENING EQUIPMENT, WHEN REQUIRED, WITH BLOWERS OR OTHER DEVICES CAPABLE OF REMOVING EXCESS AND UNDESIRABLE FINES.

B. SCREENING PLANTS

1. SCREENING PLANTS CONSIST OF A REVOLVING TROMMEL SCREEN, SHAKER SCREEN, VIBRATING SCREEN, OR OTHER DEVICES CAPABLE OF REMOVING OVERSIZE MATERIAL, EXCESS AND UNDESIRABLE FINES.

C. SCALES

1. FURNISH SCALES, WHEN REQUIRED, SATISFACTORY TO THE ENGINEER. TEST AND CERTIFY SCALES PRIOR TO THEIR USE ON THE PROJECT AND AS OFTEN THEREAFTER AS THE ENGINEER MAY CONSIDER NECESSARY TO INSURE THEIR ACCURACY. HAVE ON HAND NOT LESS THAN TEN, 50-POUND WEIGHTS FOR TESTING SCALES.
2. HOUSE THE RECORDING DEVICES OF THE SCALES IN A SUITABLE MANNER. PLACE THE SCALES IN A LOCATION SUITABLE TO FACILITATE ACCURATE WEIGHING OF LOADS. THE SCALES SHALL BE ACCURATE TO ONE-HALF OF ONE PERCENT AT ANY WEIGHT. ALTERNATE METHODS OR DEVICES FOR WEIGHING MAY BE ACCEPTABLE, PROVIDED THAT THESE METHODS OR DEVICES PRODUCE THE SAME DEGREE OF ACCURACY AS REQUIRED OF PLATFORM SCALES.

3.2 MATERIAL HANDLING:

- A. ALL WORK INVOLVED IN CLEARING AND STRIPPING PITS AND QUARRIES, INCLUDING HANDLING UNSUITABLE MATERIAL ENCOUNTERED, ARE PERFORMED WITH NO ADDITIONAL COMPENSATION BEING ALLOWED FOR THIS WORK. THE PITS AS UTILIZED SHALL IMMEDIATELY BE OPENED SO AS TO EXPOSE THE VERTICAL FACES OF THE VARIOUS STRATA OF ACCEPTABLE MATERIAL AND, UNLESS OTHERWISE DIRECTED, THE MATERIAL SHALL BE SECURED IN SUCCESSIVE VERTICAL CUTS EXTENDING THROUGH ALL THE EXPOSED STRATA.
- B. PROVIDE, UNLESS OTHERWISE SPECIFIED, MATERIAL CONTAINING AS LARGE A PROPORTION AS POSSIBLE OF CRUSHED AGGREGATE. COMBINE THE CRUSHED MATERIAL WITH THE SCREENED MATERIAL TO OBTAIN A UNIFORM PRODUCT.
- C. NO MATERIAL WILL BE ACCEPTED WHICH IS LOADED INTO HAULING UNITS IN A SEGREGATED CONDITION OR WHICH DOES NOT MEET THE REQUIRED GRADING. IN CASE THE MATERIAL DEPOSIT CONTAINS SAND OR OTHER MATERIAL IN EXCESS OF THE SPECIFICATION GRADATION REQUIREMENTS, OR OF AN UNACCEPTABLE QUALITY, SUCH EXCESS OR UNDESIRABLE MATERIAL SHALL BE REMOVED AND DISPOSED OF PRIOR TO CRUSHING, OR DURING SCREENING OPERATIONS, IF CRUSHING IS NOT REQUIRED.
- D. PROVIDE A STORAGE BIN OF AMPLE CAPACITY TO INSURE UNIFORM QUALITY AND DELIVERY OF MATERIAL. LOADING OF TRUCKS DIRECTLY FROM THE CONVEYOR BELT, FROM THE CRUSHER OR SCREENING PLANT WILL NOT BE PERMITTED.

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3.3 STOCKPILES:

- A. GRUB AND CLEAN SITES FOR AGGREGATE STOCKPILES PRIOR TO STORING AGGREGATES. ASSURE THE SITE IS FIRM, SMOOTH AND WELL DRAINED. MAINTAIN A BED OF AGGREGATE SUITABLE TO AVOID THE INCLUSION OF SOIL OR FOREIGN MATERIAL.
- B. BUILD UP COARSE AGGREGATE STOCKPILES IN TIERS OF NOT MORE THAN 4 FEET (1.2 M) IN THICKNESS. ASSURE EACH TIER IS COMPLETELY IN PLACE BEFORE THE NEXT TIER IS PLACED. DO NOT ALLOW MATERIAL TO "CONE" DOWN OVER THE NEXT LOWER TIER.
- C. DUMPING, CASTING OR PUSHING OVER THE SIDES OF STOCKPILES WILL BE PROHIBITED, EXCEPT IN THE CASE OF FINE AGGREGATE STOCKPILES.
- D. SPACE STOCKPILES OF DIFFERENT GRADATIONS OF AGGREGATE FAR ENOUGH APART, OR SEPARATED BY SUITABLE WALLS OR PARTITIONS, TO PREVENT THE MIXING OF THE AGGREGATES.
- E. ANY METHOD OF STOCKPILING AGGREGATE, WHICH ALLOWS THE STOCKPILE TO BECOME CONTAMINATED WITH FOREIGN MATTER OR CAUSES EXCESSIVE DEGRADATION OF THE AGGREGATE, WILL NOT BE PERMITTED. EXCESSIVE DEGRADATION WILL BE DETERMINED BY SIEVE TESTS OF SAMPLES TAKEN FROM ANY PORTION OF THE STOCKPILE OVER WHICH EQUIPMENT HAS OPERATED AND FAILURE OF SUCH SAMPLES TO MEET ALL GRADING REQUIREMENTS FOR THE AGGREGATE DISCONTINUANCE OF SUCH STOCKPILING PROCEDURES.
- F. TRANSFER THE AGGREGATE FROM THE STOCKPILES IN SUCH A MANNER THAT UNIFORM GRADING OF THE MATERIAL IS PRESERVED.

3.4 CONVEYOR STOCKPILING:

- A. MATERIALS STOCKPILED BY CONVEYORS SHALL BE DEPOSITED IN A SUCCESSION OF MERGING- CONE PILES. DO NOT DROP MATERIAL OVER 12 FEET (3.66 M) NOR ALLOW CONES TO EXCEED 12 FEET (3.66 M) IN HEIGHT. CONES SHOULD BE LEVELED TO A THICKNESS OF APPROXIMATELY 4 FEET (1.2 M) PRIOR TO STARTING ANOTHER TIER.

3.5 TRUCK STOCKPILING:

- A. MATERIALS STOCKPILED BY TRUCKS SHALL CONSTRUCT THE STOCKPILE IN TIERS APPROXIMATELY 4 FEET (1.2 M) IN THICKNESS. COMPLETE EACH TIER BEFORE THE NEXT TIER IS STARTED.

3.6 ASPHALT MIXING PLANTS:

- A. USE MIXING PLANTS OF EITHER THE WEIGHT BATCHING TYPE, THE CONTINUOUS FLOW MIXING TYPE, OR DRUM DRYER TYPE. USE DRUM DRYER MIXERS SPECIFICALLY DESIGNED AND CONSTRUCTED FOR PRODUCING HOT MIX.
- B. EQUIP ALL PLANTS WITH APPROVED CONVEYORS, POWER UNITS, AGGREGATE HANDLING EQUIPMENT, AGGREGATE SCREENS AND BINS THAT ARE COORDINATED AND OPERATED TO PRODUCE A UNIFORM MIXTURE WITHIN THE SPECIFIED JOB MIX TOLERANCES.
- C. USE BATCH-TYPE PLANTS HAVING A MINIMUM BATCH PRODUCTION CAPACITY OF 2,000 POUNDS (900 KG). USE CONTINUOUS FLOW OR DRUM DRYER PLANTS HAVING A MINIMUM PRODUCTION CAPACITY OF 60 TONS PER HOUR (27 KG PER HOUR). THESE CAPACITY REQUIREMENTS MAY BE MODIFIED IF SPECIFIED IN THE CONTRACT

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DOCUMENTS.

- D. STOP PRODUCTION AND REMOVE FROM THE PROJECT MIXING PLANTS THAT FAIL TO CONTINUOUSLY PRODUCE A MIXTURE MEETING REQUIREMENTS AS SPECIFIED.

3.7 INSPECTION AND CONTROL OF ASPHALT MIXING PLANT:

- A. FOR VERIFICATION OF WEIGHTS AND MEASURES, CHARACTER OF MATERIALS AND DETERMINATION OF TEMPERATURES USED IN THE PREPARATION OF THE PAVING MIXES, THE ENGINEER OR HIS AUTHORIZED REPRESENTATIVE WILL, AT ALL TIMES, HAVE ACCESS TO ALL PORTIONS OF THE MIXING PLANT, AGGREGATE PLANT, STORAGE YARDS AND OTHER FACILITIES FOR PRODUCING AND PROCESSING THE MATERIALS FOR THE WORK. ALL SAMPLING AND TESTING OF PROCESSED AND UNPROCESSED MATERIAL IS PERFORMED IN ACCORDANCE WITH THE PROVISIONS OF THE CONTRACT DOCUMENTS.

3.8 MIX DESIGN:

- A. THE OWNER'S ACCEPTANCE TESTING AGENCY WILL MAKE GRADATION ANALYSES OF THE COMPLETED MIX TO ASSURE THAT THE MATERIALS BEING PRODUCED AND USED ARE WITHIN THE TOLERANCES OF THE MIX DESIGN AND THE SPECIFICATIONS OF THE MIX BEING USED.

3.9 SAMPLING AND TESTING FOR ACCEPTANCE:

- A. SAMPLING AND TESTING OF AGGREGATES OR OTHER CONSTITUENT MATERIALS WILL BE PERFORMED BY THE OWNER'S TESTING AGENCY AT A FREQUENCY DETERMINED BY THE OWNER OR THE OWNER'S REPRESENTATIVE. MARSHALL FIELD CONTROL IS PERFORMED UNDER AASHTO T245, ASTM D6926 & D6927. FIELD DENSITY TESTING IS BY CORE TESTING FOR ACCEPTANCE PURPOSES. DENSITIES TO CONFORM TO SECTION 2510.3.28. GRADATIONS TO BE WITHIN THE JOB MIX GRADATION LIMITS. OIL CONTENT TO BE WITHIN 0.4 PERCENT OF THE MARSHALL MIX DESIGN.
- B. SAMPLES WILL BE USED TO VERIFY COMPLIANCE WITH THE REQUIREMENTS SET FORTH IN THIS SECTION. IF THERE IS A DISPUTE, A THIRD PARTY TESTING FIRM MAY BE RETAINED BY THE CONTRACTOR FOR ADDITIONAL RETESTING.

3.10 WEATHER LIMITATIONS:

- A. WHEN THE MOISTURE IN THE STOCKPILED AGGREGATE OR THE DRYER ADVERSELY EFFECTS THE QUALITY OF MIX PRODUCTION, NORMAL PLANT OPERATIONS, OR WHEN POOLS OF WATER ARE OBSERVED ON THE BASE, MIXING AND PLACING OF HOT-MIX ASPHALT IS PROHIBITED.
- B. DO NOT PLACE ASPHALT HOT-MIX SURFACE COURSE MIXTURE WHEN THE AIR TEMPERATURE IS LESS THAN 40° F (4° C) AND RISING. DO NOT PLACE ASPHALT HOT-MIX BASE COURSE MIXTURES OF COMPACTED LIFTS 4 INCHES (10 CM) OR MORE WHEN THE AIR TEMPERATURE IS LESS THAN 30° F (-1° C) AND RISING. DO NOT PLACE ASPHALT UPON A SURFACE WHICH IS FROZEN OR THAT HAS A TEMPERATURE OF LESS THAN 32° F (0° C). DO NOT PLACE PAVING DURING RAINFALL OR IN STANDING WATER.

3.11 SURFACE PREPARATION:

- A. ASSURE THE AREA TO BE PAVED IS TRUE TO LINE AND GRADE AND HAS A DRY AND PROPERLY PREPARED SURFACE BEFORE STARTING PAVING OPERATIONS. ASSURE THE SURFACE IS FREE FROM ALL LOOSE SCREENINGS AND OTHER LOOSE OR FOREIGN MATERIAL.

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3.12 NEW WORK:

- A. FOR NEW WORK, MEET THE SURFACE PREPARATION REQUIREMENTS IN SECTIONS 02230, 02234 OR 02235 OF THESE SPECIFICATIONS. PRIME PREPARED SOIL OR AGGREGATE BASES IF INDICATED AS A BID ITEM IN THE CONTRACT DOCUMENTS.
- B. BEFORE PAVING, PROOF-ROLL THE BASE WITH EQUIPMENT HAVING AT LEAST ONE 18 KIP SINGLE AXLE LOAD OR EQUIVALENT. EXCAVATE AND REPLACE AREAS THAT YIELD OR CRACK UNDER THESE WHEEL LOADS AS DIRECTED. THIS DOES NOT REPLACE OR RELAX THE BASE OR SUBGRADE COMPACTION REQUIREMENTS.
- C. PAINT THE SURFACES OF CURBS AND GUTTERS, VERTICAL FACES OF EXISTING PAVEMENTS AND ALL STRUCTURES IN CONTACT WITH ASPHALT MIXES WITH A THIN COATING OF ASPHALTIC MATERIAL TO PROVIDE A WATER-TIGHT JOINT.

3.13 OVERLAYS OVER EXISTING PAVEMENTS AND OLD BASE:

- A. WHERE A BASE IS ROUGH OR UNEVEN, PLACE A LEVELING COURSE USING A PAVER OR MOTOR GRADER AND COMPACT BEFORE THE PLACING OF SUBSEQUENT COURSES.
- B. WHEN SPECIFIED, PLACE CONSTRUCTION FABRIC TO CONTROL REFLECTIVE CRACKING, AS DETAILED, MEETING SECTION 02110.3.4 PAVEMENT OVERLAY APPLICATIONS.
- C. WHEN A LEVELING COURSE IS NOT SPECIFIED, PATCH OR CORRECT ALL DEPRESSIONS AND OTHER IRREGULARITIES, SUBJECT TO THE ENGINEER'S APPROVAL, BEFORE STARTING OTHER PAVING OPERATIONS. REMOVE ALL RICH AND UNSUITABLE PATCHES, EXCESS CRACK OR JOINT FILLER, AND ALL SURPLUS BITUMEN FROM THE AREA TO BE PAVED. DO NOT BLOT EXCESSIVE DEPOSITS OF ASPHALT WITH SAND OR STONE.
- D. APPLY A TACK COAT WHEN THE SURFACE TO BE PAVED IS AN EXISTING PORTLAND CEMENT CONCRETE, BRICK OR ASPHALT PAVEMENT. WHEN A TACK COAT IS REQUIRED, USE THE ASPHALT MATERIAL INDICATED, AT THE RATE SPECIFIED IN SECTION 02502.
- E. COAT THE SURFACES OF CURBS AND GUTTERS, VERTICAL FACES OF EXISTING PAVEMENTS AND ALL STRUCTURES IN ACTUAL CONTACT WITH ASPHALT MIXES WITH A THIN, COMPLETE COATING OF ASPHALT MATERIAL TO PROVIDE A WATER-TIGHT JOINT.

3.14 PATCHING:

- A. WEATHER LIMITATIONS
 - 1. FOLLOW PROCEDURES SET OUT IN SECTION 3.10.
- B. SURFACE PREPARATIONS
 - 1. ASSURE THE AREA TO BE PAVED IS TRUE TO LINE AND GRADE, IS DRY AND PROPERLY PREPARED SURFACE BEFORE STARTING PAVING OPERATIONS. CLEAN THE SURFACE OF ALL LOOSE SCREENINGS AND OTHER LOOSE OR FOREIGN MATERIAL.
 - 2. BEFORE PAVING, PROOF ROLL THE BASE. AREAS THAT YIELD EXCESSIVELY OR CRACK UNDER SUCH WHEEL LOADS WILL BE EXCAVATED AND REPLACED, TO CORRECT YIELDING AND CRACKING PROBLEMS. THIS DOES NOT REPLACE THE BASE OR SUBGRADE COMPACTION REQUIREMENTS. CUT THE EDGE OF EXISTING PAVEMENTS AGAINST WHICH ADDITIONAL PAVEMENT IS TO BE PLACED STRAIGHT AND VERTICAL.

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3. MINIMUM STANDARDS FOR PATCHING NEW OR EXISTING PAVEMENT INCLUDE THE FOLLOWING:
 - A. NEATLY CUT ALL ASPHALT EDGES USING A ASPHALT SAW.
 - B. CUT ASPHALT EDGES TO FORM AS REGULAR A PATCH SHAPE AS PRACTICAL AND SHOULD, IN GENERAL, APPROXIMATE A RECTANGLE.
 - C. CUT ASPHALT EDGES AT LEAST 30 CM (12 INCHES) WIDER THAN THE TRENCH WIDTH ON EACH SIDE OF TRENCH EXCAVATIONS; AND, IN GENERAL, BE CUT PARALLEL TO THE STREET CENTERLINE FOR MAINLINE CONSTRUCTION AND PERPENDICULAR TO THE STREET CENTERLINE FOR SERVICE LATERAL CONSTRUCTION.
4. REMOVE AND REPLACE ASPHALT SURFACE WIDTHS OF LESS THAN 3 FEET (90 CM).

C. COMPACTION

1. COMPACT TO A DENSITY EQUAL TO OR GREATER THAN 92 PERCENT OF MAXIMUM THEORETICAL DENSITY (RICE) AS DETERMINED BY ASTM D2041.

3.15 TRANSPORTATION OF MIX:

- A. TRANSPORT THE MIX IN VEHICLES CLEANED OF ALL FOREIGN MATERIAL WHICH MAY AFFECT THE MIX. THE TRUCK BEDS MUST BE PAINTED, OR SPRAYED WITH A LIME-WATER, SOAP OR DETERGENT SOLUTION AT LEAST ONCE A DAY OR AS OFTEN AS REQUIRED. AFTER THIS OPERATION ELEVATE THE TRUCK BED AND THOROUGHLY DRAIN IT, WITH NO EXCESS SOLUTION BEING PERMITTED. DISPATCH THE VEHICLES SO THAT ALL MATERIAL DELIVERED IS PLACED IN DAYLIGHT, UNLESS THE ENGINEER APPROVES ARTIFICIAL LIGHT. DELIVER MATERIAL TO THE PAVER AT A UNIFORM RATE AND IN AN AMOUNT WELL WITHIN THE CAPACITY OF THE PAVING AND COMPACTING EQUIPMENT.

3.16 SPREADING AND FINISHING:

- A. SPREAD AND FINISH MEETING THE FOLLOWING REQUIREMENTS
 1. THE MAXIMUM LIFT THICKNESS IS 2 1/2 INCHES (6.5 CM) FOR SURFACE COURSES AND 5 INCHES (13 CM) FOR BASE COURSES.

3.17 MECHANICAL PAVERS:

- A. SPREAD AND STRIKE OFF THE BASE AND SURFACE COURSES WITH A MECHANICAL PAVING MACHINE. OPERATE THE PAVING MACHINE SO THAT MATERIAL DOES NOT ACCUMULATE AND REMAIN ALONG THE SIDES OF THE RECEIVING HOPPER.
- B. DO NOT USE EQUIPMENT, WHICH LEAVES TRACKS OR INDENTED AREAS, WHICH CANNOT BE CORRECTED IN NORMAL OPERATION, PRODUCES FLUSHING OR OTHER PERMANENT BLEMISHES, OR FAILS TO PRODUCE A SATISFACTORY SURFACE.
- C. CONSTRUCT LONGITUDINAL JOINTS AND EDGES TO TRUE LINE MARKINGS. ESTABLISH LINES FOR THE PAVER TO FOLLOW IN PLACING INDIVIDUAL LANES PARALLEL TO THE CENTERLINE OF THE PROPOSED ROADWAY. POSITION AND OPERATE THE PAVER TO FOLLOW CLOSELY THE ESTABLISHED LINES.
- D. WHEN USING PAVERS IN ECHELON, ASSURE THE FIRST PAVER FOLLOWS THE MARKS OR LINES WITH THE SECOND PAVER FOLLOWING THE EDGE OF THE MATERIAL PLACED BY THE FIRST

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PAVER. TO ASSURE A HOT JOINT AND OBTAIN PROPER COMPACTION, ASSURE THE PAVERS WORK AS CLOSE TOGETHER AS POSSIBLE NOT EXCEEDING 100 FEET (30 M) APART. IN BACKING TRUCKS AGAINST THE PAVER, TAKE CARE NOT TO JAR THE PAVER OUT OF ITS PROPER ALIGNMENT.

- E. AS SOON AS THE FIRST LOAD OF MATERIAL HAS BEEN SPREAD, CHECK THE TEXTURE OF THE UNROLLED SURFACE TO DETERMINE ITS UNIFORMITY. SEGREGATION OF MATERIALS IS NOT PERMITTED. IF SEGREGATION OCCURS, SUSPEND SPREADING OPERATION UNTIL THE CAUSE IS DETERMINED AND CORRECTED.
- F. OFFSET TRANSVERSE JOINTS IN SUCCEEDING COURSES AT LEAST 2 FEET (0.6 M). OFFSET LONGITUDINAL JOINTS AT LEAST 6 INCHES (15 CM).
- G. CORRECT ALL IRREGULARITIES IN ALIGNMENT LEFT BY THE PAVER BY TRIMMING DIRECTLY BEHIND THE MACHINE. IMMEDIATELY AFTER TRIMMING, THOROUGHLY COMPACT THE EDGES OF THE COURSE BY TAMPING. AVOID DISTORTING THE PAVEMENT DURING THIS OPERATION.
- H. ASSURE EDGES AGAINST WHICH ADDITIONAL PAVEMENT IS TO BE PLACED IS STRAIGHT AND APPROXIMATELY VERTICAL. USE A LUTE OR COVERED RAKE IMMEDIATELY BEHIND THE PAVER, WHEN REQUIRED, TO OBTAIN A TRUE LINE AND VERTICAL EDGE. CORRECT ALL IRREGULARITIES IN THE SURFACE OF THE PAVEMENT COURSE DIRECTLY BEHIND THE PAVER. REMOVE EXCESS MATERIAL FORMING HIGH SPOTS BY A SHOVEL OR LUTE. FILL LOW AREAS WITH HOT MIX AND SMOOTH IT WITH THE BACK OF A SHOVEL BEING PULLED OVER THE SURFACE. FANNING OF MATERIAL OVER SUCH AREAS IS NOT PERMITTED.

3.18 MOTOR GRADER:

- A. WHEN MOTOR GRADERS ARE USED FOR THE SPREADING OF LEVELING COURSES, PLACE THE MATERIAL ON THE ROADBED SO THAT THE PROPER AMOUNT OF MATERIAL IS AVAILABLE. SPREAD THE MIX TO THE REQUIRED THICKNESS, LINE AND GRADE, WITH A UNIFORM SURFACE TEXTURE, WHILE AT A WORKABLE TEMPERATURE.

3.19 HAND SPREADING:

- A. IN SMALL AREAS WHERE THE USE OF MECHANICAL FINISHING EQUIPMENT IS NOT PRACTICAL, THE MIX MAY BE SPREAD AND FINISHED BY HAND, IF SO DIRECTED BY THE ENGINEER. WOOD OR STEEL FORMS, APPROVED BY THE ENGINEER, RIGIDLY SUPPORTED TO ASSURE CORRECT GRADE AND CROSS SECTION, MAY BE USED. IN SUCH INSTANCES, MEASURING BLOCKS AND INTERMEDIATE STRIPS MUST BE USED TO OBTAIN THE REQUIRED CROSS-SECTION. PERFORM HAND PLACING CAREFULLY. UNIFORMLY DISTRIBUTE THE MATERIAL TO AVOID SEGREGATION OF THE COARSE AND FINE AGGREGATE. BROADCASTING OF MATERIAL IS NOT PERMITTED. DURING THE SPREADING OPERATION, LOOSEN AND UNIFORMLY DISTRIBUTE ALL MATERIAL USING LUTES OR COVERED RAKES. REJECT MATERIAL THAT HAS FORMED INTO LUMPS AND DOES NOT BREAK DOWN READILY. FOLLOWING PLACING AND BEFORE ROLLING, CHECK THE SURFACE WITH TEMPLATES AND STRAIGHTEDGES AND CORRECT ALL IRREGULARITIES.
- B. MAINTAIN ON THE PROJECT HEATING EQUIPMENT FOR KEEPING HAND TOOLS FREE FROM ASPHALT. EXERCISE CAUTION TO PREVENT HEATING THAT MAY BURN THE MATERIAL. ASSURE THE TEMPERATURE OF THE TOOLS WHEN USED IS NOT GREATER THAN THE TEMPERATURE OF THE MIX BEING PLACED. USE HEAT ONLY TO CLEAN HAND TOOLS; PETROLEUM OILS OR SOLVENTS ARE NOT PERMITTED.

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3.20 COMPACTION:

- A. FURNISH THE NUMBER OF ROLLERS NECESSARY TO PROVIDE THE SPECIFIED PAVEMENT DENSITY. DURING ROLLING, KEEP THE ROLLER WHEELS MOIST TO AVOID PICKING UP THE MATERIAL.
- B. AFTER THE LONGITUDINAL JOINTS AND EDGES HAVE BEEN COMPACTED, START ROLLING LONGITUDINALLY AT THE SIDES AND PROGRESS TOWARD THE CENTER OF THE PAVEMENT. FOR TRANSVERSE GRADED STREETS, BEGIN ROLLING ON THE LOW SIDE AND PROGRESS TO THE HIGH SIDE, OVERLAPPING PASSES BY AT LEAST ONE-HALF THE WIDTH OF ROLLERS AND UNIFORMLY LAPPING EACH PRECEDING PASS. OPERATE THE ROLLERS AT A SLOW, UNIFORM SPEED WITH THE DRIVE ROLL OR WHEEL NEAREST THE PAVER. DO NOT EXCEED 3 MILES PER HOURS (4.8 KM PER HOUR).
- C. DO NOT QUICKLY CHANGE THE LINE OF ROLLING REVERSING DIRECTION SUDDENLY. IF ROLLING DISPLACES THE MATERIAL, RE-WORK THE AREA USING LUTES OR SHOVELS AND RESTORE IT THE ORIGINAL GRADE OF THE LOOSE MATERIAL BEFORE RE-ROLLING. DO NOT PERMIT HEAVY EQUIPMENT OR ROLLERS TO STAND ON THE FINISHED SURFACE BEFORE IT HAS BEEN COMPACTED AND HAS THOROUGHLY COOLED.
- D. WHEN PAVING IN SINGLE WIDTH, ROLL THE FIRST LANE PLACED AS FOLLOWS:
 - 1. TRANSVERSE JOINTS
 - 2. OUTSIDE EDGE
 - 3. INITIAL OR BREAKDOWN ROLLING, BEGINNING ON THE LOW SIDE AND PROGRESSING TOWARD THE HIGH SIDE
 - 4. SECOND ROLLING, SAME PROCEDURE AS 3
 - 5. FINISH ROLLING
- E. WHEN PAVING IN ECHELON, OR ABUTTING A PREVIOUSLY PLACED LANE, PERFORM THE LONGITUDINAL JOINT ROLLING THE SAME AS TRANSVERSE JOINT ROLLING.
- F. WHEN PAVING IN ECHELON, LEAVE 2 OR 3 INCHES (5 TO 7.5 CM) OF THE EDGE UNROLLED, WHICH THE SECOND PAVER CAN MATCH UNROLLED. THEN THE JOINT BETWEEN THE LANES CAN BE ROLLED TOGETHER. DO NOT LEAVE EDGES EXPOSED MORE THAN 15 MINUTES WITHOUT BEING ROLLED.
- G. IN LAYING A SURFACE MIX ADJACENT TO ANY FINISHED AREA, PLACE IT HIGH ENOUGH SO THAT, WHEN COMPACTED, THE FINISHED SURFACE IS TRUE AND UNIFORM.
- H. ON SLIGHT GRADES, CHECK GUTTERS WITH A STRAIGHTEDGE AND TEST WITH RUNNING WATER TO ASSURE DRAINAGE TO THE PLANNED OUTLET.
- I. THE AVERAGE DENSITY SHALL BE EQUAL TO OR GREATER THAN 93 PERCENT OF THE MAXIMUM DENSITY AS DETERMINED BY ASTM D2041 AND NO INDIVIDUAL SAMPLE SHALL BE LESS THAN 92 PERCENT OF MAXIMUM DENSITY.

3.21 TRANSVERSE JOINTS:

- A. CONSTRUCT AND COMPACT TRANSVERSE JOINTS TO PROVIDE A SMOOTH RIDING SURFACE. JOINTS WILL BE STRAIGHT EDGED AND STRING LINED TO ASSURE SMOOTHNESS AND TRUE ALIGNMENT.
- B. JOINT FORMED WITH BULKHEADS TO PROVIDE A STRAIGHT LINE AND VERTICAL FACE WILL BE CHECKED WITH A STRAIGHTEDGE BEFORE FRESH MATERIAL IS PLACED

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AGAINST IT TO COMPLETE THE JOINT. IF BULKHEADS ARE NOT USED TO FORM THE JOINT AND THE ROLLER IS PERMITTED TO ROLL OVER THE EDGE OF THE NEW MATERIAL, LOCATE THE JOINT LINE IN BACK OF THE ROUNDED EDGE THE DISTANCE REQUIRED TO PROVIDE A TRUE SURFACE AND CROSS-SECTION. IF A JOINT HAS BEEN DISTORTED BY TRAFFIC OR BY OTHER CAUSES, TRIM IT TO LINE. PAINT THE JOINT FACE WITH A THIN COATING OF ASPHALT BEFORE THE FRESH MATERIAL IS PLACED AGAINST IT.

- C. PLACE THE MATERIAL AGAINST THE JOINTS VERTICAL FACE WITH THE PAVING MACHINE POSITIONED SO THAT THE MATERIAL OVERLAPS THE EDGE OF THE JOINT 1 TO 2 INCHES (2.5 TO 5 CM). MAINTAIN A UNIFORM DEPTH OF THE OVERLAPPED MATERIAL . REMOVE AND DISPOSE OF THE COARSE AGGREGATE IN THE OVERLAPPED MATERIAL THAT DISLODGED DURING RAKING.
- D. POSITION ROLLERS ON THE PREVIOUSLY COMPACTED MATERIAL TRANSVERSELY SO THAT NO MORE THAN 6 INCHES (15 CM) OF THE ROLLING WHEEL RIDES ON THE EDGE OF THE JOINT. OPERATE THE ROLLER TO PINCH AND PRESS THE MIX INTO PLACE AT THE TRANSVERSE JOINT. CONTINUE ROLLING ALONG THIS LINE, SHIFTING POSITION GRADUALLY ACROSS THE JOINT, IN 6-TO 8-INCH (15 TO 20 CM) INCREMENTS, UNTIL THE JOINT HAS BEEN ROLLED BY ENTIRE WIDTH OF THE ROLLER WHEEL.
- E. KEEP THE NUMBER OF TRANSVERSE JOINTS TO A MINIMUM. WHEN PAVING SINGLE WIDTH AND MAINTAINING TRAFFIC, PAVE ONE LANE NO FARTHER THAN ONE BLOCK. COMPLETE ALL LANES TO THE SAME STATION AT THE END OF EACH PAVING DAY. WHEN PAVING IN ECHELON, BRING THE LANES UP EVEN AS IS PRACTICAL.

3.22 LONGITUDINAL JOINTS:

- A. ROLL LONGITUDINAL JOINTS DIRECTLY BEHIND THE PAVING OPERATION. ASSURE THE FIRST LANE PLACED IS TRUE TO LINE AND GRADE AND HAS A VERTICAL FACE. PLACE THE MATERIAL IN THE LANE BEING PAVED UP FIRMLY AGAINST THE FACE OF THE PREVIOUSLY PLACED LANE. POSITION THE PAVER DURING SPREADING TO ASSURE THE MATERIAL OVERLAPS THE EDGE OF THE LANE PREVIOUSLY PLACED BY 1 INCH TO 2 INCHES (25 TO 50 MM). UNIFORMLY MAINTAIN THE WIDTH AND DEPTH OF THE OVERLAPPED MATERIAL AT ALL TIMES. KEEP THE PAVER ALIGNED WITH THE LINE OR MARKINGS PLACED ALONG THE JOINT FOR ALIGNMENT PURPOSES. BEFORE ROLLING, REMOVE AND DISPOSE OF THE COARSE AGGREGATE IN THE MATERIAL OVERLAPPING THE JOINT.
- B. SHIFT ROLLERS ONTO THE PREVIOUSLY PLACED LANE SO THAT NOT MORE THAN 6 INCHES (15 CM) OF THE ROLLER WHEEL RIDES ON THE EDGE OF THE FINE MATERIAL LEFT BY BROOMING. OPERATE THE ROLLERS TO COMPACT THE FINES GRADUALLY ACROSS THE JOINT. CONTINUE ROLLING UNTIL A COMPACTED, NEAT JOINT IS OBTAINED. WHEN THE ABUTTING LANE IS NOT PLACED IN THE SAME DAY, PAINT THE JOINT WITH A VERY THIN COATING OF ASPHALT BEFORE PLACING THE ABUTTING LANE. IF THE JOINT IS DISTORTED DURING THE DAY'S WORK BY TRAFFIC OR BY OTHER CAUSES, CAREFULLY TRIM THE EDGE OF THE LANE TO A NEAT LINE.

3.23 EDGES:

- A. ROLL THE PAVEMENT EDGES CONCURRENTLY WITH OR IMMEDIATELY AFTER ROLLING THE LONGITUDINAL JOINT.
- B. EXERCISE CARE IN CONSOLIDATING THE COURSE ALONG THE ENTIRE LENGTH OF THE EDGES. IN ROLLING PAVEMENT EDGES, EXTEND THE ROLLER WHEELS 2 TO 4 INCHES (5 TO 10 CM) BEYOND THE PAVEMENT EDGE.

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3.24 BREAKDOWN ROLLING:

- A. IMMEDIATELY BEGIN BREAKDOWN ROLLING FOLLOWING THE ROLLING OF THE LONGITUDINAL JOINT AND EDGES. OPERATE ROLLERS AS CLOSE TO THE PAVER AS REQUIRED TO OBTAIN DENSITY WITHOUT CAUSING UNDUE DISPLACEMENT. OPERATE THE BREAKDOWN ROLLER WITH THE DRIVE ROLL OR WHEEL NEAREST THE FINISHING MACHINE. THE ENGINEER MAY MAKE EXCEPTIONS WHEN WORKING ON STEEP SLOPES OR SUPER-ELEVATED CURVES.

3.25 SECOND ROLLING:

- A. ASSURE THE SECOND ROLLING FOLLOWS THE BREAKDOWN ROLLING AS CLOSE AS POSSIBLE WHILE THE PAVING MIX IS STILL AT A TEMPERATURE THAT WILL PROVIDE THE SPECIFIED DENSITY.

3.26 FINISH ROLLING:

- A. PERFORM THE FINISH ROLLING WHILE THE MATERIAL IS STILL WARM ENOUGH TO REMOVE ROLLER MARKS. IF NECESSARY, THE ENGINEER MAY REQUIRE USING PNEUMATIC-TIRED ROLLERS. COMPLETE FINISH ROLLING THE SAME DAY THE MIXTURE IS PLACED.
- B. IN PLACES INACCESSIBLE TO STANDARD ROLLERS, PERFORM COMPACTION USING TRENCH ROLLERS OR OTHERS TO MEET THE SPECIFIED COMPACTION REQUIREMENTS. OPERATE THE TRENCH ROLLER AS DIRECTED UNTIL THE COURSE IS COMPACTED. HAND, MANUAL OR MECHANICAL TAMPING, MAY BE USED IN SUCH AREAS IF IT IS PROVED TO THE ENGINEER THAT THE OPERATION WILL PROVIDE THE SPECIFIED DENSITY.

3.27 SHOULDERS:

- A. WHERE PAVED SHOULDERS OR CURBS ARE NOT SPECIFIED, DO NOT PLACE THE SHOULDER MATERIAL AGAINST THE PAVEMENT EDGES UNTIL THE SURFACE COURSE ROLLING IS COMPLETED. TAKE CARE TO PREVENT DISTORTION OF THE PAVEMENT EDGE FROM SPECIFIED LINE AND GRADE. WHEN SHOULDERS ARE PAVED (EXCEPT IN CONJUNCTION WITH THE TRAVELED WAY PAVING), COLD JOINT CONSTRUCTION PROCEDURE IS REQUIRED TO ASSURE A TIGHT BOND AT THE JOINT.
- B. WHEN THE ROLLING OF THE SURFACE COURSE HAS BEEN COMPLETED AND THE EDGES HAVE BEEN THOROUGHLY COMPACTED, IMMEDIATELY PLACE SHOULDER MATERIAL AGAINST THE EDGES AND ROLL IT.

3.28 DENSITY AND SURFACE REQUIREMENTS:

- A. THE AVERAGE MAT DENSITY SHALL BE EQUAL TO OR GREATER THAN 93 PERCENT OF THE MAXIMUM DENSITY AS DETERMINED BY ASTM D2041 AND NO INDIVIDUAL SAMPLE SHALL BE LESS THAN 92 PERCENT OF MAXIMUM (RICE'S) DENSITY, PREPARED AS SPECIFIED IN PART 2-PRODUCTS IN THIS SECTION AND MADE FROM PLANT MIX MEETING THE JOB-MIX FORMULA. VERIFICATION OF MAXIMUM DENSITY AS DETERMINED BY ASTM D2041 FROM PLANT PRODUCED MATERIAL DURING PRODUCTION IS RECOMMENDED.
- B. PRODUCE A FINAL SURFACE THAT IS UNIFORM IN TEXTURE AND MEETS THE LINE AND GRADE SPECIFIED. BEFORE FINAL ACCEPTANCE OF THE PROJECT OR DURING THE PROGRESS OF THE WORK, THE ENGINEER WILL DETERMINE THE THICKNESS OF ALL COURSES. REPAIR OR REPLACE ALL UNSATISFACTORY WORK.

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- C. ASSURE DENSITY AND THICKNESS MEETS THE PLANS AND SPECIFICATIONS. DURING COMPACTION, PRELIMINARY TESTS TO AID IN CONTROLLING THE THICKNESS, MAY BE PERFORMED BY INSERTING A FLAT BLADE, CORRECTLY GRADUATED, THROUGH THE MATERIAL TO THE TOP OF THE PREVIOUSLY PLACED BASE, OR BY OTHER APPROVED METHODS.
- D. IN CHECKING COMPACTED DEPTH, THE CUTTING OF THE TEST HOLES, REFILLING WITH ACCEPTABLE MATERIALS AND PROPER COMPACTION MAY BE PERFORMED BY THE OWNER'S TESTING AGENCY.
- E. FOR TESTING THE SURFACE ON ALL COURSES, A 10-FOOT (3 M) STRAIGHTEDGE WILL BE USED WITH THE CENTERLINE OF THE STRAIGHTEDGE PLACED PARALLEL TO THE ROADWAY CENTERLINE.
- F. ANY VARIATIONS THAT EXCEED 5/16-INCH (0.8 CM) IN 10 FEET (3 M) FOR BASE COURSE AND 1/4-INCH (0.64 CM) IN 10 FEET (3 M) FOR SURFACE COURSE MUST BE CORRECTED. CORRECT IRREGULARITIES THAT MAY DEVELOP BEFORE THE COMPLETION OF ROLLING BY LOOSENING THE SURFACE MIX AND REMOVING OR ADDING MATERIALS AS IS REQUIRED. IF ANY IRREGULARITIES OR DEFECTS REMAIN AFTER THE FINAL COMPACTION, REMOVE THE SURFACE COURSE AND PLACE AND COMPACT NEW MATERIAL TO A TRUE AND EVEN SURFACE. ALL MINOR SURFACE PROJECTIONS, JOINTS AND MINOR HONEYCOMBED SURFACES MUST BE ROLLED SMOOTH TO GRADE, AS DIRECTED.
- G. REMOVE AND REPLACE AREAS OF NEW PAVEMENT REQUIRING PATCHING AS DIRECTED. PATCHING MATERIAL WILL BE TESTED FOR MEETING SPECIFICATIONS. THE COST OF TESTING IS AT CONTRACTOR EXPENSE.

3.29 PAVEMENT AND MATERIAL TESTING REQUIREMENTS:

- A. OWNER'S TESTING AGENCY WILL PROVIDE CORE SAMPLES OF ASPHALT SURFACE COURSES TO CHECK IN PLACE DENSITY AND COMPACTED DEPTH. THE CORES ARE 4-INCH (10 CM) DIAMETER. MATERIALS AND ACCEPTANCE TESTS WILL BE MADE BY THE OWNER'S TESTING AGENCY TO DETERMINE THE CONTRACTOR'S COMPLIANCE WITH THE SPECIFICATIONS.
- B. MATERIALS FAILING TO MEET THE TESTS SPECIFIED MAY BE RETESTED IF APPROVED AND AS DIRECTED BY THE ENGINEER. THE CONTRACTOR SHALL PAY THE COSTS OF ANY REQUIRED RE-TESTING FOR ACCEPTANCE PURPOSES. RE-TESTING WILL BE PERFORMED BY THE OWNER'S TESTING AGENCY UNLESS OTHERWISE APPROVED BY THE OWNER. . IF THERE IS A DISPUTE, A THIRD PARTY TESTING FIRM MAY BE RETAINED BY THE CONTRACTOR FOR ADDITIONAL RETESTING FOR THE ENGINEER'S REVIEW AND CONSIDERATION.
- C. THE COSTS OF THE FOLLOWING TESTS ARE AT CONTRACTOR EXPENSE:
 - 1. INITIAL AGGREGATE QUALITY TESTS
 - 2. JOB-MIX FORMULA
 - 3. ANY TESTS THE CONTRACTOR REQUIRES TO CONTROL HIS CRUSHING, SCREENING OR OTHER CONSTRUCTION OPERATIONS
 - 4. RETESTING OF FAILING TESTS AS PROVIDED ABOVE
- D. CORRECT ALL PAVEMENT COMPOSITION, FIELD DENSITY, OR THICKNESS, DEFICIENCIES AT CONTRACTOR EXPENSE.
- E. THE FIELD DENSITY AND THICKNESS OF THE PAVEMENT IS DETERMINED BY MEASURING

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THE CORES TESTED. THE ACTUAL THICKNESS MUST BE NO LESS THAN 1/4-INCH (6.5 MM) FROM THE SPECIFIED THICKNESS.

- F. WHEN THE MEASUREMENT OF ANY CORE IS LESS THAN THE PLAN THICKNESS BY MORE THAN THE ALLOWABLE DEVIATION, THE ACTUAL THICKNESS OF THE PAVEMENT IN THIS AREA MAY BE DETERMINED BY TAKING ADDITIONAL CORES AT INTERVALS PARALLEL TO THE CENTERLINE IN EACH DIRECTION FROM THE AFFECTED LOCATION. CONTINUE IN EACH DIRECTION UNTIL A CORE IS FOUND WHICH IS NOT DEFICIENT BY MORE THAN THE ALLOWABLE DEVIATION. THE ENGINEER WILL EVALUATE AREAS FOUND DEFICIENT IN THICKNESS AND DETERMINE WHICH AREAS WARRANT REMOVAL. REMOVE AND REPLACE THE AREAS WITH ASPHALTIC CONCRETE OF THE THICKNESS SHOWN ON THE PLANS. ADDITIONAL CORING IS CONSIDERED AS RE-TESTING OF FAILING AREAS.

PART 4: MEASUREMENT AND PAYMENT

4. 1 TONNAGE BASIS:

A. ASPHALT CONCRETE PAVEMENT

1. THESE ITEMS ARE MEASURED BY THE TON OF 2,000 POUNDS (900 KG) OF ASPHALT PAVING MIXTURE, INCLUDING THE WEIGHT OF THE ASPHALT. THE QUANTITIES MEASURED FOR PAYMENT ARE THE AMOUNT OF ASPHALT PAVING MATERIALS ACTUALLY USED IN THE COMPLETED AND ACCEPTED WORK IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.
2. "ASPHALT CONCRETE PAVEMENT" IS PAID FOR AT THE UNIT PRICE BID PER TON OF 2,000 POUNDS (900 KG).
3. PRICE AND PAYMENT IS FULL COMPENSATION FOR CLEANING BASE OR UNDERLYING COURSE; FOR PRODUCING, FURNISHING, TRANSPORTING, STOCKPILING, HEATING, DRYING AND SCREENING OF AGGREGATE MATERIALS; FOR FURNISHING, HANDLING, MEASURING, MIXING, MANIPULATING AND PLACING OF MATERIALS; FOR HAULING, PLACING, SHAPING, COMPACTING AND FINISHING OF THE PAVING MIX; FOR IMPROVING UNSATISFACTORY AREAS; FOR FURNISHING SAMPLES; FOR FURNISHING, TESTING AND CERTIFYING OF SCALES; FOR FURNISHING THE WEIGH HOUSE; FOR ALL MATERIALS (EXCLUSIVE OF ASPHALT), MANIPULATION, LABOR, TOOLS, EQUIPMENT AND INCIDENTALS NECESSARY TO COMPLETE THE WORK IN FULL COMPLIANCE WITH THE PLANS AND SPECIFICATIONS.
4. PAYMENT IS MADE UNDER:
 - A. ASPHALT CONCRETE PAVEMENT BASE COURSE - PER TON (METRIC TON)
 - B. ASPHALT CONCRETE SURFACE COURSE GRADE "_____" - PER TON (METRIC TON).

B. ASPHALT CEMENT

1. THIS ITEM IS MEASURED BY THE TON OF 2,000 POUNDS (900 KG). THE TONNAGE TO BE PAID FOR IS THE NUMBER OF TONS OF THE ASPHALT CEMENT MATERIALS USED AS ORDERED IN THE ACCEPTED WORK. TONNAGE USED IN THE PAVING MIXTURE IS COMPUTED FROM THE TRUCK WEIGH TICKETS BY USING THE PERCENTAGE OF ASPHALT IN THE APPROVED MIX (AND VERIFIED BY EXTRACTED ASPHALT CEMENT CONTENT BY ASTM D6307). "PERFORMANCE GRADED ASPHALT CEMENT", MEASURED AS PROVIDED ABOVE, WILL BE PAID

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- FOR AT THE UNIT PRICES BID PER TON.
2. PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, HANDLING, STORING, HEATING, TRANSPORTING AND PLACING IN THE MIXTURE; FOR ALL SAMPLES AND FOR ALL LABOR, TOOLS, EQUIPMENT AND INCIDENTALS NECESSARY TO COMPLETE THE WORK IN FULL COMPLIANCE WITH THE PLANS AND SPECIFICATIONS.
 3. PAYMENT IS MADE UNDER:
 - A. PG 58-22 ASPHALT CEMENT – PER TON (METRIC TON).
 - B. PG 58-28 ASPHALT CEMENT – PER TON (METRIC TON).
 - C. PG 64-22 ASPHALT CEMENT – PER TON (METRIC TON).
 - D. PG 64-28 ASPHALT CEMENT – PER TON (METRIC TON).
- C. HYDRATED LIME
1. THIS ITEM IS MEASURED BY THE TON OF 2,000 POUNDS (900 KG) FOR THE AMOUNT OF HYDRATED LIME ACTUALLY USED IN THE COMPLETED AND ACCEPTED WORK.
 2. THE QUANTITIES OF "MINERAL FILLER", MEASURED AS PROVIDED ABOVE, ARE PAID FOR AT THE UNIT PRICE BID PER TON. PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, STORING, HANDLING, AND OTHER CHARGES, ALL TOOLS, EQUIPMENT, LABOR AND PERFORMANCE OF ALL WORK NECESSARY TO MIX THE MATERIAL WITH THE ASPHALT CONCRETE AND ALL OTHER INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
 3. PAYMENT IS MADE UNDER:
 - A. MINERAL FILLER - PER TON (METRIC TON).
4. 2 SQUARE YARD BASIS:
- A. ASPHALT CONCRETE PAVEMENT
1. THESE ITEMS ARE MEASURED BY THE SQUARE YARD OF ASPHALT PAVEMENT SURFACE AREA. THE QUANTITIES MEASURED FOR PAYMENT ARE THE SQUARE YARDS (SQUARE METERS) OF SPECIFIED THICKNESS OF ASPHALT PAVING IN THE COMPLETED AND ACCEPTED WORK AS MEASURED IN THE FIELD. "_____" THICKNESS OF ASPHALT CONCRETE PAVEMENT BASE OR SURFACE COURSE. GRADE "_____" IS PAID FOR AT THE UNIT PRICE BID PER SQUARE YARD (SQUARE METER).
 2. PRICE AND PAYMENT IS FULL COMPENSATION FOR CLEANING BASE OR UNDERLYING COURSE; FOR PRODUCING, FURNISHING, TRANSPORTING, STOCKPILING, HEATING, DRYING AND SCREENING OF AGGREGATE MATERIALS; FOR FURNISHING, HANDLING, MEASURING, MIXING, MANIPULATING AND PLACING OF MATERIALS; FOR HAULING, PLACING, SHAPING, COMPACTING AND FINISHING OF THE PAVING MIX; FOR IMPROVING UNSATISFACTORY AREAS; FOR FURNISHING SAMPLES; FOR ALL MATERIALS (EXCLUSIVE OF ASPHALT AND MINERAL FILLER), MANIPULATION, LABOR, TOOLS, EQUIPMENT AND INCIDENTALS NECESSARY TO COMPLETE THE WORK IN FULL COMPLIANCE WITH THE PLANS AND SPECIFICATIONS.
 3. PAYMENT IS MADE UNDER:
 - A. "_____" THICKNESS OF ASPHALT CONCRETE PAVEMENT - BASE

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COURSE - PER SQUARE YARD (SQUARE METER).

- B. "_____"THICKNESS OF ASPHALT CONCRETE PAVEMENT - SURFACE COURSE GRADE"_____" - PER SQUARE YARD (SQUARE METER).

4. ASPHALT CEMENT

- A. NO SEPARATE MEASUREMENT AND PAYMENT IS MADE FOR THIS ITEM. THE COST FOR THIS ITEM IS TO BE INCLUDED IN THE COST FOR ASPHALT CONCRETE PAVEMENT BASE AND/OR SURFACE COURSE.

5. HYDRATED LIME

- A. THIS ITEM IS MEASURED BY THE TON OF 2,000 POUNDS (900 KG) FOR THE AMOUNT OF HYDRATED LIME ACTUALLY USED IN THE COMPLETED AND ACCEPTED WORK. THE QUANTITY OF "HYDRATED LIME", MEASURED AS PROVIDED ABOVE, IS PAID FOR AT THE UNIT PRICE BID PER TON.

- B. PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, STORING, HANDLING AND OTHER CHARGES, ALL TOOLS, EQUIPMENT, LABOR AND PERFORMANCE OF ALL WORK NECESSARY TO MIX THE MATERIAL WITH THE ASPHALT CONCRETE AND ALL OTHER INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

- C. PAYMENT IS MADE UNDER:

1) HYDRATED LIME - PER TON (METRIC TON).

4. 3 LINEAR FOOT BASIS:

A. ASPHALT CONCRETE PAVEMENT BASE AND SURFACE COURSES

1. THESE ITEMS ARE MEASURED BY THE LINEAR FOOT OF ASPHALT PAVEMENT TRENCH RESTORATION. THE QUANTITIES MEASURED FOR PAYMENT ARE THE LINEAR FEET OF SPECIFIED THICKNESS OF ASPHALT PAVING IN THE COMPLETED AND ACCEPTED WORK AS MEASURED IN THE FIELD ALONG THE TRENCH CENTERLINE.

2. PRICE AND PAYMENT IS FULL COMPENSATION FOR CLEANING BASE OR UNDERLYING COURSE; FOR PRODUCING, FURNISHING, TRANSPORTING, STOCKPILING, HEATING, DRYING AND SCREENING OF AGGREGATE MATERIALS; FOR FURNISHING, HANDLING, MEASURING, MIXING, MANIPULATING AND PLACING OF MATERIALS; FOR HAULING, PLACING, SHAPING, COMPACTING AND FINISHING OF THE PAVING MIX; FOR IMPROVING UNSATISFACTORY AREAS; FOR FURNISHING SAMPLES; FOR ALL MATERIALS (EXCLUSIVE OF ASPHALT AND MINERAL FILLER), MANIPULATION, LABOR, TOOLS, EQUIPMENT AND INCIDENTALS NECESSARY TO COMPLETE THE WORK IN FULL COMPLIANCE WITH THE PLANS AND SPECIFICATIONS.

3. PAYMENT IS MADE UNDER:

- A. "_____"THICKNESS OF ASPHALT CONCRETE PAVEMENT - BASE

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COURSE - PER LINEAL FOOT (LINEAL METER).

- B. "_____"THICKNESS OF ASPHALT CONCRETE PAVEMENT - SURFACE COURSE GRADE"_____" - PER LINEAL FOOT (LINEAL METER).

4. PAYMENT IS MADE UNDER:

- A. ASPHALT CONCRETE PAVEMENT BASE COURSE - PER LINEAL FOOT (LINEAL METER).

- B. ASPHALT CONCRETE PAVEMENT SURFACE COURSE GRADE"_____" - PER LINEAL FOOT (LINEAL METER).

B. ASPHALT CEMENT

1. NO SEPARATE MEASUREMENT AND PAYMENT IS MADE FOR THIS ITEM. THE COST FOR THIS ITEM IS TO BE INCLUDED IN THE COST FOR ASPHALT CONCRETE PAVEMENT BASE AND/OR SURFACE COURSES.

C. HYDRATED LIME

1. THIS ITEM IS MEASURED BY THE TON OF 2,000 POUNDS (900 KG) FOR THE AMOUNT OF HYDRATED LIME ACTUALLY USED IN THE COMPLETED AND ACCEPTED WORK.
2. THE QUANTITY OF "MINERAL FILLER", MEASURED AS PROVIDED ABOVE, IS PAID FOR AT THE UNIT PRICE BID PER TON. PRICE AND PAYMENT IS FULL COMPENSATION FOR FURNISHING, STORING, HANDLING AND OTHER CHARGES, ALL TOOLS, EQUIPMENT, LABOR AND PERFORMANCE OF ALL WORK NECESSARY TO MIX THE MATERIAL WITH THE ASPHALT CONCRETE AND ALL OTHER INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
3. PAYMENT IS MADE UNDER:
- A. MINERAL FILLER - PER TON (METRIC TON).

4. 4 PATCHING:

- A. PATCHING IS PAID FOR AT THE CONTRACT UNIT PRICE BID. PRICE AND PAYMENT IS FULL COMPENSATION FOR WORK AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

1. PAYMENT IS MADE BY EITHER OF THE FOLLOWING AS IDENTIFIED UNDER IN THE CONTRACT DOCUMENTS:

2. SQUARE FOOT BASIS

A. THESE ITEMS ARE MEASURED BY THE SQUARE FOOT OF ASPHALT PAVEMENT. THE QUANTITIES MEASURED FOR PAYMENT ARE THE SQUARE FEET OF SPECIFIED THICKNESS OF ASPHALT PAVING IN THE COMPLETED AND ACCEPTED WORK AS MEASURED IN THE FIELD.

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3. TONNAGE BASIS
 - A. THESE ITEMS ARE MEASURED BY THE TON OF 2,000 POUNDS (900 KG) OF ASPHALT PAVING MIXTURE, INCLUDING THE WEIGHT OF THE ASPHALT CEMENT. THE QUANTITIES MEASURED FOR PAYMENT ARE THE AMOUNT OF ASPHALT PAVING MATERIALS ACTUALLY USED IN THE COMPLETED AND ACCEPTED WORK IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.
 - B. PAYMENT WILL NOT BE MADE FOR CORRECTION OF DEFECTIVE WORK AS DESCRIBED IN SECTION 3.29.
4. PRICE AND PAYMENT IS FULL COMPENSATION FOR CLEANING BASE OR UNDERLYING COURSE; FOR PRODUCING, FURNISHING, TRANSPORTING, STOCKPILING, HEATING, DRYING AND SCREENING OF AGGREGATE MATERIALS; FOR FURNISHING, HANDLING, MEASURING, MIXING, MANIPULATING AND PLACING OF MATERIALS; FOR HAULING, PLACING, SHAPING, COMPACTING AND FINISHING OF THE PAVING MIX; FOR IMPROVING UNSATISFACTORY AREAS; FOR FURNISHING SAMPLES; FOR ALL MATERIALS (EXCLUSIVE OF ASPHALT AND MINERAL FILLER), MANIPULATION, LABOR, TOOLS, EQUIPMENT AND INCIDENTALS NECESSARY TO COMPLETE THE WORK IN FULL COMPLIANCE WITH THE PLANS AND SPECIFICATIONS.
5. PAYMENT IS MADE UNDER:
 - A. " _____ "THICKNESS OF ASPHALT CONCRETE PAVEMENT - BASE COURSE - PER TON (900 KG) OR SQUARE FOOT (SQUARE METER).
 - B. " _____ "THICKNESS OF ASPHALT CONCRETE PAVEMENT - SURFACE COURSE GRADE" ____ " - PER TON (900 KG) OR SQUARE FOOT (SQUARE METER).

END OF SECTION 02510

SECTION 02515 - PORTLAND CEMENT CONCRETE PAVEMENT

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS CONSTRUCTING PORTLAND CEMENT CONCRETE PAVEMENT TO THE LINES, GRADES, THICKNESSES, AND CROSS SECTIONS ON THE PLANS ON A PREPARED SUBGRADE OR BASE COURSE.

1.2 REFERENCES

ASTM C-143	SLUMP OF HYDRAULIC CEMENT CONCRETE
ASTM C-231	AIR CONTENT OF FRESHLY MIXED CONCRETE
ASTM C-138	DENSITY(UNIT WEIGHT), YIELD, AND AIR CONTENT(GRAVIMETRIC) OF CONCRETE
ASTM C-39	COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS
ASTM C-78	FLEXURAL STRENGTH OF CONCRETE
ASTM C-150	STANDARD SPECIFICATION FOR PORTLAND CEMENT
ASTM C-595	STANDARD SPECIFICATION FOR BLENDED HYDRAULIC CEMENTS
ASTM C-157	STANDARD PERFORMANCE SPECIFICATION FOR HYDRAULIC CEMENT
ASTM C-33	STANDARD SPECIFICATION FOR CONCRETE AGGREGATES
ASTM C-94	STANDARD SPECIFICATION FOR READY-MIXED CONCRETE
AASHTO M 85	STANDARD SPECIFICATION FOR PORTLAND CEMENT
AASHTO M 183	STANDARD SPECIFICATION FOR STRUCTURAL STEEL
AASHTO M 157	STANDARD SPECIFICATION FOR READY-MIXED CONCRETE
AASHTO M 213	STANDARD SPECIFICATION FOR PREFORMED EXPANSION JOINT FILLERS FOR CONCRETE PAVING AND STRUCTURAL CONSTRUCTION
AASHTO M 182	STANDARD SPECIFICATION FOR SHEET MATERIALS FOR CURING CONCRETE
AASHTO M 148	STANDARD SPECIFICATION FOR LIQUID MEMBRANE-FORMING FOR CURING CONCRETE

PART 2: PRODUCTS

2.1 MATERIALS

- A. FURNISH MATERIALS MEETING THE FOLLOWING, SECTION REQUIREMENTS:

1. PORTLAND CEMENT SECTION 3310

- A. USE PORTLAND CEMENT FOR PAVING MEETING AASHTO M 85, ASTM C150 TYPES I, II, III AND V OR ASTM C-595 TYPE IP OR ASTM C-1157 TYPES GU, MS, HE, AND HS. THE ENGINEER WILL SPECIFY THE TYPE OF CEMENT TO BE USED.

2. AIR ENTRAINING AGENTS SECTION 3310

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3. ADMIXTURES SECTION 3310
4. WATER SECTION 3310
5. FINE AGGREGATE FOR CONCRETE
 - A. USE FINE AGGREGATE FOR CONCRETE MEETING ASTM C33.
6. COARSE AGGREGATE FOR CONCRETE
 - A. USE COARSE AGGREGATE FOR CONCRETE MEETING ASTM C33.
7. REINFORCING STEEL
 - A. USE REINFORCING STEEL MEETING, SECTION 03210 AND THE FOLLOWING.
 - B. DOWELS
 - 1) USE DOWEL BARS FOR RIGID PAVEMENT EXPANSION JOINTS OR DEVICES MEETING AASHTO M1 83 (ASTM A36). ASSURE DOWEL BARS ARE PLAIN AND FREE FROM BURRING OR OTHER DEFORMATIONS THAT PREVENT SLIPPAGE IN THE CONCRETE. PAINT ONE-HALF THE BAR LENGTH WITH ONE COAT OF ZINC OR TAR PAINT.
 - C. SLEEVES
 - 1) USE METAL SLEEVES FOR DOWEL BARS OF STANDARD MANUFACTURE THAT COVER 2-IN MM), PLUS OR MINUS 1/4-INCH (6-5 MM), OF THE DOWEL, HAVING ONE CLOSED END AND INTERNAL STOP THAT HOLDS THE DOWEL BAR AT LEAST 1-INCH (25 MM) FROM THE END. AVOID COLLAPSING THE SLEEVE DURING CONSTRUCTION.
- B. JOINT FILLERS AND SEALERS
 1. FURNISH A ONE-PIECE JOINT FILLER SIZED THE FULL DEPTH AND WIDTH OF THE JOINT. IF A MULTIPLE PIECED JOINT FILLER IS APPROVED, FASTEN THE ABUTTING ENDS FOLLOWING THE FILLER MANUFACTURER'S RECOMMENDATIONS.
 2. USE POURABLE JOINT SEALER MEETING ASTM D3406.
 3. USE TWO-COMPONENT POLYURETHANE OR POLYSULFIDE-BASE SEALANT MEETING, A.N.S.I A 116.1-1960 FLOW AND STRENGTH REQUIREMENTS WHERE SPECIFIED.
 4. USE EITHER CLASS A (SELF-LEVELING) OR CLASS B (NON-SAG) SEALANT FOR HORIZONTAL JOINTS. USE CLASS B SEALANT FOR SLOPED OR VERTICAL JOINTS.
 5. USE PREFORMED JOINT FILLER MEETING, AASHTO M213 REQUIREMENTS, PUNCHED TO RECEIVE THE DOWELS SHOWN ON THE PLANS.
 6. USE PREFORMED COMPRESSION JOINTS MANUFACTURED TO THE DIMENSIONS SPECIFIED ON THE PLANS, FROM MATERIALS MEETING ASTM D 2628.
 7. FURNISH A CERTIFICATION FOR EACH SHIPMENT OF JOINTS INDICATING THAT THE MATERIAL HAS BEEN SAMPLED, TESTED, AND INSPECTED UNDER ASTM D 2628. ASSURE EACH CERTIFICATION FURNISHED IS SIGNED BY A MANUFACTURER'S AUTHORIZED

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AGENT OR INDEPENDENT TESTING AGENCY.

8. IF RECOMMENDED BY THE MANUFACTURER, USE A MANUFACTURER APPROVED LUBRICANT-ADHESIVE TO PROVIDE LUBRICATION AND BOND FOR THE JOINT.

C. CURING AND PROTECTIVE COATING MATERIALS

1. FURNISH MATERIALS MEETING, THE FOLLOWING REQUIREMENTS:

AASHTO M182 (CLASS 3)	BURLAP CLOTH MADE FROM JUTE OR KENAF:
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AASHTO M 171 (ASTM C 171)	SHEET MATERIALS FOR CURING CONCRETE:
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AASHTO M 148	LIQUID MEMBRANE-FORMING COMPOUNDS FOR CURING CONCRETE
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D. PROPORTIONING

1. HAVE A QUALIFIED INDEPENDENT TESTING LABORATORY, APPROVED BY THE ENGINEER, DETERMINE THE MIX DESIGN TO MEET FLEXURAL OR COMPRESSIVE STRENGTH OF THE PAVEMENT AS SPECIFIED IN THE CONTRACT DOCUMENTS. PROPORTION THE CONCRETE MIX UNDER SECTION 03310.2.3 AND HAVE A MAXIMUM 4" (102 MM) SLUMP (2" (51MM) SLIP FORM METHOD).

PART3: EXECUTION

3.1 GENERAL

- A. OBTAIN THE ENGINEER'S APPROVAL OF EQUIPMENT AND TOOLS USED FOR HANDLING, MATERIALS AND PERFORMING ALL PARTS OF THE WORK. APPROVAL APPLIES TO DESIGN, CAPACITY, AND MECHANICAL CONDITIONS. ASSURE THE EQUIPMENT IS ON SITE AHEAD OF THE START OF CONSTRUCTION OPERATIONS FOR THE ENGINEER'S EXAMINATION.

3.2 BATCHING PLANT AND EQUIPMENT

A. GENERAL

1. THE BATCHING, PLANT INCLUDES BINS, WEIGHING HOPPERS AND SCALES FOR THE FINE AGGREGATE AND EACH COARSE AGGREGATE SIZE. FURNISH A SEPARATE SCALE, BIN, AND HOPPER FOR CEMENT IF CEMENT IS USED IN BULK. ASSURE THE WEIGHING HOPPER IS PROPERLY SEALED AND VENTED TO PREVENT DUST DURING OPERATION.

B. BINS AND HOPPERS

1. PROVIDE BINS WITH ADEQUATE SEPARATE COMPARTMENTS FOR FINE AGGREGATE AND FOR EACH SIZE OF COARSE AGGREGATE IN THE BATCHING PLANT.

C. SCALES

1. USE EITHER BEAM TYPE OR SPRINGLESS-DIAL TYPE SCALES FOR WEIGHING, AGGREGATES AND CEMENT. ASSURE THE SCALE IS ACCURATE TO WITHIN 0.5 PERCENT THROUGHOUT THE RANGE OF USE. WHEN BEAM-TYPE SCALES ARE USED, EQUIP THE SCALE WITH A "TELL-TALE" DIAL OR OTHER DEVICE FOR INDICATING, THAT THE REQUIRED LOAD IN THE WEIGHING HOPPER IS BEING APPROACHED. THE

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DEVICE ON WEIGHING BEAMS MUST CLEARLY INDICATE CRITICAL POSITION. ASSURE POISES ARE DESIGNED TO BE SECURED IN ANY POSITION AND TO PREVENT INADVERTENT CHANGE. ASSURE THE WEIGH BEAM AND "TELL-TALE" DEVICE ARE IN FULL VIEW OF THE OPERATOR AS THE HOPPER IS CHARGED AND OPERATOR HAS CONVENIENT ACCESS TO ALL CONTROLS.

2. HAVE CERTIFIED SCALES. HAVE ON HAND NOT LESS THAN TEN, 50-POUND (22.7 KG) WEIGHTS FOR FREQUENT TESTING OF ALL SCALES.
3. BATCHING PLANTS MAY BE EQUIPPED TO PROPORTION AGGREGATES AND BULK CEMENT USING, AUTOMATIC WEIGHING DEVICES OF AN APPROVED TYPE.
4. OBTAIN THE ENGINEER'S APPROVAL FOR ANY DEVIATIONS FROM THE ABOVE STATED BATCH PLANT AND EQUIPMENT REQUIREMENTS BEFORE CONCRETE MANUFACTURE.

3.3 STOCKPILED AGGREGATE

- A. THIS WORK IS STORING AGGREGATE MATERIAL FOR USE ON THE PROJECT AT THE SPECIFIED LOCATIONS.
- B. MATERIALS
 1. ASSURE THE AGGREGATES MEET THE APPLICABLE REQUIREMENTS OF ASTM C-33; AGGREGATES, FOR THE TYPE OF MATERIAL REQUIRED.
- C. CONSTRUCTION
 1. CLEAR AND GRUB THE STOCKPILE SITE. ASSURE THE SITE IS FIRM, SMOOTH AND WELL DRAINED. PLACE AN AGGREGATE BED TO PREVENT CONTAMINATION OF THE STOCKPILES.
 2. BUILD THE STOCKPILES IN MAXIMUM 4 FEET (1.22 M) LAYERS, WITH THE PRECEDING LAYER COMPLETELY IN PLACE BEFORE STARTING, THE NEXT LAYER. DEPOSIT THE MATERIAL TO PREVENT CONING, EXCLUDING FINE AGGREGATE APPROXIMATELY 90 PERCENT FINER THAN A NO.4 SIEVE.
 3. DO NOT DUMP, CAST, OR PUSH MATERIAL OVER STOCKPILE SIDES EXCLUDING FINE AGGREGATE SPECIFIED ABOVE.
 4. SPACE OR SEPARATE USING WALLS, STOCKPILES OF DIFFERENT AGGREGATE TYPES OR SIZES TO PREVENT INTERMINGLING OF THE AGGREGATES.
 5. SUBMIT AND OBTAIN ENGINEER'S APPROVAL OF OPERATIONAL PLAN FOR STOCKPILING ANY MATERIAL OBTAINED BY WET PIT OR DREDGING OPERATIONS.
 6. THE ENGINEER MAY TAKE RANDOM SAMPLES FROM STOCKPILE AREAS WHERE EQUIPMENT HAS BEEN OPERATED. STOP OPERATING EQUIPMENT OVER STOCKPILES IF TESTS SHOW DEGRADATION IS OCCURRING
 7. REMOVE AND TRANSPORT STOCKPILED MATERIAL TO PREVENT SEGREGATION.

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3.4 MIXING

A. GENERAL

1. MIX CONCRETE ON SITE, AT A CENTRAL PLANT, OR WHOLLY OR PARTIALLY IN TRUCK MIXERS. ASSURE EACH MIXER HAS A MANUFACTURER'S PLATE SHOWING THE DRUM CAPACITY OF MIXED CONCRETE AND ROTATION SPEED OF THE MIXING DRUM OR BLADES ATTACHED IN A PROMINENT PLACE.

B. ON SITE MIXERS

1. MIX CONCRETE IN AN APPROVED MIXER ABLE TO COMBINE THE AGGREGATES, CEMENT, AND WATER INTO A THOROUGHLY MIXED AND UNIFORM MASS WITHIN THE SPECIFIED MIXING PERIOD, AND OF DISCHARGING AND DISTRIBUTING THE MIXTURE WITHOUT SEGREGATION ON THE PREPARED GRADE. ASSURE THE MIXER IS EQUIPPED WITH AN APPROVED TIMING DEVICE THAT AUTOMATICALLY LOCKS THE DISCHARGE LEVER WHEN THE DRUM HAS BEEN CHARGED AND RELEASES AT THE END OF THE MIXING PERIOD.
2. FOLLOW THE MANUFACTURER'S RECOMMENDATIONS FOR CLEANING THE MIXER. REPAIR OR REPLACE THE PICKUP AND THROW-OVER BLADES IN THE DRUM OR DRUMS WHEN THEY ARE WORN DOWN 1 INCH (25.4 MM) OR MORE.
3. HAVE AVAILABLE AT THE JOB SITE A COPY OF THE MANUFACTURER'S DESIGN, SHOWING BLADE DIMENSIONS AND ARRANGEMENT, AND ORIGINAL BLADE HEIGHT AND DEPTH; OR PLACE PERMANENT MARKS ON BLADES 1 INCH (25.4 MM) FROM THE NEW BLADE END. DRILLED HOLES OF 1/4-INCH (6.4 MM) DIAMETER NEAR EACH END AND AT THE MID- POINT OF EACH BLADE ARE ACCEPTABLE MARKINGS.

C. TRUCK MIXERS AND TRUCK AGITATORS

1. ASSURE TRUCK MIXERS FOR MIXING AND HAULING CONCRETE, AND TRUCK AGITATORS USED FOR HAULING CENTRAL-MIXED CONCRETE MEET SECTION 03310.3.3 MIXING REQUIREMENTS.

D. NON-AGITATOR TRUCKS

1. ASSURE BODIES OF NON-AGITATING, HAULING EQUIPMENT FOR CONCRETE ARE SMOOTH, MORTAR TIGHT METAL CONTAINERS, CAPABLE OF DISCHARGING THE CONCRETE AT A CONTROLLED RATE WITHOUT SEGREGATION. DISCHARGE OF CONCRETE TO BE FROM THE BOTTOM OF THE CONTAINER. IF THE EQUIPMENT BODY IS TILTED TO DISCHARGE CONCRETE, ASSURE BAFFLES RETARD THE LOAD.

3.5 FINISHING EQUIPMENT.

A. FINISHING MACHINE

1. USE A SUITABLE FINISHING MACHINE.

B. VIBRATORS

1. VIBRATORS MAY BE EITHER THE SURFACE PAN TYPE OR THE INTERNAL TYPE WITH IMMERSSED TUBE OR MULTIPLE SPUDS. VIBRATORS MAY BE ATTACHED TO THE SPREADER, THE FINISHING MACHINE, OR MOUNTED ON A SEPARATE CARRIAGE. DO NOT PERMIT VIBRATORS TO COME IN CONTACT WITH JOINTS, LOAD TRANSFER DEVICES,

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SUBGRADE, OR SIDE FORMS. MAINTAIN THE SURFACE VIBRATOR FREQUENCY AT 3,500 OR MORE IMPULSES PER MINUTE. MAINTAIN FREQUENCY OF INTERNAL TYPES AT 5,000 IMPULSES PER MINUTE OR MORE FOR TUBE VIBRATORS. MAINTAIN 7,000 IMPULSES PER MINUTE OR MORE FOR SPUD VIBRATORS.

2. MAINTAIN A MINIMUM FREQUENCY OF 3,500 IMPULSES PER MINUTE WHEN SPUD- TYPE INTERNAL VIBRATORS, EITHER HAND-OPERATED OR ATTACHED TO SPREADERS OR FINISHING, MACHINES, ARE USED ADJACENT TO FORMS.

C. CONCRETE SAW

1. WHEN SAWING CONCRETE JOINTS, USE SAWING EQUIPMENT CAPABLE OF PRODUCING THE SPECIFIED CUT PRODUCING A STRAIGHT LINE. PROVIDE ARTIFICIAL LIGHTING FOR NIGHT WORK TO PRODUCE WORK OF DAYTIME QUALITY. ASSURE THIS EQUIPMENT IS ON THE JOB BOTH BEFORE AND DURING CONCRETE PLACEMENT.

D. FORMS

1. USE STRAIGHT SIDE METAL FORMS HAVING:
 - A. A MINIMUM 7/32-INCH (5.6 MM) THICKNESS
 - B. A MINIMUM 10 FEET (3.05 M) LENGTH.
 - C. A DEPTH AT LEAST EQUAL TO THE PRESCRIBED EDGE THICKNESS OF THE CONCRETE
 - D. NO HORIZONTAL JOINTS
 - E. A BASE WIDTH EQUAL TO AT LEAST THE DEPTH OF THE FORMS.
2. USE FLEXIBLE OR CURVED FORMS FOR CURVES OF 100-FOOT (30.5 M) RADIUS OR LESS. OBTAIN ENGINEER APPROVAL BEFORE USING FLEXIBLE OR CURVED FORMS. PROVIDE FORM ANCHORS CAPABLE OF WITHSTANDING, WITHOUT VISIBLE SPRING OR SETTLEMENT, THE IMPACT AND VIBRATION OF THE CONSOLIDATING AND FINISHING EQUIPMENT. ASSURE FLANGE BRACES EXTEND OUTWARD ON THE BASE AT LEAST TWO-THIRDS THE HEIGHT OF THE FORM.
3. DO NOT USE FORMS WITH BATTERED TOP SURFACES, BENT, TWISTED, OR BROKEN FORMS IN THE WORK.
4. DO NOT USE REPAIRED FORMS UNTIL INSPECTED AND APPROVED. USE BUILT-UP FORMS ONLY WHERE THE TOTAL PAVEMENT AREA OF ANY SPECIFIED THICKNESS ON THE PROJECT IS LESS THAN 2,000 SQUARE YARDS (1672 M²). ASSURE THE TOP FORM FACE DOES NOT VARY FROM A TRUE PLANE MORE THAN 1/8-INCH IN 10 FEET (3.2 MM IN 3.5 M), AND THE UPSTANDING LEG DOES NOT VARY MORE THAN 1/4-INCH (6.35 MM). ASSURE THE FORMS ARE CAPABLE OF LOCKING THE ENDS OF ABUTTING FORM SECTIONS TOGETHER TIGHTLY PROVIDING A SECURE SETTING.

3.6 GRADE PREPARATION

- A. ONCE THE BASE AND OR SUBGRADE IS GRADED AND COMPACTED TO THE SPECIFIED REQUIREMENTS, TRIM THE GRADE TO SPECIFIED ELEVATION.
- B. BRING THE SUBGRADE OR BASE COURSE TO THE SPECIFIED CROSS SECTION WHEN SIDE FORMS ARE SET TO GRADE.
- C. FILL AND COMPACT LOW AREAS WITH APPROVED MATERIAL, OR FILL WITH CONCRETE

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INTEGRAL WITH THE PAVEMENT.

- D. MAINTAIN THE FINISHED GRADE UNTIL THE PAVEMENT IS PLACED.
- E. KEEP THE SUBGRADE OR BASE COURSE UNIFORMLY MOIST UNTIL THE CONCRETE IS PLACED. DO NOT OVER WET CREATING MUD OR WATER TO POND.

3.7 SETTING FORMS

A. BASE SUPPORT

- 1. PREPARE THE FOUNDATION UNDER THE FORMS SO THAT WHEN THE FORM IS SET, IT IS IN CONTACT FOR ITS WHOLE LENGTH AT THE SPECIFIED GRADE. FILL AND COMPACT TO GRADE WITH GRANULAR MATERIAL, ANY GRADE AT THE FORM LINE FOUND TO BE BELOW ESTABLISHED GRADE. CORRECT OUT OF SPECIFICATION GRADE LINES BY TAMPING, OR BY CUTTING, AS REQUIRED.

B. FORM SETTING

- 1. SET FORMS IN ADVANCE OF CONCRETE PLACING TO PREVENT PLACING DELAYS. ONCE FORMS ARE SET TO CORRECT GRADE, COMPACT THE GRADE ON THE INSIDE AND OUTSIDE EDGES OF THE FORM BASE. STAKE FORMS WITH AT LEAST THREE PINS FOR EACH 10- FOOT (3.05 M) SECTION. PIN EACH SIDE OF EVERY JOINT. ASSURE FORM SECTIONS ARE TIGHTLY LOCKED, FREE FROM PLAY OR MOVEMENT IN ANY DIRECTION. ASSURE THE FORMS DO NOT DEVIATE FROM TRUE LINE IN EXCESS OF 1/4-INCH (6.35 MM) AT ANY POINT. CORRECT ALL FORM SETTLEMENT OR SPRINGING, UNDER THE FINISHING, MACHINE. CLEAN AND OIL FORMS BEFORE PLACING CONCRETE.

C. GRADE AND ALIGNMENT

- 1. CHECK AND CORRECT ALL FORM ALIGNMENT AND GRADE ELEVATION IMMEDIATELY BEFORE PLACING, CONCRETE.

D. CURBS AND GUTTERS AS FORMS

- 1. EDGES OF PREVIOUSLY PLACED CONCRETE GUTTER SECTION MAY BE USED AS A FORM.

3.8 HANDLING, MEASURING, AND BATCHING MATERIALS

- A. SET UP THE BATCH PLANT SITE, LAYOUT, EQUIPMENT, AND TRANSPORTING MATERIAL TO ASSURE AN UNINTERRUPTED SUPPLY OF MATERIAL TO THE WORK. STOCKPILE AGGREGATES FROM DIFFERENT SOURCES AND OF DIFFERENT GRADATIONS TO PREVENT CO-MINGLING.
- B. HANDLE AGGREGATES FROM STOCKPILES OR OTHER SOURCES TO THE BATCHING PLANT TO PREVENT SEGREGATION. AGGREGATES THAT ARE SEGREGATED OR MIXED WITH EARTH OR FOREIGN MATERIAL CANNOT BE USED IN THE WORK. STOCKPILE OR BIN ALL AGGREGATES PRODUCED OR HANDLED BY HYDRAULIC METHODS AND WASHED AGGREGATES FOR AT LEAST 12 HOURS BEFORE BATCHING. RAIL SHIPMENT EXCEEDING 12 HOURS WILL BE ACCEPTED AS ADEQUATE BINNING ONLY IF THE CAR BODIES PERMIT FREE DRAINAGE.
- C. SEPARATELY WEIGH THE FINE AND COARSE AGGREGATE INTO HOPPERS IN THE AMOUNTS SPECIFIED IN THE MIX. MEASURE CEMENT BY THE SACK OR BY WEIGHT. USE SEPARATE SCALES AND HOPPERS FOR WEIGHING THE CEMENT, WITH A DEVICE THAT INDICATES THE COMPLETE CEMENT BATCH DISCHARGE INTO THE BATCH BOX OR

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CONTAINER. ONE SACK OF BULK CEMENT IS 94 POUNDS (42.64 KG).

- D. MEASURE ALL ADMIXTURES INTO THE MIXER WITHIN $\pm 3\%$ ACCURACY.

3.9 MIXING CONCRETE

- A. MIX THE CONCRETE AT THE WORK SITE USING A CENTRAL-MIX PLANT OR TRUCK MIXERS. MIXING TIME IS MEASURED FROM THE TIME ALL MATERIALS, EXCEPT WATER, ARE IN THE DRUM. MEET AASHTO M 157 AND OR ASTM C-94 REQUIREMENTS FOR READY-MIX CONCRETE MIXING AND DELIVERY.
- B. OPERATE THE MIXER AT THE MANUFACTURER'S RECOMMENDED DRUM SPEED ON THE NAME PLATE. REMOVE AND DISPOSE OF OUTSIDE THE WORK AT CONTRACTOR EXPENSE, ANY CONCRETE MIXED LESS THAN THE SPECIFIED TIME. DO NOT EXCEED THE MIXER'S NOMINAL CAPACITY, IN CUBIC FEET, AS SHOWN ON THE MANUFACTURER'S STANDARD RATING PLATE ON THE MIXER. AN OVERLOAD UP TO 10 PERCENT ABOVE THE MIXER'S NOMINAL CAPACITY MAY BE PERMITTED IF CONCRETE TESTS FOR STRENGTH, SEGREGATION, AND UNIFORM CONSISTENCY ARE SATISFACTORY, AND IF NO CONCRETE SPILL OCCURS.
- C. RE-TEMPERING, CONCRETE BY ADDING WATER OR BY OTHER MEANS IS NOT PERMITTED. WHEN CONCRETE IS DELIVERED IN TRANSIT MIXERS OR AGITATORS, ADDITIONAL WATER MAY BE ADDED TO THE BATCH MATERIALS AND ADDITIONAL MIXING, TIME TO INCREASE THE SLUMP TO MEET THE SPECIFIED REQUIREMENTS, IF PERMITTED BY THE ENGINEER, PROVIDING THE FOLLOWING, CONDITIONS ARE MET:
1. MAXIMUM ALLOWABLE WATER-CEMENT RATIO IS NOT EXCEEDED.
 2. MAXIMUM ALLOWABLE SLUMP IS NOT EXCEEDED.
 3. MAXIMUM ALLOWABLE MIXING AND AGITATING, TIME (OR DRUM REVOLUTIONS) IS NOT EXCEEDED.
 4. CONCRETE IS REMIXED FOR AT LEAST ONE-HALF THE MINIMUM REQUIRED MIXING, TIME OR NUMBER OF REVOLUTIONS.
- D. CONCRETE NOT MEETING THESE REQUIREMENTS WILL BE REJECTED. OBTAIN THE ENGINEER'S APPROVAL FOR ADMIXTURES THAT INCREASE THE WORKABILITY OR ACCELERATE THE SET.

3.10 LIMITATIONS OF MIXING

- A. DO NOT MIX, PLACE, OR FINISH CONCRETE WHEN LIGHT CONDITIONS PREVENT MEETING, THE CONTRACT REQUIREMENTS. OBTAIN THE ENGINEER'S APPROVAL OF ARTIFICIAL LIGHTING
- B. DISCONTINUE CONCRETE MIX OPERATIONS WHEN THE AMBIENT TEMPERATURE IS 40° F (4°C) AND FALLING. DO NOT RESUME CONCRETE WORK UNTIL THE AMBIENT TEMPERATURE IS 35°F (2°C) AND RISING.
- C. WHEN CONCRETING WORK IS APPROVED DURING COLD WEATHER, THE AGGREGATES MAY BE HEATED BY EITHER STEAM OR DRY HEAT BEFORE BEING PLACED IN THE MIXER. ASSURE THE MATERIAL IS UNIFORMLY HEATED WITHOUT INJURING IT.
- D. MAINTAIN THE MIXED CONCRETE TEMPERATURE BETWEEN 50°F (10°C) AND 90°F (32°C) DURING PLACEMENT IN THE FORMS

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- E. THE ENGINEER MAY DIRECT HEATING THE WATER AND AGGREGATES IF THE AIR TEMPERATURE IS 35°F (2°C) OR LESS AT THE TIME OF PLACING, CONCRETE. HEAT WATER AND AGGREGATE TO BETWEEN 70°F (21°C) AND 150°F (66°C). DO NOT PLACE CONCRETE ON FROZEN SUBGRADE OR USE FROZEN AGGREGATES IN THE CONCRETE.

3.11 PLACING CONCRETE

- A. EACH PLACING/FINISHING CREW MUST HAVE AT LEAST ONE ACI FLATWORK FINISHER TECHNICIAN LEVEL OR ABOVE, ON SITE AT ALL TIMES.
- B. PLACE THE CONCRETE ON THE GRADE, HANDLING, IT AS LITTLE AS POSSIBLE. ASSURE TRUCK MIXERS, TRUCK AGITATORS, OR NON-AGITATING HAULING EQUIPMENT ARE CAPABLE OF CONCRETE DISCHARGE WITHOUT SEGREGATING, THE MATERIALS. UNLOAD THE CONCRETE INTO AN APPROVED SPREADER AND SPREAD ON THE GRADE TO PREVENT SEGREGATION. CONTINUOUSLY PLACE CONCRETE BETWEEN TRANSVERSE JOINTS WITHOUT THE USE OF INTERMEDIATE BULKHEADS. PERFORM NECESSARY HAND SPREADING, USING ONLY SHOVELS. DO NOT PERMIT WORKMEN TO WALK IN FRESHLY MIXED CONCRETE WITH BOOTS OR SHOES COATED WITH EARTH OR FOREIGN SUBSTANCES.
- C. WHERE CONCRETE IS TO BE PLACED ADJOINING A PREVIOUSLY CONSTRUCTED LANE OF PAVEMENT AND MECHANICAL EQUIPMENT WILL BE OPERATED UPON THE EXISTING LANE OF PAVEMENT, ASSURE THAT LANE HAS ATTAINED 80 PERCENT OF DESIGN STRENGTH. IF ONLY FINISHING EQUIPMENT IS CARRIED ON THE EXISTING LANE, PAVING IN THE ADJOINING LANES MAY BE PERMITTED.
- D. THOROUGHLY CONSOLIDATE CONCRETE AGAINST AND ALONG THE FACES OF ALL FORMS AND ALONG THE FULL LENGTH AND ON BOTH SIDES OF ALL JOINT ASSEMBLIES USING VIBRATORS. DO NOT PERMIT VIBRATORS TO CONTACT JOINT ASSEMBLIES, THE GRADE, OR A SIDE FORM. DO NOT OPERATE VIBRATORS MORE THAN 15 SECONDS IN ANY ONE LOCATION.
- E. DEPOSIT CONCRETE AS CLOSE TO EXPANSION AND CONTRACTION JOINTS AS POSSIBLE WITHOUT DISTURBING THEM. DO NOT DUMP FROM THE DISCHARGE BUCKET OR HOPPER ONTO A JOINT ASSEMBLY UNLESS THE HOPPER IS CENTERED ON THE JOINT ASSEMBLY.
- F. IMMEDIATELY REMOVE ANY CONCRETE SPILLS FROM COMPLETED SLAB SURFACES, USING METHODS APPROVED BY THE ENGINEER.

3.12 TESTING

- A. USE ACI GRADE I OR EQUIVALENT CERTIFIED FIELD-TESTING TECHNICIANS FOR ALL CONCRETE TESTS.
1. FURNISH THE CONCRETE REQUIRED FOR TESTING AS PER SECTION 01400.
 2. SAMPLE, MAKE SPECIMENS, AND TEST CONCRETE UNDER THE FOLLOWING:

SLUMP	AASHTO T1 19 (ASTM C-143)
AIR CONTENT (GRAVEL OR STONE)	AASHTO T1 52 (ASTM C-23 1) (SLAG
OR HIGHLY POROUS AGGR.)	ASTM C-173
CEMENT CONTENT & UNIT WEIGHT	AASHTO T121 (ASTM C-138)
STRENGTH (COMPRESSIVE)	AASHTO T22 (ASTM C-39)
(FLEXURAL, THIRD POINT METHOD)	AASITFO T97 (ASTM C-78)
MAKING AND CURING TEST	AASHTO T97 (ASTM C-78)
SPECIMENS IN THE FIELD	

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3. CURE BEAMS IN THE FIELD BY THE METHOD SPECIFIED FOR THE PAVEMENT.

3.13 STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT

- A. PLACE THE CONCRETE, STRIKE IT OFF, CONSOLIDATE, AND FINISH IT TO THE PLANNED CROSS SECTION AND ELEVATION.
- B. WHEN PLACING REINFORCED CONCRETE PAVEMENT IN TWO LAYERS, STRIKE-OFF THE FIRST LAYER TO PLAN DEPTH AND PLACE THE REINFORCING FULL LENGTH ITS FINAL POSITION WITHOUT FURTHER MANIPULATION. PLACE THE SECOND CONCRETE LAYER, STRIKE IT OFF, AND SCREED. REMOVE AND REPLACE ANY BOTTOM LAYER CONCRETE THAT HAS BEEN IN PLACE MORE THAN 30 MINUTES WITHOUT BEING COVERED WITH THE TOP LAYER AT CONTRACTOR EXPENSE. WHEN REINFORCED CONCRETE IS PLACED IN ONE LAYER, THE REINFORCEMENT MAY BE POSITIONED IN ADVANCE OF CONCRETE PLACEMENT OR IT MAY BE PLACED BY MECHANICAL OR VIBRATORY MEANS IN PLASTIC CONCRETE, AFTER THE CONCRETE IS SPREAD.
- C. ASSURE REINFORCING STEEL IS FREE FROM DIRT, OIL, PAINT, GREASE, MILL SCALE, AND LOOSE OR THICK RUST.

3.14 JOINTS

- A. CONSTRUCT JOINTS AS SPECIFIED IN THE CONTRACT DOCUMENTS.
- B. LONGITUDINAL JOINT
 - 1. PLACE DEFORMED STEEL TIE BARS OF SPECIFIED LENGTH, SIZE, SPACING, AND MATERIAL AS SHOWN ON THE PLANS. PLACE REINFORCING USING APPROVED MECHANICAL EQUIPMENT OR RIGIDLY SECURED BY CHAIRS OR OTHER APPROVED SUPPORTS. ASSURE TIE BARS ARE NOT PAINTED, COATED WITH ASPHALT OR OTHER MATERIAL, OR ENCLOSED IN TUBES OR SLEEVES. WHEN ADJACENT LANES OF PAVEMENT ARE CONSTRUCTED SEPARATELY, USE STEEL SIDE FORMS THAT WILL FORM A KEYWAY ALONG THE CONSTRUCTION JOINT. TIE BARS MAY BE BENT AT RIGHT ANGLES AGAINST THE FORM OF THE FIRST LANE CONSTRUCTED AND STRAIGHTENED INTO FINAL POSITION BEFORE THE CONCRETE OF THE ADJACENT LANE IS PLACED, OR INSTEAD OF BENT TIE BARS, APPROVED TWO-PIECE CONNECTORS MAY BE USED.
 - 2. LONGITUDINAL FORMED JOINTS ARE A GROOVE, OR CLEFT, EXTENDING DOWNWARD FROM, AND NORMAL TO, THE PAVEMENT SURFACE. MAKE THESE JOINTS USING AN APPROVED MECHANICALLY OR MANUALLY OPERATED DEVICE TO THE PLAN DIMENSIONS AND LINE WHILE THE CONCRETE IS IN A PLASTIC STATE. SEAL THE GROOVE, OR CLEFT, WITH EITHER A PRE-MOLDED STRIP OR POURED MATERIAL AS REQUIRED.
 - 3. PLACE THE LONGITUDINAL SAWED JOINTS SO THAT THEIR ENDS CONTACT WITH ANY TRANSVERSE JOINTS.
 - 4. CUT LONGITUDINAL SAWED JOINTS USING APPROVED CONCRETE SAWS TO THE PLAN DEPTH, WIDTH, AND LINE. USE GUIDELINES OR DEVICES TO ASSURE CUTTING THE LONGITUDINAL JOINT AS SHOWN ON THE PLANS. SAW THE LONGITUDINAL JOINT BEFORE THE CURE PERIOD ENDS OR SHORTLY THEREAFTER AND BEFORE ANY EQUIPMENT OR VEHICLES ARE PERMITTED ON THE PAVEMENT. THOROUGHLY CLEAN THE SAWED AREA USING BOTH WATER AND

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COMPRESSED AIR. IMMEDIATELY REMOVE FROM THE JOINT ALL CONCRETE PIECES, AGGREGATE AND RESIDUE LEFT FROM THE SAWING. ASSURE THAT THE CUT DEPTH IS UNIFORM. START SEALING AS SOON AS THE JOINT IS DRY. FORM LONGITUDINAL JOINTS BY PLACING A CONTINUOUS STRIP OF PLASTIC OR OTHER INERT MATERIAL. ASSURE THE JOINT INSERT MATERIAL IS STRONG, NON-STRETCHABLE, 3 MIL THICK, 2-INCH (50.8 MM) WIDE, INCAPABLE OF BONDING WITH THE CONCRETE AND WILL FORM A WEAKENED PLANE 2-INCH (50.8 MM) MINIMUM DEPTH.

5. INSERT THE JOINT MATERIAL USING A MECHANICAL DEVICE THAT PLACES THE MATERIAL IN A CONTINUOUS STRIP, EXCEPT WHERE INTERVENING STRUCTURES BREAK THE CONTINUITY OF PAVING. SPLICES IN THE JOINT MATERIAL ARE PERMITTED IF THEY CAN MAINTAIN THE CONTINUITY OF THE JOINT MATERIAL AS PLACED. PLACE THE JOINT MATERIAL SO THAT THE TOP OF THE STRIP IS NOT ABOVE, NOR MORE THAN 1/4-INCH (6.35 MM) BELOW, THE FINISHED CONCRETE SURFACE. ONCE PLACED, ASSURE THE VERTICAL AXIS OF THE JOINT MATERIAL IS WITHIN 10 DEGREES OF A PLANE NORMAL TO THE PAVEMENT SURFACE. ASSURE FINAL STRIP ALIGNMENT IS PARALLEL WITH THE PAVEMENT CENTER LINE AND DOES NOT VARY MORE THAN 1 INCH (25.4 MM) FROM THE EDGE OF A 12-FOOT (3.7 M) STRAIGHTEDGE. THE INSTALLATION DEVICE MUST CONSOLIDATE THE CONCRETE ABOUT THE JOINT MATERIAL. ONCE THE JOINT MATERIAL IS INSTALLED, ASSURE THE CONCRETE IS FREE OF SEGREGATION, ROCK POCKETS OR VOIDS AND THE FINISHED CONCRETE SURFACE ON EACH SIDE OF THE JOINT IS IN THE SAME PLANE.

C. TRANSVERSE EXPANSION JOINTS

1. PLACE THE EXPANSION JOINT FILLER CONTINUOUSLY FROM FORM TO FORM, SHAPED TO THE SUBGRADE AND THE KEYWAY ALONG THE FORM. FURNISH PREFORMED JOINT FILLER IN LENGTHS EQUAL TO THE PAVEMENT WIDTH OR EQUAL TO ONE LANE WIDTH. USE DAMAGED OR REPAIRED JOINT FILLER ONLY WITH THE ENGINEER'S APPROVAL.
2. ENSURE THE EXPANSION JOINT FILLER IS HELD VERTICALLY. USE AN APPROVED INSTALLING BAR, OR OTHER DEVICE IF REQUIRED TO SECURE PREFORMED EXPANSION JOINT FILLER AT THE PROPER GRADE AND ALIGNMENT DURING CONCRETE PLACING AND FINISHING - ASSURE FINISHED JOINTS DO NOT DEVIATE MORE THAN 1/4-INCH (6.35 MM) HORIZONTALLY FROM A STRAIGHT LINE. IF JOINT FILLERS ARE ASSEMBLED IN SECTION, NO OFFSETS ARE PERMITTED BETWEEN ADJACENT UNITS. NO CONCRETE PLUGS ARE PERMITTED ANYWHERE WITHIN THE EXPANSION SPACE.

D. TRANSVERSE CONTRACTION JOINTS

1. TRANSVERSE CONTRACTION JOINTS ARE WEAKENED PLANES CREATED BY FORMING OR CUTTING GROOVES IN THE PAVEMENT SURFACE AND, WHEN SHOWN ON THE PLANS, ARE TO INCLUDE LOAD TRANSFER ASSEMBLIES.
2. FORM TRANSVERSE STRIP CONTRACTION BY INSTALLING A PARTING STRIP TO BE LEFT IN PLACE.
3. MAKE FORMED GROOVES BY DEPRESSING AN APPROVED TOOL OR DEVICE INTO THE PLASTIC CONCRETE. LEAVE THE TOOL OR DEVICE IN PLACE UNTIL THE CONCRETE HAS ATTAINED ITS INITIAL SET AND THEN REMOVE IT WITHOUT DISTURBING THE ADJACENT CONCRETE, UNLESS IT IS DESIGNED TO REMAIN IN PLACE.

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4. MAKE SAWED CONSTRUCTION JOINTS BY SAWING GROOVES IN THE PAVEMENT SURFACE OF THE DIMENSIONS AND SPACING AND LINES ON THE PLANS, USING AN APPROVED CONCRETE SAW. START SAWING JOINTS AS SOON AS THE CONCRETE HAS HARDENED SUFFICIENTLY TO PERMIT SAWING WITHOUT EXCESSIVE RAVELING. SAW ALL JOINTS BEFORE UNCONTROLLED SHRINKAGE CRACKING OCCURS. WHEN REQUIRED, CONTINUE SAW OPERATIONS BOTH DURING THE DAY AND NIGHT, REGARDLESS OF WEATHER CONDITIONS. DO NOT SAW A PLANNED JOINT WHEN A VOLUNTEER CRACK DEVELOPS AT OR NEAR THE PLANNED JOINT LOCATION. DISCONTINUE SAWING WHEN A CRACK DEVELOPS AHEAD OF THE SAW. TYPICALLY, SAW ALL JOINTS IN SEQUENCE. SAW ALL CONTRACTION JOINTS IN LANES AND ADJACENT TO PREVIOUSLY CONSTRUCTED LANES BEFORE UNCONTROLLED CRACKING OCCURS. IF CONDITIONS EXIST THAT MAKE IT IMPRACTICAL TO PREVENT ERRATIC CRACKING BY EARLY SAWING, FORM THE CONTRACTION JOINT GROOVE BEFORE INITIAL SET OF CONCRETE AS PROVIDED ABOVE.
5. WHEN DIRECTED, ROUT OR SAW RANDOM CRACKS AND FILL WITH JOINT SEALER. THOROUGHLY CLEAN THE SAWED AREA USING WATER AND COMPRESSED AIR. IMMEDIATELY REMOVE ALL PIECES OF CONCRETE, AGGREGATE AND RESIDUE FROM THE JOINT CAUSED BY SAWING. TAKE CARE TO MAINTAIN UNIFORM CUT DEPTH. SEAL THE JOINT AS SOON AS IT IS DRY.
6. MAKE SURE TRANSVERSE FORMED CONTRACTION JOINTS COMPLY WITH SECTION 02515 3.14 REQUIREMENTS FOR THE LONGITUDINAL FORMED JOINT.
7. CONSTRUCT TRANSVERSE CONSTRUCTION JOINTS IF THERE IS AN INTERRUPTION EXCEEDING 30 MINUTES IN THE CONCRETING WORK. DO NOT CONSTRUCT A TRANSVERSE JOINT WITHIN 5 FEET (1.5 M) OF AN EXPANSION JOINT, CONTRACTION JOINT, OR WEAKENED PLANE. IF SUFFICIENT CONCRETE HAS NOT BEEN MIXED AT THE TIME OF INTERRUPTION TO FORM A SLAB AT LEAST 5 FEET (1.5 M.) LONG, REMOVE AND DISPOSE OF EXCESS CONCRETE BACK TO THE LAST PRECEDING JOINT AS DIRECTED.

3.15 LOAD TRANSFER DEVICES

- A. WHEN USED, HOLD DOWELS IN POSITION PARALLEL TO THE SURFACE AND CENTERLINE OF THE SLAB BY A METAL DEVICE THAT IS LEFT IN THE PAVEMENT.
- B. THOROUGHLY COAT WITH AN APPROVED LUBRICANT, THE PORTION OF EACH DOWEL PAINTED WITH ONE COAT OF LEAD OR TAR PAINT, AS REQUIRED UNDER SECTION 02515.2.1; MATERIALS. FURNISH AN APPROVED METAL DOWEL CAP OR SLEEVE MEETING SECTION 02515.2.1; MATERIALS REQUIREMENTS, FOR EACH DOWEL BAR USED WITH THE EXPANSION JOINTS. ASSURE THE CAPS OR SLEEVES FIT THE DOWEL BAR TIGHTLY.
- C. INSTEAD OF USING DOWEL ASSEMBLIES AT CONTRACTION JOINTS, DOWEL BARS MAY BE PLACED IN THE FULL PAVEMENT THICKNESS USING AN APPROVED MECHANICAL DEVICE.

3.16 FINAL STRIKE-OFF, CONSOLIDATION, AND FINISHING

- A. SEQUENCE
 1. SEQUENCE THE WORK AS FOLLOWS: STRIKE-OFF, CONSOLIDATE, FLOAT AND REMOVE LATENCY, STRAIGHT-EDGE, AND FINAL SURFACE FINISH.
 2. IF APPLYING WATER TO THE SURFACE IS PERMITTED, APPLY IT AS A FOG SPRAY

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USING AN APPROVED SPRAY EQUIPMENT.

B. FINISHING AT JOINTS

1. PLACE THE CONCRETE ADJACENT TO JOINTS, UNDER AND AROUND ALL LOAD TRANSFER DEVICES, JOINT ASSEMBLY UNITS, AND OTHER FEATURES DESIGNED TO EXTEND INTO THE PAVEMENT, FREE OF VOIDS OR SEGREGATION. MECHANICALLY VIBRATE CONCRETE ADJACENT TO JOINTS MEETING SECTION 02515.3.11, PLACING CONCRETE REQUIREMENTS.
2. ONCE THE CONCRETE HAS BEEN PLACED AND VIBRATED ADJACENT TO THE JOINTS AS REQUIRED IN SECTION 02515.3.11; PLACING CONCRETE, BRING THE FINISHING MACHINE FORWARD, OPERATING IT TO AVOID DAMAGE TO OR MISALIGNMENT OF JOINTS. IF UNINTERRUPTED OPERATION OF THE FINISHING MACHINE, TO, OVER, AND BEYOND THE JOINTS, CAUSES SEGREGATION OF CONCRETE, DAMAGE TO, OR MISALIGNMENT OF THE JOINTS, LIFT THE FINISHING MACHINE AND SET IT DIRECTLY ON TOP OF THE JOINT AND RESUME THE FINISHING. WHEN THE SECOND SCREED IS CLOSE ENOUGH TO PERMIT THE EXCESS MORTAR IN FRONT OF IT TO FLOW OVER THE JOINT, LIFT THE SCREED AND CARRY IT OVER THE JOINT. THEREAFTER, THE FINISHING MACHINE MAY BE RUN OVER THE JOINT WITHOUT THE SCREEDS BEING LIFTED, PROVIDED THERE IS NO SEGREGATED CONCRETE IMMEDIATELY BETWEEN THE JOINT AND THE SCREED OR ON TOP OF THE JOINT.

C. MACHINE FINISHING

1. VIBRATE ALL CONCRETE PAVEMENT UNLESS OTHERWISE APPROVED FOR SMALL AREAS OR FOR SHORT PERIODS OF TIME DUE TO EQUIPMENT FAILURE. ASSURE VIBRATORS FOR FULL WIDTH VIBRATION OF CONCRETE PAVING SLABS MEET SECTION 02515.3.5.B, VIBRATORS REQUIREMENTS. IF CONCRETE UNIFORMITY AND DENSITY IS NOT OBTAINED USING THE VIBRATORY METHOD AT JOINTS, ALONG FORMS, AT STRUCTURES, AND THROUGHOUT THE PAVEMENT, FURNISH EQUIPMENT AND METHODS WHICH WILL PRODUCE PAVEMENT MEETING SPECIFICATIONS.

D. HAND FINISHING

1. HAND FINISHING IS PERMITTED UNDER THE FOLLOWING CONDITIONS:
 - A. IF MECHANICAL EQUIPMENT BREAKS DOWN, HAND FINISHING CONCRETE. ALREADY DEPOSITED ON THE GRADE WHEN THE BREAKDOWN OCCURS IS PERMITTED.
 - B. WIDTHS OR AREAS OF IRREGULAR DIMENSIONS, WHERE MECHANICAL FINISHING EQUIPMENT IS IMPRACTICAL.
 - C. AS SOON AS CONCRETE IS PLACED, STRIKE IT OFF AND SCREED IT. USE AN APPROVED PORTABLE SCREED. PROVIDE A SECOND SCREED FOR STRIKING OFF THE BOTTOM LAYER OF CONCRETE IF REINFORCEMENT IS USED.
 - D. ASSURE THE SCREED FOR THE SURFACE IS AN APPROVED DESIGN, SUFFICIENTLY RIGID TO RETAIN ITS SHAPE, AND CONSTRUCTED OF METAL, AND AT LEAST 2 FEET (.6 M) LONGER THAN THE MAXIMUM WIDTH OF THE SLAB TO BE STRUCK OFF.
 - E. OBTAIN CONSOLIDATION USING A VIBRATOR OR OTHER APPROVED

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EQUIPMENT.

- F. MOVE THE SCREED FORWARD ON THE FORMS WITH A COMBINED LONGITUDINAL AND TRANSVERSE MOTION, ALWAYS MOVING IN THE DIRECTION THE WORK IS PROGRESSING AND OPERATED TO ENSURE THAT NEITHER END IS RAISED FROM THE SIDE FORMS DURING THE STRIKE OFF PROCESS. IF NECESSARY, REPEAT THIS UNTIL THE SURFACE IS UNIFORM IN TEXTURE, TRUE TO GRADE AND CROSS SECTION, AND FREE FROM POROUS AREAS.

2. FLOATING

- A. ONCE THE CONCRETE IS STRUCK OFF AND CONSOLIDATED, USE OF ONE OF THE FOLLOWING METHODS AS SPECIFIED OR APPROVED.

- B. HAND METHOD

- 1) USE A HAND-OPERATED, LONGITUDINAL FLOAT AT LEAST 12 FEET (3.7 M) LONG AND 6 INCHES (152.4 MM) WIDE, STIFFENED TO PREVENT FLEXING AND WARPING. WORK THE FLOAT IN A SAWING MOTION, OPERATING FROM FOOT BRIDGES RESTING ON THE SIDE FORMS AND SPANNING AND NOT TOUCHING THE CONCRETE. MOVE AHEAD ALONG THE PAVEMENT CENTERLINE IN SUCCESSIVE SECTIONS NOT EXCEEDING ONE-HALF THE LENGTH OF THE FLOAT. WASTE ALL EXCESS WATER OR SOUPY MATERIAL OVER THE SIDE FORMS ON EACH PASS.

- C. MECHANICAL METHOD

- 1) OBTAIN THE ENGINEER'S APPROVAL OF THE MECHANICAL FLOAT BEFORE USE. ADJUST THE FLOAT TRACKS TO THE REQUIRED CROWN. ASSURE THE FLOAT IS ADJUSTED TO THE TRANSVERSE FINISHING MACHINE TO MAINTAIN A MORTAR WAVE AHEAD OF THE FLOAT AT ALL TIMES. ENSURE THE FLOAT PASSES OVER EACH PAVEMENT AREA AT LEAST TWICE. WASTE ALL EXCESS WATER OR SOUPY MATERIAL OVER THE SIDE FORMS ON EACH PASS.

- D. ALTERNATE MECHANICAL METHOD

- 1) AS AN ALTERNATE TO ITEM (2) ABOVE, THE CONTRACTOR MAY USE A MACHINE HAVING A CUTTING AND SMOOTHING FLOAT, OR FLOATS, SUSPENDED FROM AND GUIDED BY A RIGID FRAME. THIS FRAME MUST BE CARRIED BY 4 OR MORE VISIBLE WHEELS RIDING ON, AND IN CONSTANT CONTACT WITH, THE SIDE FORMS.
 - 2) IF NECESSARY, FOLLOWING ONE OF THE PRECEDING FLOAT METHODS, LONG-HANDLED FLOATS HAVING BLADES A MINIMUM 5 FEET (1.52 M) LONG AND 6 INCHES (152.4 MM) WIDE MAY BE USED TO SMOOTH AND FILL IN OPEN-TEXTURED AREAS IN THE PAVEMENT. DO NOT USE LONG-HANDLED FLOATS TO FLOAT THE ENTIRE PAVEMENT SURFACE IN PLACE OF, OR SUPPLEMENTING, ONE OF THE PRECEDING FLOATING METHODS. WHEN STRIKE-OFF AND CONSOLIDATION ARE PERFORMED BY HAND AND THE PAVEMENT CROWN WILL NOT PERMIT USING A LONGITUDINAL FLOAT, FLOAT THE SURFACE TRANSVERSELY USING THE LONG-HANDLED FLOAT. TAKE CARE TO NOT WORK THE PAVEMENT CROWN DURING THE

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WORK.

E. STRAIGHT EDGE TESTING AND SURFACE CORRECTION

1. ONCE FLOATING IS COMPLETED, EXCESS WATER REMOVED, AND THE CONCRETE IS STILL PLASTIC, TEST THE CONCRETE SURFACE FOR TRUENESS WITH A 10-FOOT (3.05 M) STRAIGHTEDGE. FURNISH AND USE AN 10-FOOT (3.05 M) STRAIGHTEDGE SWUNG FROM HANDLES 3 FEET (.91 M) LONGER THAN ONE-HALF THE SLAB WIDTH. HOLD THE STRAIGHTEDGE IN CONTACT WITH THE SURFACE IN SUCCESSIVE POSITIONS PARALLEL TO THE ROAD CENTERLINE AND THE GO OVER THE WHOLE SLAB AREA, AS REQUIRED. ADVANCE ALONG THE ROAD IN NOT TO EXCEED ONE-HALF THE STRAIGHTEDGE LENGTH. IMMEDIATELY FILL AN DEPRESSIONS WITH FRESH MIXED CONCRETE, STRIKE OFF, CONSOLIDATE, AND REFINISH. TRIM HIGH AREAS AND REFINISH. GIVE SPECIAL ATTENTION TO ASSURE THAT SURFACES ACROSS JOINTS MEET THE SMOOTHNESS REQUIREMENTS. CONTINUE STRAIGHTEDGE TESTING AND SURFACE CORRECTIONS UNTIL THE ENTIRE SURFACE MEETS THE REQUIRED GRADE AND CROSS SECTION.

F. FINAL FINISH

1. THE FINAL FINISH AS SPECIFIED IN THE CONTRACT DOCUMENTS AS TO THE TYPE OF SURFACE TEXTURE. THE FOLLOWING TYPES OF SURFACE TEXTURES MAY BESPECIFIED: TYPE I - TRANSVERSE TINING, TYPE II - LONGITUDINAL TINING, TYPE III - NYLON OR ARTIFICIAL GRASS DRAG, TYPE IV.- NYLON OR BRISTLE BROOM, TYPE V - BELT FINISH, AND TYPE VI - BURLAP DRAG. WHEN FINAL, LONGITUDINAL TEXTURING HAS BEEN COMPLETED BY THE BURLAP DRAG, TEXTURE THE PLASTIC PAVEMENT SURFACE TO THE DESIGNATED TEXTURE AS APPROVED BY THE ENGINEER. A BELT FINISH DOES NOT NEED TO BE PRECEDED BY A BURLAP DRAG.

A. TYPE I - TRANSVERSE TINING

- 1) PRODUCE THE MAINLINE FINISH USING MECHANICAL EQUIPMENT DESCRIBED AS FOLLOWS: THE TRANSVERSE GROOVING MACHINE MUST BE EITHER A VIBRATING ROLLER OR A COMB EQUIPPED WITH STEEL TINES. THE MACHINE MUST BE SELF-PROPELLED AND AUTOMATICALLY LIFT THE ROLLER OR TINE COMB AT THE PAVEMENT END. OBTAIN THE ENGINEER'S APPROVAL OF HAND GROOVING METHODS IN THOSE AREAS WHERE THE MECHANICAL EQUIPMENT ARE NOT PRACTICAL.
- 2) ASSURE THE EQUIPMENT HAS RECTANGULAR OR CIRCULAR SHAPED SPRING STEEL TINES THAT ARE SPACED 1/2- TO 1-INCH (12.7 - 25.4 MM) CENTER TO CENTER. MAKE THE GROOVES PERPENDICULAR TO THE PAVEMENT CENTER LINE AND THE TRANSVERSE GROOVES BEING 0.090 TO 0. 125 INCHES (2.3 - 3.2 NUN) WIDE AND 1/8- TO 3/16-INCH (3.2 - 4.8 MM) DEEP. ACCELERATION LANES, DECELERATION LANES, AND IRREGULAR SECTIONS MAY BE FINISHED BY METHODS OTHER THAN MECHANICAL, IF THEY PRODUCE A SIMILAR TRANSVERSE GROOVE.

B. TYPE II - LONGITUDINAL TINING

- 1) PRODUCE THE MAINLINE FINISH USING MECHANICAL EQUIPMENT MEETING THE FOLLOWING: THE LONGITUDINAL GROOVING

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MACHINE MUST BE EITHER A VIBRATING ROLLER OR A COMB EQUIPPED WITH STEEL TINES, BE SELF-PROPELLED AND AUTOMATICALLY LIFT THE ROLLER OR TINE COMB AT THE PAVEMENT END. OBTAIN THE ENGINEER'S APPROVAL OF HAND GROOVING METHODS IN AREAS WHERE MECHANICAL EQUIPMENT CANNOT BE USED.

- 2) ASSURE THE EQUIPMENT HAS RECTANGULAR OR CIRCULAR SHAPED SPRING STEEL TINES THAT ARE SPACED 1/2- TO 1-INCH (12.7 - 25.4 MM) CENTER TO CENTER. MAKE THE GROOVES PARALLEL TO THE PAVEMENT CENTER LINE AND THE LONGITUDINAL GROOVES 0.090 TO 0.125 INCHES (2.3 - 3.2 MM) WIDE AND 1/8- TO 3/16-INCH (3.2 - 4.8 MM) DEEP. OPERATE THE MECHANICAL EQUIPMENT FROM A BRIDGE WHEN THE PAVEMENT IS 4.9 M (16 FEET) OR MORE IN WIDTH.
- 3) ACCELERATION LANES, DECELERATION LANES, AND IRREGULAR SECTIONS MAY BE FINISHED BY METHODS OTHER THAN MECHANICAL, IF THEY PRODUCE A SIMILAR TYPE OF LONGITUDINAL GROOVE.

C. TYPE III - NYLON OR ARTIFICIAL GRASS DRAG

- 1) PRODUCE THE PAVEMENT FINISH USING A NYLON OR ARTIFICIAL GRASS DRAG, APPROVED BY THE ENGINEER. PRODUCE A SURFACE BY PULLING THE DRAG LONGITUDINALLY. FOR A PAVEMENT WIDTH OF 16 FEET (4.9 M) OR MORE, MOUNT THE DRAG ON A BRIDGE THAT TRAVELS ON THE FORMS. USE A DRAG OF AT LEAST 3 FEET (.91 M) WIDE AND MAINTAIN FULL CONTACT THE PAVEMENTS FULL WIDTH. MAINTAIN DRAGS CLEAN AND FREE FROM ENCRUSTED MORTAR. REPLACE DRAGS THAT CANNOT BE CLEANED WITH NEW ONES.

D. TYPE IV - NYLON OR BRISTLE BROOM

- 1) APPLY BROOM TEXTURING WHEN THE WATER SHEEN HAS DISAPPEARED. DRAW THE BROOM FROM THE CENTER TO THE EDGE OF THE PAVEMENT WITH ADJACENT STROKES OVERLAPPING. PERFORM THE BROOMING SO THAT THE SURFACE CORRUGATIONS ARE UNIFORM IN APPEARANCE AND HAVE A MINIMUM DEPTH OF 1/16-INCH (1.6 MM) AND A MAXIMUM DEPTH OF 1/8-INCH (3.2 MM). COMPLETE BROOMING BEFORE THE CONCRETE SURFACE WILL BE TORN OR ROUGHENED BY THE WORK. PRODUCE A FINISHED SURFACE FREE FROM ROUGH AND POROUS AREAS, IRREGULARITIES AND DEPRESSIONS RESULTING FROM POOR WORKMANSHIP. MECHANICAL BROOMING, IN LIEU OF THE MANUAL BROOMING, IS PERMITTED IF THE SPECIFIED RESULTS CAN BE OBTAINED.

E. TYPE V - BELT FINISH (PAVING WITH RIGID FORMS)

- 1) WHEN STRAIGHT EDGING IS COMPLETE AND THE WATER SHEEN HAS DISAPPEARED, AND JUST BEFORE THE CONCRETE BECOMES NON- PLASTIC, BELT THE SURFACE WITH A TWO-PLY, CANVAS BELT A MINIMUM 8 INCHES (203.2 MM) WIDE AND A MINIMUM 3 FEET (.9 M) LONGER THAN THE PAVEMENT WIDTH. EQUIP HAND BELTS

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WITH HANDLES TO PERMIT CONTROLLED, UNIFORM MANIPULATION. WORK THE BELT WITH SHORT STROKES TRANSVERSE TO THE ROAD CENTERLINE ADVANCING PARALLEL TO THE CENTERLINE.

F. TYPE VI - BURLAP DRAG

- 1) USE A DRAG OF SEAMLESS STRIP DAMP BURLAP OR COTTON FABRIC TO PRODUCE A ROUGHENED SURFACE, DRAGGING IT LONGITUDINALLY ALONG THE PAVEMENTS FULL WIDTH. FOR PAVEMENT 16 FEET (4.9 M) OR MORE IN WIDTH, MOUNT THE DRAG ON A BRIDGE THAT TRAVELS ON THE RAILS. USE A DRAG AT LEAST 3 FEET (.91 M) WIDE, MAINTAINING CONTACT WITH THE FULL PAVEMENT WIDTH. MAINTAIN DRAGS CLEAN AND FREE FROM ENCRUSTED MORTAR. REPLACE DRAGS THAT CANNOT BE CLEANED WITH NEW DRAGS.

3.17 EDGING AT FORMS AND JOINTS

- A. AFTER THE FINAL FINISH AND BEFORE THE CONCRETE HAS TAKEN ITS INITIAL SET, ROUND THE EDGES OF THE PAVEMENT ALONG EACH SIDE OF EACH SLAB, AND ON EACH SIDE OF TRANSVERSE EXPANSION JOINTS, FORMED JOINTS, TRANSVERSE CONSTRUCTION JOINTS, AND EMERGENCY CONSTRUCTION JOINTS WITH AN APPROVED TOOL TO THE SPECIFIED RADIUS. PRODUCE A RADIUS HAVING A SMOOTH, DENSE MORTAR FINISH. DO NOT DISTURB THE SLAB SURFACE WITH THE TOOL DURING THE WORK.
- B. AT ALL JOINTS, REMOVE ALL TOOL MARKS ON THE SLAB ADJACENT TO THE JOINTS BY BROOMING THE SURFACE. DO NOT DISTURB THE ROUNDING OF THE SLAB COMER WHEN BROOMING THE SURFACE. COMPLETELY REMOVE ALL CONCRETE ON TOP OF THE JOINT FILLER.
- C. TEST ALL JOINTS WITH A STRAIGHTEDGE BEFORE THE CONCRETE HAS SET AND CORRECT IF ONE SIDE OF THE JOINT IS HIGHER THAN THE OTHER OR IF AN EDGE IS HIGHER OR LOWER THAN THE ADJACENT SLABS.

3.18 SURFACE TEST

- A. AS SOON AS THE CONCRETE HAS HARDENED TO PERMIT TESTING, TEST THE PAVEMENT SURFACE WITH A 10-FOOT (3.05 M) STRAIGHTEDGE OR OTHER APPROVED DEVICE. MARK AND GRIND HIGH SPOTS EXCEEDING 1/4-INCH (6.35 MM.), BUT UNDER 1/2-INCH IN 10 FEET (12.7 MM IN 3.05 M), USING AN APPROVED GRINDING TOOL TO AN ELEVATION WHERE THE AREA OR SPOT WILL NOT SHOW SURFACE DEVIATIONS EXCEEDING 1/4-INCH (6.35 MM) WHEN TESTED WITH A 10- FOOT (3.05 M) STRAIGHTEDGE. USE STACKED HEAD, VERTICAL BLADE GRINDERS THAT WILL PROVIDE A COEFFICIENT OF FRICTION APPROXIMATELY EQUAL TO THAT OF THE UN-GROUND PAVEMENT. KEEP GRINDING GROOVES PARALLEL TO THE DIRECTION OF TRAVEL. WHERE THE DEPARTURE FROM CORRECT CROSS SECTION EXCEEDS 1/2-INCH (12.7 MM)), REMOVE AND REPLACE THE PAVEMENT BY HAND AT CONTRACTOR EXPENSE.
- B. ANY AREA OR SECTION SO REMOVED CANNOT BE LESS THAN 5 FEET (1.52M) LONG THE FULL LANE WIDTH. WHEN REQUIRED TO REMOVE AND REPLACE A SECTION OF PAVEMENT REMOVE AND REPLACE ANY REMAINING PORTION OF THE SLAB ADJACENT TO THE JOINTS THAT IS LESS THAN 5 FEET (1.52 M) LONG.

3.19 CURING

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- A. IMMEDIATELY AFTER THE FINISHING OPERATIONS ARE COMPLETE AND THE SURFACE CANNOT BE MARRED, COVER AND CURE THE ENTIRE SURFACE OF THE NEWLY PLACED CONCRETE MEETING ONE OF THE FOLLOWING METHODS. IMMEDIATELY STOP CONCRETE WORK WHEN INSUFFICIENT COVER MATERIAL OR LACK OF WATER WOULD PREVENT OBTAINING THE SPECIFIED CURE RESULTS. DO NOT LEAVE THE CONCRETE EXPOSED FOR MORE THAN 1/2-HOUR BETWEEN STAGES OF CURING OR DURING THE CURING PERIOD.
- 1. COTTON OR BURLAP MATS
 - A. COVER THE ENTIRE PAVEMENT SURFACE WITH MATS, EXTENDING LEAST TWICE THE PAVEMENT THICKNESS BEYOND THE SLAB EDGES. ASSURE THAT THE ENTIRE SURFACE AND BOTH EDGES OF THE SLAB ARE COMPLETELY COVERED. BEFORE PLACING MATS, SATURATE THE MATS THOROUGHLY WITH WATER. PLACE AND WEIGHT THE MATS TO REMAIN IN CONTACT WITH THE COVERED SURFACE. KEEP THE MATS WETTED AND IN PLACE FOR 72 HOURS AFTER THE CONCRETE HAS BEEN PLACED.
 - 2. WATERPROOFED PAPER
 - A. COVER THE PAVEMENT TOP AND SIDES ENTIRELY WITH WATERPROOFED PAPER. LAP THE UNITS AT LEAST 18 INCHES (.46 M). PLACE AND WEIGHT THE PAPER TO MAINTAIN CONTACT WITH THE SURFACE. ASSURE THE PAPER EXTENDS BEYOND THE SLAB EDGES AT TWICE THE PAVEMENT THICKNESS. IF LAID LONGITUDINALLY, PAPER, NOT MANUFACTURED IN SIZES THAT WILL PROVIDE THIS WIDTH, MUST BE SECURELY SEWED OR CEMENTED TOGETHER WITH JOINTS BEING SEALED SO THAT THEY DO NOT OPEN UP OR SEPARATE DURING THE CURE PERIOD. MAINTAIN THE COVERING IN PLACE FOR 72 HOURS AFTER THE CONCRETE HAS BEEN PLACED. THOROUGHLY WET THE PAVEMENT SURFACE BEFORE PLACING THE PAPER.
 - 3. STRAW CURING
 - A. WHEN USING THIS TYPE OF CURING, INITIALLY CURE THE PAVEMENT USING BURLAP OR COTTON MATS, MEETING SECTION 02515.3.19.A.A ABOVE, UNTIL AFTER FINAL SET OF THE CONCRETE OR, IN ANY CASE, FOR 12 HOURS AFTER THE CONCRETE IS PLACED. ONCE THE MATS ARE REMOVED, THOROUGHLY WET AND COVER THE SURFACE AND SIDES OF THE PAVEMENT WITH AT LEAST 8 INCHES (203.2 MM) (WETTED THICKNESS) OF STRAW OR HAY. REPAIR OR REPLACE STRAW OR HAY COVERING DISPLACED DURING THE CURING PERIOD AND SATURATE WITH WATER FOR 3 DAYS. THOROUGHLY WET THE COVERING DOWN THE MORNING OF THE FOURTH DAY. KEEP THIS COVER IN PLACE UNTIL THE CONCRETE HAS ATTAINED THE REQUIRED STRENGTH. WHEN PERMISSION IS GIVEN TO OPEN THE PAVEMENT TO TRAFFIC, REMOVE AND DISPOSE OF THE COVERING LEAVING THE RIGHT-OF-WAY IN A NEAT AND PRESENTABLE CONDITION. DO NOT DISPOSE OF THE COVERING BY BURNING ON, OR ADJACENT TO, THE PAVEMENT.

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4. WHITE PIGMENTED IMPERVIOUS MEMBRANE
 - A. UNIFORMLY SPRAY THE ENTIRE PAVEMENT SURFACE WITH WHITE PIGMENTED CURING COMPOUND IMMEDIATELY AFTER THE FINISHING OF THE SURFACE AND BEFORE THE SET OF THE CONCRETE HAS TAKEN PLACE, OR IF THE PAVEMENT IS CURED INITIALLY WITH BURLAP OR COTTON MATS, THE CURING COMPOUND MAY BE APPLIED UPON REMOVAL OF THE MATS.
 - B. DO NOT APPLY THE CURING COMPOUND DURING RAINFALL.
 - C. APPLY CURING COMPOUND UNDER PRESSURE AT 1 GALLON PER 150 SQUARE FEET (3.79 L PER 13.95 SQUARE METERS) USING MECHANICAL SPRAYERS. USE SPRAYING EQUIPMENT OF THE FULLY ATOMIZING TYPE EQUIPPED WITH A TANK AGITATOR. AT THE TIME OF USE, ASSURE THE COMPOUND IS THOROUGHLY MIXED WITH THE PIGMENT UNIFORMLY DISPERSED THROUGHOUT THE VEHICLE. DURING APPLICATION, CONTINUOUSLY STIR THE COMPOUND USING MECHANICAL MEANS. HAND SPRAYING OF ODD WIDTHS OR SHAPES AND ON CONCRETE SURFACES EXPOSED BY THE REMOVAL OF FORMS IS PERMITTED. DO NOT APPLY CURING COMPOUND TO THE INSIDE FACES OF JOINTS TO BE SEALED.
 - D. USE CURING COMPOUND PRODUCING A FILM THAT WILL HARDEN WITHIN 30 MINUTES AFTER APPLICATION IMMEDIATELY RE-APPLY CURING COMPOUND DAMAGED FROM ANY CAUSE WITHIN THE REQUIRED CURING PERIOD.
 - E. UPON REMOVAL OF SIDE FORMS, APPLY CURING COMPOUND TO THE EXPOSED SLAB SIDES.
5. WHITE POLYETHYLENE SHEETING
 - A. COVER ENTIRELY THE TOP SURFACE AND SIDES OF THE PAVEMENT WITH POLYETHYLENE SHEETING. LAP THE PIECES AT LEAST 18 INCHES (35 CM). PLACE AND WEIGHT THE SHEETING SO IT REMAINS IN CONTACT WITH THE SURFACE. LAY SHEETING SO IT EXTENDS BEYOND THE EDGES OF THE SLAB AT LEAST TWICE THE THICKNESS OF THE PAVEMENT. MAINTAIN THE COVERING IN PLACE FOR 72 HOURS AFTER THE CONCRETE HAS BEEN PLACED.
- B. CURING IN COLD WEATHER
 1. WHEN THE AVERAGE DAILY TEMPERATURE IS BELOW 40°F (4°C), CURE BY COVERING THE PAVEMENT WITH AT LEAST 12 INCHES (304.8 MM) OF LOOSE, DRY HAY OR STRAW, OR EQUIVALENT PROTECTIVE COVERING AUTHORIZED BY THE ENGINEER. LEAVE COVERING IN PLACE FOR 10 DAYS.
 2. WHEN CONCRETE IS PLACED AND THE AIR TEMPERATURE COULD DROP BELOW 35 F, PROVIDE THE VOLUME OF STRAW, HAY, GRASS, OR OTHER BLANKETING MATERIAL AT THE WORK SITE. ANYTIME THE TEMPERATURE MAY BE EXPECTED TO REACH THE FREEZING POINT DURING THE DAY OR NIGHT, SPREAD THE MATERIAL OVER THE PAVEMENT TO THE REQUIRED DEPTH TO PREVENT FREEZING OF THE CONCRETE. MAINTAIN THE COVERING FOR A MINIMUM 10 DAYS. BE RESPONSIBLE FOR THE QUALITY AND STRENGTH OF THE CONCRETE PLACED DURING COLD WEATHER AND REMOVE AND REPLACE AT CONTRACTOR EXPENSE ANY CONCRETE INJURED BY FREEZING.

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3.20 REMOVING FORMS

- A. REMOVE FORMS ONLY AFTER THE FRESHLY PLACE CONCRETE HAS SET FOR 12 HOURS, EXCLUDING AUXILIARY FORMS USED TEMPORARILY IN WIDENED AREAS. CAREFULLY REMOVE FORMS TO PREVENT DAMAGE TO THE PAVEMENT. ONCE THE FORMS ARE REMOVED, CURE THE SLAB SIDES AS SPECIFIED HEREIN. REMOVE AND REPLACE MAJOR HONEYCOMBED AREAS. THE MINIMUM AREA TO BE REMOVED IS 10 FEET IN LENGTH (3.05 M), THE FULL WIDTH OF THE LANE INVOLVED. WHEN IT IS NECESSARY TO REMOVE AND REPLACE A PAVEMENT SECTION, ANY REMAINING PORTION OF THE SLAB, ADJACENT TO THE JOINTS, LESS THAN 5 FEET (1.52 M) IN LENGTH IS TO BE REMOVED AND REPLACED.

3.21 SEALING JOINTS

- A. IF THE JOINTS ARE TO BE SEALED, FILL THEM WITH JOINT SEALING MATERIAL BEFORE THE PAVEMENT IS OPENED TO TRAFFIC AND AS SOON AS PRACTICAL AFTER COMPLETION OF THE CURING PERIOD. JUST BEFORE SEALING, THOROUGHLY CLEAN EACH JOINT OF ALL FOREIGN MATERIAL, INCLUDING MEMBRANE CURING COMPOUND, ASSURING THE JOINT FACES ARE CLEAN AND SURFACE DRY WHEN THE SEAL IS APPLIED. STIR MATERIAL FOR HOT APPLIED SEAL DURING HEATING
- B. APPLY THE SEALING MATERIAL TO EACH JOINT OPENING MEETING THE PLAN DETAILS OR AS DIRECTED BY THE ENGINEER. POUR SO THAT THE MATERIAL DOES NOT SPILL ON THE EXPOSED CONCRETE SURFACES. REMOVE AND CLEAN FROM CONCRETE SURFACES ALL EXCESS SEALING MATERIAL. THE USE OF SAND OR SIMILAR MATERIAL AS A COVER FOR THE SEAL IS NOT PERMITTED. DO NOT PLACE POURED JOINT SEALING MATERIAL WHEN THE AMBIENT TEMPERATURE IS LESS THAN 50°F (10°C), UNLESS APPROVED BY THE ENGINEER.

3.22 PROTECTION OF PAVEMENT

- A. PROTECT THE PAVEMENT AND ITS APPURTENANCES AGAINST BOTH PUBLIC AND CONTRACTOR TRAFFIC. THIS INCLUDES SUPPLYING WATCHMEN TO DIRECT TRAFFIC AND THE ERECTION AND MAINTENANCE OF WARNING SIGNS AND LIGHTS.
- B. TO PROTECT THE CONCRETE AGAINST RAIN BEFORE THE CONCRETE IS SUFFICIENTLY HARDENED, HAVE AVAILABLE AT ALL TIMES MATERIALS FOR THE PROTECTION OF THE EDGES AND SURFACE OF THE UNHARDENED CONCRETE. PROTECTIVE MATERIALS CONSIST OF STANDARD METAL FORMS OR WOOD PLANK HAVING A MINIMUM NOMINAL THICKNESS OF 2 INCHES (50.8 MM) AND A MINIMUM NOMINAL WIDTH OF THE PAVEMENT THICKNESS AT ITS EDGE FOR THE PROTECTION OF THE PAVEMENT EDGES, AND COVERING MATERIAL SUCH AS BURLAP OR COTTON MATS, CURING PAPER, OR PLASTIC SHEETING MATERIAL FOR THE PROTECTION OF THE SURFACE OF THE PAVEMENT. STOP PAVING WHEN RAIN APPEARS IMMINENT AND HAVE ALL AVAILABLE PERSONNEL BEGIN PLACING FORMS AGAINST THE SIDE OF THE PAVEMENT AND COVER THE SURFACE OF THE UNHARDENED CONCRETE WITH THE PROTECTIVE COVERING.
- C. REPAIR OR REPLACE ALL DAMAGE TO THE PAVEMENT OCCURRING BEFORE FINAL ACCEPTANCE AT CONTRACTOR EXPENSE.

3.23 OPENING TO TRAFFIC

- A. OBTAIN THE ENGINEER'S APPROVAL TO OPEN THE PAVEMENT TO TRAFFIC. PAVEMENT CANNOT BE OPENED TO TRAFFIC UNTIL SPECIMEN BEAMS, MEETING 3.12; TESTING, HAVE REACHED THE DESIGN FLEXURAL STRENGTH, TESTED UNDER THE THIRD-POINT METHOD ACCORDING TO SECTION 3.12; TESTING. IF THE TESTS ARE NOT PERFORMED, THE PAVEMENT MAY BE OPENED AT THE DISCRETION OF THE ENGINEER. CLEAN THE PAVEMENT BEFORE OPENING TO TRAFFIC.

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3.24 CONCRETE PAVEMENT - SLIPFORM METHOD

- A. PAVEMENT MAY BE CONSTRUCTED WITHOUT USING FIXED FORMS. WHEN THE SLIPFORM METHOD IS USED, MEET THE FOLLOWING PROVISIONS:

1. GRADE

- A. ONCE THE GRADE OR BASE IS PLACED AND COMPACTED TO THE SPECIFIED DENSITY, CUT THE GRADE AND AREAS THAT WILL SUPPORT THE PAVING MACHINE TO THE REQUIRED ELEVATION USING AN APPROVED FINE-GRADING MACHINE. USE A SELF-PROPELLED OR TOWED FINE-GRADING MACHINE HAVING THE WEIGHT AND POWER TO TRIM THE COMPACTED MATERIAL WITHOUT GOUGING OR TEARING THE SURFACE. ASSURE THE MACHINE IS EQUIPPED WITH CUTTING EDGES OR SURFACE SHAVERS CONTROLLED FROM AN INDEPENDENT CONTROL REFERENCE WIRE HAVING AN AUTOMATIC CONTROL DEVICE. TO AVOID EXCESSIVE DEPTHS OF CUT, THE MACHINE IS TO FINE GRADE MAKING SUCCESSIVE PASSES, WITH EACH PASS CONTROLLED FROM THE INDEPENDENT REFERENCE LINE THROUGH THE AUTOMATIC CONTROL. RE- COMPACT TO THE SPECIFIED DENSITY, ALL BASE DISTURBED BY THE GRADING OPERATION, BEFORE PLACING CONCRETE. MAINTAIN THE GRADING OPERATIONS IN ADVANCE OF CONCRETE PLACEMENT. REPAIR DAMAGE TO THE GRADE CAUSED BY TRAFFIC BEFORE PLACING THE CONCRETE.

2. PLACING CONCRETE

- A. PLACE CONCRETE USING AN APPROVED, SLIPFORM PAVER ABLE TO SPREAD, CONSOLIDATE, SCREED, AND FLOAT-FINISH THE FRESHLY PLACED CONCRETE IN ONE COMPLETE PASS TO THE SPECIFIED LINE, GRADE, AND CROSS SECTION WITH A MINIMUM OF HAND FINISHING. ASSURE THE MACHINE IS EQUIPPED WITH VIBRATORS, VIBRATING THE CONCRETE THE PAVEMENTS FULL WIDTH AND DEPTH. VIBRATORS MUST BE VIBRATING TUBES OR ARMS WORKING IN THE CONCRETE, OR A VIBRATING SCREED OR PAN OPERATING ON THE CONCRETE SURFACE. ASSURE THE SLIDING FORMS ARE CAPABLE OF RESISTING DISPLACEMENT BY THE WET CONCRETE. USE FORMS THAT TRAIL BEHIND THE PAVER AND PREVENT SLUMPING OF THE CONCRETE DURING THE WORK.
- B. ASSURE THE CONCRETE DOES NOT EXCEED A SLUMP OF 2 INCHES (50.8 MM). OPERATE THE SLIPFORM PAVER AT A UNIFORM SPEED. COORDINATE ALL CONCRETE MIXING, DELIVERING, AND SPREADING TO MAINTAIN UNIFORM PROGRESS WITH MINIMUM STOPPING AND STARTING OF THE PAVING WORK. IMMEDIATELY STOP VIBRATORY AND TAMPING WHEN IT IS NECESSARY TO STOP THE PAVER. DO NOT APPLY ANY OUTSIDE TRACTIVE FORCE TO THE PAVER NOT CONTROLLED BY IT.

3. FINISHING

- A. MEET THE SURFACE SMOOTHNESS AND TEXTURE REQUIREMENTS OF SECTION 02515.3.16.F; FINAL FINISH, AND SECTION 02515.3.18; SURFACE TEST.

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4. CURING

- A. PERFORM CURING USING ONE OF THE METHODS IN SECTION 02515.3.19, CURING.

5. JOINTS

- A. CONSTRUCT ALL JOINTS UNDER SECTION 02515.3.14, JOINTS.

3.25 TOLERANCE IN PAVEMENT THICKNESS

- A. THE PAVEMENT THICKNESS WILL BE DETERMINED BY MEASURING CORES. THE ACTUAL PAVEMENT THICKNESS MUST BE WITHIN 1/4-INCH (6.35 MM) OF THE SPECIFIED THICKNESS.
- B. WHEN ANY CORE IS LESS THAN THE PLAN THICKNESS BY MORE THAN THE ALLOWABLE DEVIATION, ADDITIONAL CORES WILL BE TAKEN FROM THE AREA AT MINIMUM 10-FOOT (3-05 M) INTERVALS PARALLEL TO THE CENTERLINE IN EACH DIRECTION FROM THE AFFECTED LOCATION UNTIL, IN EACH DIRECTION, A CORE IS FOUND WHICH IS NOT DEFICIENT BY MORE THAN THE ALLOWABLE DEVIATION. THE ENGINEER WILL EVALUATE AREAS FOUND DEFICIENT IN THICKNESS BY MORE THAN THE ALLOWABLE DEVIATION. REMOVE AND REPLACE DEFICIENT AREAS TO THE SPECIFIED THICKNESS AT CONTRACTOR EXPENSE.

PART 4: MEASUREMENT AND PAYMENT

4.1 MEASUREMENT AND PAYMENT

- A. THE PAVEMENT IS MEASURED BY THE SQUARE YARD (SQ METER) OR LINEAR FOOT (LINEAR METER) OF FULL-DEPTH PAVEMENT. THE ENGINEER WILL MEASURE THE NUMBER OF SQUARE YARDS (SQ METERS) OR LINEAR FEET (LINEAR METER) AFTER CONSTRUCTION OF THE PAVEMENT HAS BEEN COMPLETED.
- B. ACCEPTED PAVEMENT IS PAID FOR AT THE CONTRACT UNIT PRICE PER SQUARE YARD (SQ METER) OR LINEAR FOOT (LINEAR METER) AS CALLED FOR IN THE CONTRACT DOCUMENTS. THIS PRICE CONSTITUTES FULL COMPENSATION FOR FURNISHING AND PREPARING ALL MATERIALS, INCLUDING ALL JOINTS, JOINT FILLER, DOWELS, AND REINFORCING IF REQUIRED IN THE CONSTRUCTION DRAWINGS OR SPECIAL PROVISIONS; PLACING, FINISHING, CURING; AND ALL LABOR, EQUIPMENT, TOOLS AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.
- C. PAYMENT WILL BE MADE UNDER:
1. CONCRETE PAVEMENT - SQ. YD. OR LINEAR FOOT (SQ. METER. OR LINEAR METER)

END OF SECTION 02515

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SECTION 02528 - CONCRETE CURB AND GUTTER

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS CONSTRUCTING COMBINED CURB AND GUTTER USING STRUCTURAL CONCRETE AND MEETING THE LINES, DIMENSIONS, AND GRADES SHOWN ON THE PLANS AND THESE SPECIFICATIONS.
- B. STANDARD DRAWINGS IN APPENDIX A THAT ARE APPLICABLE TO THIS SECTION ARE:
 - 1. STANDARD DRAWING 02528-1, STANDARD CURB AND GUTTER
 - 2. STANDARD DRAWING 02528-2, DRIVE-OVER CURB AND GUTTER

1.2 REFERENCES

- | | |
|--------------|--|
| AASHTO M 213 | STANDARD SPECIFICATION FOR PREFORMED EXPANSION JOINT FILLERS FOR CONCRETE PAVING AND STRUCTURAL CONSTRUCTION |
| AASHTO M 148 | STANDARD SPECIFICATION FOR LIQUID-FORMING COMPOUNDS FOR CURING CONCRETE |

PART 2: PRODUCTS

2.1 STRUCTURAL CONCRETE

- A. FURNISH STRUCTURAL CONCRETE MEETING THE REQUIREMENTS OF SECTION 03310, STRUCTURAL CONCRETE.

2.2 REINFORCING STEEL

- A. FURNISH REINFORCING STEEL MEETING THE REQUIREMENTS OF SECTION 03210, REINFORCING STEEL.

2.3 PRE-FORMED EXPANSION JOINT MATERIAL

- A. FURNISH JOINT MATERIAL MEETING THE REQUIREMENTS OF AASHTO M213.

2.4 GRAVEL BASE MATERIAL

- A. FURNISH GRAVEL BASE MEETING ALL APPLICABLE PORTIONS OF SECTION 02235, CRUSHED BASE COURSE, AND MEETING GRADATION REQUIREMENTS FOR 1" MINUS MATERIAL.

2.5 CURING AND PROTECTIVE COATING MATERIALS

- A. LIQUID MEMBRANE-FORMING COMPOUNDS FOR CURING CONCRETE
 - 1. FURNISH LIQUID MEMBRANE-FORMING COMPOUND MEETING THE REQUIREMENTS OF AASHTO M148, TYPE 1, CLEAR OR TRANSLUCENT.

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B. EMULSIFIED LINSEED OIL COMPOUND

1. ASSURE IT MEETS ALL REQUIREMENTS OF AASHTO M148 AND CONTAINS AT LEAST 2.7 POUNDS (0.32 KG) OF LINSEED OIL PER GALLON (LITER). FURNISH A MANUFACTURER'S CERTIFICATION SHOWING THAT THE FORMULATED WEIGHT OF LINSEED OIL PER GALLON EQUALS OR EXCEEDS THIS LIMIT.

PART 3: EXECUTION

3.1 GENERAL

- A. CONCRETE CURB AND GUTTER MAY BE MACHINE-LAID OR HAND-FORMED. PERFORM WORK MEETING THESE REQUIREMENTS AND THE APPLICABLE REQUIREMENTS OF SECTION 03310, STRUCTURAL CONCRETE.

3.2 FOUNDATION PREPARATION

- A. EXCAVATE THE FOUNDATION TO THE SPECIFIED DEPTH. ASSURE THE SUBGRADE OR BASE COURSE FOR THE CONCRETE HAS A FIRM AND EVEN SURFACE AND IS COMPACTED MEETING SECTION 02230, STREET EXCAVATION, BACKFILL, AND COMPACTION.
- B. COMPLETE EXCAVATION TO THE LINES SHOWN IN THE CONTRACT DOCUMENTS.
- C. PLACE AT LEAST 3 INCHES (7.5 CM) OF GRAVEL BASE MATERIAL AND COMPACT IT TO A FIRM, EVEN SURFACE UNDER ALL CURB AND GUTTER. THIS REQUIREMENT IS WAIVED IF CURB AND GUTTER IS INSTALLED ON A PORTION OF STREET BASE COURSE MATERIAL OF 3 INCHES (7.5 CM) OR MORE IN THICKNESS.
- D. FOR NEW STREET CONSTRUCTION OR STREET RECONSTRUCTING, PLACE GRAVEL BASE COURSE FOR THE STREET TO THE BACK OF THE CURB.

3.3 FORMS

- A. USE METAL FORMS UNLESS OTHERWISE APPROVED OF THE DEPTH EQUAL TO THE FACE OF THE ITEM BEING CONSTRUCTED. OBTAIN ENGINEER APPROVAL OF IN-PLACE FORMS BEFORE PLACING CONCRETE.
- B. ASSURE FORMS PRODUCE THE SHAPE, LINES, AND DIMENSIONS SHOWN ON THE PLANS AND/OR DRAWINGS. ASSURE FORMS PREVENT LEAKAGE OF MORTAR AND MAINTAIN POSITION AND ALIGNMENT. THOROUGHLY CLEAN AND OIL BEFORE PLACING AND DO NOT REMOVE FORMS UNTIL THE CONCRETE HAS HARDENED SUFFICIENTLY TO PREVENT DAMAGE.
- C. WHERE THE CURB AND GUTTER IS TO ABUT AN EXISTING SIDEWALK, USE AN APPROVED FACE-OF-GUTTER FORM SECURED TO MAINTAIN AN ESTABLISHED GUTTER GRADE. VARY THE CURB HEIGHT TO ASSURE THE TOP OF CURB MATCHES AS NEARLY AS POSSIBLE THE STANDARD CURB AND GUTTER CROSS SECTION. OBTAIN ENGINEER APPROVAL TO HAND FORM LENGTHS NOT EXCEEDING 10 FEET (3M).
- D. FORM RADII USING FLEXIBLE OR CURVED METAL FORMS SET TO FIT THE SPECIFIED CURVATURE. OBTAIN ENGINEER APPROVAL BEFORE USING WOOD FORMS. RADII MAY BE FORMED BY USING SEGMENTS OF STRAIGHT FORMS IF THE LENGTH OF THE STRAIGHT SEGMENT DOES NOT EXCEED ONE-TENTH OF THE LENGTH OF THE RADIUS.

3.4 REINFORCEMENT

- A. PLACE REINFORCEMENT AS REQUIRED. PLACE AND HOLD IN POSITION BEFORE PLACING CONCRETE.

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CONCRETE CURB AND GUTTER

3.5 PLACING CONCRETE

- A. PLACE AND COMPACT THE SUBGRADE TO THE SPECIFIED GRADE BEFORE PLACING CONCRETE. DAMPEN THE SUBGRADE JUST BEFORE PLACING THE CONCRETE. SPADE AND TAMP THE CONCRETE THOROUGHLY INTO THE FORMS TO PROVIDE A DENSE, COMPACTED CONCRETE FREE OF ROCK POCKETS. FLOAT, FINISH, AND BROOM THE EXPOSED SURFACES. EACH PLACING/FINISHING CREW SHALL HAVE AT LEAST ONE ACI FLATWORK FINISHING TECHNICIAN LEVEL OR ABOVE, ON SITE AT ALL TIMES.
- B. DO NOT PLACE CONCRETE AT A RATE THAT EXCEEDS THE FINISHING OPERATION'S ABILITY TO MEET THESE SPECIFICATIONS.
- C. MACHINES OR EQUIPMENT THAT EXTRUDE CURB AND GUTTER MAY BE USED WHEN APPROVED, PROVIDED THEY PRODUCE A FINISHED PRODUCT MATCHING THAT OBTAINED BY THE SET-FORM METHOD. USE SLIP-FORM MACHINES THAT ARE AUTOMATICALLY CONTROLLED FOR LONGITUDINAL GRADE, ALIGNMENT, AND TRANSVERSE SLOPE BY SENSING DEVICES OPERATING FROM STRING LINES SET FROM CONSTRUCTION STAKES PLACED BY THE ENGINEER.

3.6 STRIPPING FORMS AND FINISHING

A. FORMS

- 1. REMOVE FORMS WHEN THE CONCRETE IS SUFFICIENTLY SET TO PREVENT CHIPPING OR SPALLING. WHEN FORMS ARE REMOVED BEFORE THE CURING PERIOD HAS EXPIRED, PROTECT THE CONCRETE EDGES WITH MOIST EARTH OR SPRAY EDGES WITH CURING COMPOUND. CLEAN, OIL, AND EXAMINE ALL FORMS FOR DEFECTS BEFORE THEY ARE USED AGAIN.

B. FINISHING

- 1. FINISH THE SURFACE OF CONCRETE CURBS AND GUTTERS TRUE TO THE LINES AND GRADES SHOWN ON THE PLANS.
- 2. FILL HONEYCOMB OR OTHER BLEMISHES IN FORMED SURFACES WITH GROUT TO THE SPECIFIED FINISH. TOOL ALL EDGES TO A 1/4-INCH (6.4 MM) RADIUS. FLOAT THE SURFACE USING A MAGNESIUM FLOAT TO A SMOOTH AND UNIFORM SURFACE. WHEN THE CONCRETE IN THE CURB AND GUTTER HAS HARDENED SUFFICIENTLY, GIVE THE SURFACE A BROOM FINISH. OBTAIN ENGINEER APPROVAL OF THE BROOM BEFORE USE. BROOM THE SURFACE WITHOUT TEARING THE CONCRETE. BROOM TO PRODUCE REGULAR CORRUGATIONS NOT EXCEEDING 1/8-INCH (3.2 MM) DEEP.

C. CREW

- 1. DO NOT APPLY ADDITIONAL SURFACE WATER. THE ENGINEER MAY PERMIT ADDING WATER, BUT IT MUST BE APPLIED BY FOG SPRAY ONLY. USE OF AN EVAPORATION RETARDANT, CONFILM, OR EQUAL, FOLLOWING THE MANUFACTURER'S DIRECTIONS IS PERMITTED.

3.7 CURING

- A. CURING MEETING SECTION 03310, STRUCTURAL CONCRETE, REQUIREMENTS.

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3.8 JOINTS

- A. PLACE CURB AND GUTTER MONOLITHICALLY WITH NO CONSTRUCTION JOINTS PERMITTED, EXCEPT AT PLANNED EXPANSION JOINTS.
- B. CONSTRUCT EXPANSION JOINTS AT RADIUS POINTS, CONSTRUCTION JOINTS, JUNCTIONS WITH EXISTING CONCRETE, OPPOSITE TO OR AT EXPANSION JOINTS IN ADJACENT CONCRETE, AND AT MAXIMUM 300-FOOT (92 M) INTERVALS, IN A CONTINUOUS RUN OF CONCRETE BEING PLACED. FORM EXPANSION JOINTS USING ½-INCH (12.7 MM) THICK, PRE-FORMED EXPANSION JOINT FILLER, AS SPECIFIED IN SECTION 02528.2.3.
- C. FORM OR CUT CONTRACTION JOINTS 1/8-INCH (3.2 MM) WIDE TO ONE-FOURTH THE DEPTH OF THE CONCRETE BEING PLACED. CONSTRUCT THE JOINTS TO COINCIDE WITH THE JOINTS IN ADJACENT CONCRETE OR IN UNIFORM SECTIONS 10 FEET (3 M) IN LENGTH. WHERE REQUIRED TO MAKE A CLOSURE, SECTIONS LESS THAN 10 FEET (3 M) IN LENGTH WILL BE PERMITTED WITH THE MINIMUM LENGTH BEING 4 FEET (1.2 M). WHEN CONTRACTION JOINTS ARE MADE BY APPROVED FORMING OR GROOVING BEFORE THE CONCRETE HAS SET, TOOL THE EDGES TO THE APPROVED RADIUS.

3.9 CURB BACKFILL

- A. COMPLETE THE CURB BACKFILL TO 4 INCHES (10 CM) BELOW THE TOP OF CURB BEFORE FINAL GRADING OF THE SUBGRADE AND PLACING THE BASE COURSE.
- B. BACKFILL USING IMPERVIOUS DIRT UP TO 4 INCHES (10 CM) BELOW TOP OF CURB. DO NOT USE SAND OR GRAVEL BACKFILL IN THIS AREA.
- C. IN AREAS OF EXISTING LAWNS, USE BLACK LOAM OR APPROVED TOPSOIL FOR THE TOP 4 INCHES (10 CM) OF BACKFILL. PLACE IT OUT FROM THE CURB AND IN THE AMOUNT REQUIRED TO REPLACE THE TURF OR LAWN REMOVED DURING INSTALLATION. PLACE THE BACKFILL TO A POINT LEVEL WITH THE TOP OF THE CURB, IMMEDIATELY ADJACENT TO THE CURB, AND GRADE AND BLEND TO MATCH THE EXISTING UNDISTURBED LAWN AREA.
- D. WHERE LAWNS DO NOT EXIST, PLACE THE TOP 4 INCHES (10 CM) OF BACKFILL USING IMPERVIOUS DIRT AND CONFORMING TO THE TYPICAL SECTIONS SHOWN ON THE PLANS.
- E. COMPACT BACKFILL TO PREVENT SETTLEMENT AND LEVEL THE SURFACE TO BE FREE DRAINING.

3.10 PRIME AND SEAL COAT PREPARATION

- A. PAINT THE EDGE OF THE GUTTER ADJACENT TO THE ASPHALT SURFACING WITH AN ASPHALT PRIME COAT BEFORE PLACING THE PAVEMENT SURFACE COURSE. WHEN AN ASPHALT SEAL COAT IS SPECIFIED, APPLY THE OIL AND COVER AGGREGATE 3 INCHES (7.6 CM) ON TO THE GUTTER TO PROVIDE A GOOD SEAL ON THE JOINT BETWEEN THE CONCRETE AND PAVEMENT.

3.11 TOLERANCES

- A. PERFORM THE WORK TO PRODUCE A CURB AND GUTTER MEETING THE SPECIFIED LINE AND GRADE UNIFORM IN APPEARANCE AND STRUCTURALLY SOUND. REMOVE AND REPLACE AT CONTRACTOR EXPENSE CURB AND GUTTER HAVING UNSIGHTLY BULGES, RIDGES, AND/OR LOW SPOTS IN THE GUTTER, OR OTHER DEFECTS AS DIRECTED. GRADE CANNOT DEVIATE MORE THAN 1/8-INCH (3.2 MM), AND ALIGNMENT NOT VARY MORE THAN ¼-INCH (6.4 CM) FROM PLAN ELEVATION, GRADE OR ALIGNMENT. TOLERANCES MAY BE CHECKED USING SURVEY INSTRUMENTS, STRAIGHT EDGES, OR WATER PUDDLING. PUDDLED WATER CANNOT EXCEED ¼-INCH (6.4 MM) IN DEPTH.

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CONCRETE CURB AND GUTTER

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PART 4: MEASUREMENT AND PAYMENT

4.1 COMBINED CONCRETE CURB AND GUTTER

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE LINEAL FEET (METER) OF COMBINED CURB AND GUTTER IN PLACE AT THE CONTRACT UNIT PRICE BID FOR "COMBINED CONCRETE CURB AND GUTTER". PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL MATERIALS, CURING OF CONCRETE, PAINTING FACE GUTTER WITH PRIMER, ALL PRE-MOLDED MASTIC MATERIAL FOR EXPANSION JOINTS, CONTRACTION JOINTS, STEEL DOWELS AND SLEEVES, ALL EQUIPMENT, TOOLS, LABOR, AND FOR THE PERFORMANCE OF ALL WORK AND INCIDENTALS NECESSARY TO COMPLETE THE ITEM. THE LINEAL FEET (METER) MEASUREMENT IS THE HORIZONTAL DISTANCE MEASURED ALONG THE FACE OF THE CURB.
- B. CURB EXCAVATION AND BACKFILL IS PAID FOR SEPARATELY, AS SPECIFIED IN SECTION 02230, STREET EXCAVATION, BACKFILL, AND COMPACTION. PAYMENT IS MADE UNDER COMBINED CONCRETE CURB AND GUTTER – PER LINEAL FOOT (METER).

END OF SECTION 02528

SECTION 02529 - CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND MISCELLANEOUS NEW CONCRETE CONSTRUCTION

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS THE CONSTRUCTION OF CONCRETE SIDEWALK AND DRIVEWAY APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS, NEW STREET MONUMENTS, AND ALL OTHER MISCELLANEOUS NEW CONCRETE CONSTRUCTION COMPLETE IN PLACE.

1.2 REFERENCES

AASHTO M 213	STANDARD SPECIFICATION FOR PREFORMED EXPANSION JOINT FILLERS FOR CONCRETE PAVING AND STRUCTURAL CONSTRUCTION
AASHTO M 148	STANDARD SPECIFICATION FOR LIQUID-FORMING COMPOUNDS FOR CURING CONCRETE

- A. STANDARD DRAWINGS IN APPENDIX A APPLICABLE TO THIS SECTION ARE AS FOLLOWS.

1.	STANDARD DRAWING NO. 02529-1	-DOUBLE GUTTER DETAIL FOR STREET INTERSECTION
2.	STANDARD DRAWING NO. 02529-2	-STANDARD FILLET
3.	STANDARD DRAWING NO. 02529-3	-TYPE I STREET MONUMENT
4.	STANDARD DRAWING NO. 02529-4	-TYPE II STREET MONUMENT
5.	STANDARD DRAWING NO. 02529-5A	-BOULEVARD DRIVEWAY APPROACH
6.	STANDARD DRAWING NO. 02529-5B	-CURB WALK DRIVEWAY APPROACH
7.	STANDARD DRAWING NO. 02529-6	-RETROFIT DRIVE APPROACH
8.	STANDARD DRAWING NO. 02529-7A	-BOULEVARD ALLEY APPROACH
9.	STANDARD DRAWING NO. 02529-7B	-CURB WALK ALLEY APPROACH
10.	STANDARD DRAWING NO. 02529-8	-ACCESSIBILITY RAMP
11.	STANDARD DRAWING NO. 02529-9	-SWALE CROSSING
12.	STANDARD DRAWING NO. 02529-10	-MAILBOX MOUNTING FOR CURBLINE DELIVERY

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CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND
MISCELLANEOUS NEW CONCRETE CONSTRUCTION

PART 2: PRODUCTS

2.1 STRUCTURAL CONCRETE

- A. FURNISH STRUCTURAL CONCRETE MEETING THE REQUIREMENTS OF SECTION 03310, STRUCTURAL CONCRETE.

2.2 REINFORCING STEEL

- A. FURNISH REINFORCING STEEL MEETING THE REQUIREMENTS OF SECTION 03210, REINFORCING STEEL. USE 6 X 6 X 10 GAUGE WIRE MESH UNLESS OTHERWISE SPECIFIED.

2.3 PRE-FORMED EXPANSION JOINT MATERIAL

- A. FURNISH JOINT MATERIAL MEETING THE REQUIREMENTS OF AASHTO M213.

2.4 GRAVEL BASE MATERIAL

- A. FURNISH CRUSHED BASE MATERIAL MEETING APPLICABLE REQUIREMENTS OF SECTION 02235, CRUSHED BASE COURSE, AND MEETING THE GRADATION REQUIREMENTS FOR 1" MINUS MATERIAL.

2.5 CURING AND PROTECTIVE COATING MATERIALS

- A. LIQUID MEMBRANE-FORMING COMPOUNDS FOR CURING CONCRETE

- 1. USE LIQUID MEMBRANE-FORMING COMPOUNDS MEETING THE REQUIREMENTS OF AASHTO M148, TYPE 1, CLEAR OR TRANSLUCENT. APPLY THE COMPOUND BETWEEN APRIL 15 AND AUGUST 14.

- B. EMULSIFIED LINSEED OIL COMPOUND

- 1. APPLY WATER-SOLUBLE OR EMULSIFIED LINSEED OIL COMPOUND BETWEEN AUGUST 15 AND APRIL 14 AS A PROTECTIVE COAT. ASSURE IT MEETS ALL REQUIREMENTS OF AASHTO M148 AND CONTAINS AT LEAST 2.7 POUNDS OF LINSEED OIL PER GALLON. FURNISH A MANUFACTURER'S CERTIFICATION SHOWING THAT THE FORMULATED WEIGHT OF LINSEED OIL PER GALLON EQUALS OR EXCEEDS THIS LIMIT.

PART 3: EXECUTION

3.1 GENERAL

- A. CONSTRUCT SIDEWALKS AND DRIVEWAY APPROACHES, EITHER NEW OR REPLACEMENT, VALLEY GUTTER AND CURB TURN FILLETS AT THE LOCATIONS SHOWN ON THE PLANS AND WHERE DIRECTED BY THE ENGINEER MEETING THESE SPECIFICATIONS AND THE APPLICABLE PORTIONS OF SECTION 03310, STRUCTURAL CONCRETE.
- B. THE USE OF SLIP FORM MACHINES IS PROHIBITED FOR ITEMS IN THIS SECTION UNLESS OTHERWISE SPECIFIED OR PERMITTED BY THE ENGINEER.

3.2 FOUNDATION PREPARATION

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- A. EXCAVATE TO THE SPECIFIED DEPTH. ASSURE THE SUBGRADE WHERE THE CONCRETE TO BE PLACED HAS A FIRM AND EVEN SURFACE AND IS COMPACTED AS SPECIFIED IN SECTION 02230, STREET EXCAVATION, BACKFILL AND COMPACTION.
- B. PLACE AND COMPACT AT LEAST 3 INCHES (76 MM) OF GRAVEL BASE MATERIAL TO A FIRM, EVEN SURFACE. THIS REQUIREMENT IS WAIVED FOR CONCRETE IF IT IS TO BE INSTALLED ON STREET BASE COURSE MATERIAL EXCEEDING 3 INCHES (76 MM) OR MORE IN THICKNESS.

3.3 FORMS

- A. FURNISH FORMS TO PRODUCE THE SHAPE, LINES, AND DIMENSIONS SHOWN ON THE PLANS AND/OR DRAWINGS. ASSURE FORMS PREVENT LEAKAGE OF MORTAR AND ARE MAINTAINED IN PROPER POSITION AND ACCURATE ALIGNMENT. THOROUGHLY CLEAN AND OIL FORMS WITH AN APPROVED FORM OIL BEFORE PLACING CONCRETE AND REMOVE FORMS ONLY AFTER THE CONCRETE HAS HARDENED SUFFICIENTLY TO SUPPORT ALL LOADS WITHOUT DAMAGE.
- B. FORM RADII USING FLEXIBLE OR CURVED METAL FORMS SET TO THE REQUIRED CURVATURE. USE WOOD FORMS ONLY WITH THE ENGINEER'S APPROVAL. RADII MAY BE FORMED BY USING SEGMENTS OF STRAIGHT FORMS IF THE LENGTH OF THE STRAIGHT SEGMENT DOES NOT EXCEED ONE-TENTH OF THE LENGTH OF THE RADIUS.
- C. USE 6-INCH (15 CM) FORMS AND 6-INCH (15 CM) PRE-FORMED EXPANSION JOINT MATERIAL FOR CONCRETE 6 INCHES (15 CM) IN DEPTH.

3.4 REINFORCEMENT

- A. PLACE AND HOLD IN POSITION REINFORCEMENT MEETING THE CONTRACT REQUIREMENTS BEFORE PLACING THE CONCRETE.

3.5 PLACING CONCRETE

- A. ASSURE THE SUBGRADE IS COMPACTED AND BROUGHT TO SPECIFIED GRADE BEFORE PLACING CONCRETE. DAMPEN THE SUBGRADE IMMEDIATELY BEFORE PLACING THE CONCRETE. SPADE AND TAMP THE CONCRETE INTO THE FORMS PROVIDING A DENSE, COMPACTED CONCRETE FREE OF ROCK POCKETS. FLOAT, FINISH AND BROOM THE EXPOSED SURFACES. EACH PLACING/FINISHING CREW SHALL HAVE AT LEAST ONE ACI FLATWORK FINISHER TECHNICIAN LEVEL OR ABOVE, ON SITE AT ALL TIMES.
- B. ASSURE THE RATE OF CONCRETE PLACEMENT DOES NOT EXCEED THE RATE AT WHICH THE VARIOUS PLACING AND FINISHING OPERATIONS CAN BE PERFORMED IN ACCORDANCE WITH THESE SPECIFICATIONS.

3.6 STRIPPING FORMS AND FINISHING

- A. FORMS
 - 1. REMOVE FORMS WHEN THE CONCRETE IS SUFFICIENTLY SET TO PREVENT CHIPPING OR SPALLING. WHEN FORMS ARE REMOVED BEFORE THE CURING PERIOD HAS EXPIRED, PROTECT THE CONCRETE EDGES WITH MOIST EARTH OR SPRAY EDGES WITH CURING COMPOUND. CLEAN, OIL, AND EXAMINE ALL FORMS FOR DEFECTS BEFORE THEY ARE USED AGAIN.

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CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND
MISCELLANEOUS NEW CONCRETE CONSTRUCTION

B. FINISHING

1. FINISH THE CONCRETE SURFACE TRUE TO THE LINES AND GRADES SHOWN ON THE PLANS. FLOAT THE CONCRETE SURFACE USING A MAGNESIUM FLOAT TO A SMOOTH AND UNIFORM SURFACE. PLASTERING OF THE SURFACE IS PROHIBITED. EDGE ALL OUTSIDE EDGES OF THE SLAB AND ALL JOINTS USING A ¼-INCH (6.5 MM) RADIUS-EDGING TOOL. AFTER CONCRETE HAS HARDENED SUFFICIENTLY, GIVE THE SURFACE A BROOM FINISH. ASSURE THE BROOM STROKES ARE SQUARE ACROSS THE CONCRETE FROM EDGE TO EDGE, OVERLAPPING ADJACENT STROKES. BROOM WITHOUT TEARING THE CONCRETE. ASSURE THE BROOMED FINISH PRODUCES REGULAR CORRUGATIONS NOT EXCEEDING 1/8-INCH (3 MM) IN DEPTH.

3.7 CURING

- A. CURE MEETING SECTION 03310, STRUCTURAL CONCRETE REQUIREMENTS.

3.8 JOINTS

- A. EXTEND ISOLATION JOINTS THE FULL DEPTH OF THE CONCRETE AND FILL USING ½-INCH (12 MM) THICK, PRE-FORMED JOINT FILLER AS SPECIFIED IN SECTION 02529.3.3. PLACE ISOLATION JOINTS MEETING THIS REQUIREMENT WHERE NEW CONCRETE ABUTS EXISTING CONCRETE. FORM ISOLATION JOINTS AROUND ALL APPURTENANCES, SUCH AS MANHOLES, UTILITY POLES, ETC. EXTENDING INTO AND THROUGH THE CONCRETE.
- B. INSTALL PRE-FORMED JOINT FILLER BETWEEN CONCRETE AND ANY FIXED STRUCTURE, SUCH AS A BUILDING OR BRIDGE. ASSURE ALL EXPANSION JOINT MATERIALS EXTEND THE FULL DEPTH OF THE CONCRETE. PLACE ISOLATION JOINTS AT RADIUS POINTS, JUNCTIONS WITH EXISTING CONCRETE, AND OPPOSITE TO OR AT EXPANSION JOINTS IN ADJACENT CONCRETE. FORM COLD JOINTS AT UNIONS OF CONSECUTIVE POURS AS SHOWN ON THE PLANS OR DIRECTED BY THE ENGINEER. ASSURE THE COLD JOINT IS VERTICAL, THE FULL DEPTH OF THE CONCRETE, AND TOOLED TO A ¼-INCH (6.5 MM) RADIUS.
- C. DIVIDE SIDEWALK INTO SECTIONS USING CONTRACTION JOINTS FORMED BY A JOINTING TOOL OR OTHER APPROVED METHODS. EXTEND THE CONTRACTION JOINTS INTO THE CONCRETE FOR AT LEAST ONE-FOURTH OF ITS DEPTH AND BE APPROXIMATELY 1/8-INCH (3 MM) WIDE. UNLESS OTHERWISE DIRECTED, SPACE CONTRACTION JOINTS AT MAXIMUM 10-FOOT (3 M) INTERVALS OR AT A DISTANCE EQUAL TO THE SIDEWALK WIDTH, WHICHEVER IS LESS. IN CONTINUOUS SIDEWALK RUNS, INSTALL ISOLATION JOINTS AT THE LOCATION OF A REGULAR CONTRACTION JOINT IF THE DISTANCE BETWEEN ISOLATION JOINTS DOES NOT EXCEED 300 FEET (91 M).

3.9 BACKFILL

- A. IN AREAS ADJACENT TO EXISTING LAWNS, BACKFILL THE TOP 4 INCHES (100 MM) USING BLACK LOAM OR GOOD TOPSOIL SUITABLE FOR LAWN GROWTH. PLACE IT OUT FROM THE SIDEWALK OR DRIVEWAY TO REPLACE TURF OR LAWN REMOVED DURING INSTALLATION. PLACE THE BACKFILL LEVEL WITH THE TOP OF THE CURB, IMMEDIATELY ADJACENT TO THE CURB, GRADED AND BLENDED TO MATCH THE EXISTING UNDISTURBED LAWN AREA.
- B. WHERE LAWNS DO NOT EXIST, BACKFILL THE TOP 4 INCHES (100 MM) WITH IMPERVIOUS DIRT AND PLACE TO MEET THE TYPICAL SECTIONS SHOWN ON THE PLANS.
- C. COMPACT BACKFILL TO PREVENT SETTLEMENT AND LEVEL THE SURFACE TO A NEAT APPEARING AND FREE DRAINING SURFACE.

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3.10 TOLERANCES

- A. ASSURE ALL ITEMS OF CONSTRUCTION COVERED BY THIS SECTION PRESENT CLEAN, UNIFORM SURFACES AND LINES FREE OF IRREGULARITIES AND DISTORTIONS. PLANE SURFACES AND VERTICAL TANGENT LINES ARE TESTED WITH A 10-FOOT STRAIGHTEDGE AND CANNOT DEVIATE MORE THAN ¼-INCH (6.5 MM) FROM THE STRAIGHTEDGE.

3.11 MISCELLANEOUS NEW CONCRETE CONSTRUCTION

- A. CONSTRUCT NEW STREET MONUMENTS, NEW STREET LIGHT BASES, AND OTHER MISCELLANEOUS CONCRETE CONSTRUCTION IN ACCORDANCE WITH DETAIL DRAWINGS.

PART 4: MEASUREMENT AND PAYMENT

4.1 CURB TURN FILLETS

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE NUMBER OF CURB TURN FILLETS CONSTRUCTED, COMPLETE IN PLACE, INCLUDING CURB, AT THE CONTRACT UNIT PRICE BID FOR "CURB TURN FILLETS". PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL MATERIAL, EXCAVATION, BACKFILL, CURING OF CONCRETE, PRE-MOLDED MASTIC MATERIAL, EQUIPMENT, TOOLS AND LABOR, AND FOR THE PERFORMANCE OF ALL WORK AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

- 1. PAYMENT IS MADE UNDER CURB TURN FILLETS – PER EACH.

4.2 CONCRETE VALLEY GUTTERS

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE SQUARE FOOT AT THE CONTRACT UNIT PRICE BID FOR "CONCRETE VALLEY GUTTERS". PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL MATERIAL, EXCAVATION, BACKFILL, CURING OF CONCRETE, PRE-MOLDED MASTIC MATERIAL, REINFORCING STEEL, EQUIPMENT, TOOLS AND LABOR, AND FOR THE PERFORMANCE OF ALL WORK AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

- 1. PAYMENT IS MADE UNDER CONCRETE VALLEY GUTTERS – PER SQUARE FOOT.

4.3 CONCRETE DRIVEWAY APRONS

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE SQUARE FOOT (AS DEFINED ON THE PLAN DETAIL AND EXCLUDING CURB) AT THE CONTRACT UNIT PRICE BID FOR "CONCRETE DRIVEWAY APRONS". PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL MATERIAL, EXCAVATION, BACKFILL, CURING OF CONCRETE, PRE-MOLDED MASTIC MATERIAL, EQUIPMENT, TOOLS AND LABOR, AND FOR THE PERFORMANCE OF ALL WORK AND INCIDENTALS NECESSARY TO COMPLETE THIS FORM.

- 1. PAYMENT IS MADE UNDER CONCRETE DRIVEWAY APRONS – PER SQUARE FOOT (SQUARE METER).

4.4 CONCRETE SIDEWALK

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE SQUARE FOOT (SQUARE METER) AT THE UNIT PRICE BID FOR "NEW CONCRETE SIDEWALK". PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL MATERIAL, EXCAVATION, BACKFILL, CURING OF CONCRETE, PRE-MOLDED MASTIC MATERIAL, EQUIPMENT, TOOLS AND LABOR, AND FOR THE PERFORMANCE OF ALL WORK

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CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND
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AND INCIDENTALS NECESSARY TO COMPLETE THIS ITEM.

1. PAYMENT IS MADE UNDER CONCRETE SIDEWALK – PER SQUARE FOOT (SQUARE METER).

4.5 STREET MONUMENTS

- A. THIS ITEM IS MEASURED AND PAID FOR BY THE NUMBER OF MONUMENTS CONSTRUCTED AS SHOWN ON THE PLANS AT THE CONTRACT UNIT PRICE BID FOR "INSTALL MONUMENTS, TYPE I OR II". PRICE AND PAYMENT IS FULL COMPENSATION FOR ALL MATERIALS, EXCAVATION, BACKFILL, FORMING AND CURING OF CONCRETE, EQUIPMENT, TOOLS AND LABOR, AND FOR THE PERFORMANCE OF ALL WORK AND INCIDENTALS NECESSARY TO COMPLETE THIS FORM.

1. PAYMENT IS MADE UNDER INSTALL MONUMENTS, TYPE I – PER EACH.
TYPE II – PER EACH.

END OF SECTION 02529

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CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND
MISCELLANEOUS NEW CONCRETE CONSTRUCTION

**SECTION 02581 - PAVEMENT MARKINGS AND MARKERS
(PRE-FORMED PLASTIC, PAINTS AND ENAMELS)**

PART 1: GENERAL

1.1 DESCRIPTION

- A. THIS WORK IS PAINTING PAVEMENT LINES, WORDS AND SYMBOLS, OR APPLYING PLASTIC LINES, WORDS, SYMBOLS, CHANNELIZATION BUTTONS, AND OTHER REFLECTIVE MARKERS MEETING THESE SPECIFICATIONS, THE STANDARD DRAWINGS, AND IN REASONABLY CLOSE CONFORMITY WITH THE LINES AND DIMENSIONS SHOWN IN THE CONTRACT DOCUMENTS OR ESTABLISHED BY THE ENGINEER.

PART 2: PRODUCT

2.1 PRE-FORMED PLASTIC PAVEMENT MARKING MATERIAL

- A. FURNISH PLASTIC PAVEMENT MARKINGS AND LEGENDS CONSISTING OF REFLECTORIZED, PRE- FABRICATED, HOMOGENEOUS, THERMOPLASTIC RIBBON OF THE SPECIFIED THICKNESS. ASSURE THE PLASTIC CONTAINS REFLECTIVE GLASS SPHERES UNIFORMLY DISTRIBUTED THROUGHOUT ITS CROSS SECTION AND IS CAPABLE OF BEING AFFIXED TO BITUMINOUS OR PORTLAND CEMENT CONCRETE PAVEMENTS USING A LIQUID CONTACT CEMENT OR PRE-COATED, PRESSURE- SENSITIVE ADHESIVE. FURNISH WHITE AND YELLOW MEETING STANDARD HIGHWAY COLORS. ASSURE THE WHITE PLASTIC MATERIAL IS NON-YELLOWING, AND THE YELLOW PLASTIC MATERIAL IS NON-FADING FOR THEIR EXPECTED USEFUL LIFE.
- B. FOR STRIP LINE WIDTHS OF 6 INCHES (150 MM) OR LESS, FURNISH PLASTIC PAVEMENT STRIPING MATERIAL IN A SINGLE MANUFACTURED WIDTH EQUAL TO THE SPECIFIED WIDTH. FOR SPECIFIED STRIPE LINE WIDTHS EXCEEDING 6 INCHES (150 MM), FURNISH PLASTIC PAVEMENT STRIPING MATERIAL IN A SINGLE MANUFACTURED WIDTH EQUAL TO THE SPECIFIED WIDTH OR IN TWO OR MORE WIDTHS TOTALING THE SPECIFIED WIDTH.
- C. CUT THE PLASTIC MARKING MATERIAL EDGES CLEAN AND TRUE. USE AT LEAST 0.09-INCH (2.25 MM) THICK PLASTIC MATERIAL FOR INLAYING INTO NEW ASPHALTIC SURFACES. USE AT LEAST 0.06-INCH (1.50 MM) THICK PLASTIC MATERIAL FOR APPLICATION TO EXISTING SURFACES OR TO HARDENED NEW SURFACES.
- E. ASSURE PLASTIC PAVEMENT MARKINGS FOR INLAY INTO NEW ASPHALTIC SURFACES ARE CAPABLE OF BEING APPLIED JUST BEFORE THE FINAL ROLLING OF THE NEW SURFACE AND CAN BE ROLLED INTO PLACE WITH CONVENTIONAL PAVEMENT ROLLERS. FOR INLAY APPLICATIONS, ASSURE THE PLASTIC AND ADHESIVE ARE NOT DAMAGED BY PAVEMENT TEMPERATURES EXCEEDING 175° F (79° C) OR BY WATER ON ROLLER DRUMS. ASSURE THE PLASTIC PAVEMENT MARKING MATERIAL AND ITS ADHESIVE ARE TACK FREE TO PROVIDE EASY HANDLING WITHOUT USING A PROTECTIVE BACKING AND CAN BE REPOSITIONED ON THE SURFACE BEFORE BEING PERMANENTLY FIXED IN POSITION. PRE-COATED ADHESIVE MUST BE UNIFORMLY DISTRIBUTED OVER THE ENTIRE CONTACT SURFACE OF THE PLASTIC MATERIAL.
- F. FURNISH PLASTIC PAVEMENT MARKING MATERIAL CAPABLE OF MOLDING ITSELF TO PAVEMENT CONTOURS, BREAKS, AND OTHER SURFACE IRREGULARITIES UNDER TRAFFIC AT NORMAL PAVEMENT TEMPERATURES. ASSURE THE PLASTIC MATERIAL WILL FUSE WITH ITSELF AND WITH PREVIOUSLY APPLIED MARKINGS OF THE SAME COMPOSITION UNDER NORMAL USE CONDITIONS.

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PAVEMENT MARKINGS AND MARKERS (PRE-FORMED PLASTIC, PAINTS AND ENAMELS)

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- G. ASSURE PAVEMENT LEGENDS AND SYMBOLS MEET THE APPLICABLE SHAPES AND SIZES SPECIFIED BY THE "MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES" AS ADOPTED BY THE FHWA.
- H. ASSURE PRODUCT AGENTS OR DISTRIBUTORS FURNISH THE MANUFACTURER'S SPECIFICATIONS SHOWING THAT THE MATERIAL FURNISHED MEETS OR EXCEEDS THESE REQUIREMENTS AND SUBMIT EVIDENCE OF SUCCESSFUL PRODUCT USE OVER A ONE-YEAR PERIOD UNDER SIMILAR CLIMATIC CONDITIONS. PLASTIC PAVEMENT MARKING MATERIAL NOT MEETING THIS USE REQUIREMENT WILL BE REJECTED.
- I. SUBMIT A 4-INCH (100 MM) BY 1-FOOT (300 MM) SAMPLE FROM EACH LOT OF PLASTIC MATERIAL PROPOSED FOR USE ON THE PROJECT TO THE ENGINEER FOR APPROVAL. USE ONLY APPROVED PLASTIC PAVEMENT MARKING MATERIAL ON THE PROJECT.

1. COMPOSITION REQUIREMENTS

- A. FURNISH PRE-FORMED PLASTIC PAVEMENT MARKING MATERIAL CONSISTING OF PLASTICIZERS, PIGMENTS, AND GRADED GLASS SPHERES COMBINED AND PROPORTIONED TO MEET THE FOLLOWING REQUIREMENTS.

- 1) PIGMENTS: MINIMUM 20% TITANIUM DIOXIDE OF TOTAL PIGMENT FOR WHITE MARKING MATERIAL; MINIMUM 18% MEDIUM CHROME YELLOW OF TOTAL PIGMENT FOR YELLOW MARKING MATERIAL. USE GRADED GLASS SPHERES THAT ARE CLEAN, TRANSPARENT, AND MEET THE REQUIREMENTS OF SECTION 02581.2.02.A.1. ASSURE THE GLASS SPHERES ARE UNIFORMLY DISTRIBUTED THROUGHOUT THE ENTIRE MATERIAL.

2. PHYSICAL REQUIREMENTS

- A. TENSILE STRENGTH

- 1) ASSURE THE PLASTIC MATERIAL HAS A MINIMUM TENSILE STRENGTH OF 40 PSI (270 KPA) OF CROSS SECTION WHEN TESTED UNDER ASTM D638. THE BREAK RESISTANCE IS BASED ON AN AVERAGE OF AT LEAST THREE (3) SAMPLES TESTED AT A TEMPERATURE OF 70° – 80° F (22° – 27° C) USING A JAW SPEED OF 0.25 INCHES (6.25 MM) PER MINUTE.

- B. PLASTIC PULL TEST

- 1) A 1"-6" (25 MM – 150 MM) SAMPLE OF THE PLASTIC MATERIAL MUST SUPPORT A DEAD WEIGHT OF 0.66 LB PER 0.01 INCH (.28 KG PER 2.50 MM) OF MATERIAL THICKNESS FOR AT LEAST 5 MINUTES AT 70° – 80° F (22° – 27° C).

- C. BEND TEST

- 1) THE PLASTIC MATERIAL MUST BE FLEXIBLE SO THAT AT 80° F (27° C), A 3" BY 6" (75 MM BY 150 MM) SAMPLE OF THE MATERIAL CAN BE BENT OVER A 1" (25 MM) DIAMETER MANDREL UNTIL THE END FACES ARE PARALLEL AND 1" (25 MM) APART WITHOUT SHOWING ANY FRACTURE LINES IN THE UPPERMOST SURFACE UNDER UNASSISTED VISUAL INSPECTION.

- D. SKID RESISTANCE

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- 1) THE SURFACE FRICTION OF THE PLASTIC CANNOT BE LESS THAN 35 BPN WHEN TESTED UNDER ASTM E303.

E. RESEAL TEST

- 1) THE PLASTIC MUST RE-SEAL TO ITSELF WITHOUT ADHESIVES WHEN TESTED AS FOLLOWS: OVERLAP TWO 1" BY 3" (25 MM BY 75 MM) PIECE FACE-TO-FACE SO THAT THEY FORM A SINGLE 1" (25 MM) BY 5" (125 MM) WITH A 1 SQUARE INCH (25 SQUARE MM) OVERLAP IN THE CENTER.
- 2) PLACE THE PIECE ON A HARD SURFACE WITH A 1000 GRAM WEIGHT RESTING UNIFORMLY ON THE ENTIRE OVERLAP AREA AND MAINTAIN AT 140° TO 190° F (60°-88° C) FOR 2 HOURS. THE ACTUAL TEMPERATURE TO BE MAINTAINED DEPENDS ON THE MATERIAL BEING TESTED BUT MUST BE WITHIN THE SPECIFIED RANGE. AFTER COOLING TO ROOM TEMPERATURE, THE PIECES MUST NOT SEPARATE WITHOUT TEARING.

F. REFLECTIVITY

- 1) FURNISH REFLECTIVE PAVEMENT MARKING MATERIAL HAVING REFLECTIVE VALUES NOT LESS THAN THOSE LISTED IN THE TABLE BELOW. REFLECTIVE VALUES ARE MEASURED UNDER FEDERAL SPECIFICATIONS L-S-300C. THE REFLECTIVE VALUES MUST BE MEASURED ON A 2 BY 2-1/2 FOOT (.6 M BY .75 M) PANEL AT 85° INCIDENCE AND BE EXPRESSED AS AVERAGE CANDLEPOWER PER FOOT (METER)- CANDLE PER 5 SQUARE FEET (1.5 M 2) OF MATERIAL.

<u>DIVERGENCE ANGLE</u>	<u>WHITE</u>	<u>YELLOW</u>
0.2 DEGREES	0.20	0.15
0.5 DEGREES	0.15	0.10

2.2 WATERBORNE PAVEMENT MARKING PAINT

A. WATERBORNE PAVEMENT MARKING PAINT

1. FURNISH ACRYLIC LATEX WHITE AND LEAD-FREE YELLOW WATERBORNE PAVEMENT MARKING PAINT MEETING THE FOLLOWING REQUIREMENTS.
 - A. COMPOSITION – THE EXACT COMPOSITION IS AT THE MANUFACTURER'S DISCRETION EXCEPT THAT THE VEHICLE IS TO BE 100% ACRYLIC POLYMER AND THE PAINT IS NOT TO CONTAIN ANY INGREDIENT LISTED BELOW.
 - 1) LEAD OR CHROMATE COMPOUNDS; MERCURY; LEAD; CHROMATE COMPOUNDS; CHLORINATED SOLVENTS; HYDROLYSABLE CHLORINE DERIVATIVES; ETHYLENE BASED GLYCOL ETHERS AND THEIR ACETATES.

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2) MEET THE FOLLOWING REQUIREMENTS:

	<u>WHITE</u>	<u>YELLOW</u>
PIGMENT, % SOLIDS	68 MAX	68 MAX
ASTM D-3723		
TOTAL SOLIDS, % BY WEIGHT	75 MIN	75 MIN
ASTM D-2369		
TITANIUM DIOXIDE, LBS./GAL.	1 LB. MIN.	0.15 LB. MIN
ASTM D-4563 & D-1394		
% NON-VOLATILE VEHICLE OF TOTAL VEHICLE WEIGHT	41 MIN.	41 MIN.
ASTM D-2697		
VOC CONTENT, MAXIMUM	150 G/L	150 G/L
EPA METHOD 24		
PH, MIN.	9.6	9.6
ASTM E-70		
VISCOSITY (KREBS STORMER), K.U.,	80-95	80-95
ASTM D-562 @ 77°F, (25° C)		
GRIND, HEGMAN, MIN. ASTM D-	2	2
1210		
DEVIATION IN PERCENT WEIGHT	±.30	±.30
PER GALLON, MAX. (FROM		
MINIMUM VALUES SPECIFIED		
DAYLIGHT ¹ REFLECTANCE, MIN.	85	59.12
ASTM D-2805		
CONTRAST RATIO, 15 MILS WET	0.92	0.88
MIN., ASTM D-2805		

¹THE Y-TRISTIMULUS VALUE (LUMINANCE) IS OBTAINED USING A STANDARDIZED TRISTIMULUS COLORIMETER USING A C ILLUMINANT AT A TWO- DEGREE OBSERVATION ANGLE. THE PAINT SAMPLE IS DRAWN TO A 15 MIL WET FILM THICKNESS OVER A WHITE SUBSTRATE. THE DEPARTMENT USES A HUNTER LAB MINISCAN XE COLORIMETER AND LENETA CORPORATION FORM 5C OPACITY CHARTS TO DETERMINE THIS VALUE.

²COLOR TO MATCH THE V+ COLOR ON THE HALE COLOR CHART ±6%.

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ASTM TEST

WHITE AND YELLOW

D 711 MOD.¹

DRY TIME, 15 MIL WET FILM, 65% RH, MINUTES, MAX. 10

D1640 MOD.²

DRY THROUGH @ 90% RH, 15 MIL WET FILM, MINUTES, MAX. 130

ASTM TEST

WHITE AND YELLOW

D 2243³

FREEZE-THAW, WHITE AND YELLOW.....PASS D 2486

SCRUB RESISTANCE, CYCLES MIN..... 600

D-969

BLEEDING RATIO, MIN..... 0.95

¹USE A WET FILM THICKNESS OF 15 PLUS OR MINUS 1 MIL.
IMMEDIATELY PLACE IN A HUMIDITY CHAMBER CONTROLLED AT
65± 3% RELATIVE HUMIDITY AND 72.5° F ± 2.5° F (22.5°C ± 1.4°
C) WITH MINIMAL AIRFLOW.

²APPLY A 15± 1 MIL THICK FILM TO A NON-ABSORBENT SUBSTRATE
AND PLACE IN A HUMIDITY CHAMBER CONTROLLED AT 85±5% R.H.
AND 72.5°F ± 2.5°F (22.5°C ± 1.4°C). DETERMINE DRY THROUGH
TIME UNDER ASTM D 1640 EXERTING THE MINIMUM PRESSURE
NEEDED TO MAINTAIN CONTACT WITH THE THUMB AND FILM.

³SEE B (7), FREEZE-THAW STABILITY.

- 3) TITANIUM. USE TITANIUM DIOXIDE MEETING ASTM D-476, TYPE I
OR II.

B. CHARACTERISTICS

- 1) FLEXIBILITY AND ADHESION. APPLY 15 MIL WET FILM THICKNESS TO
A 3" BY 5" (75 MM BY 130 MM) TIN PANEL. DRY AT 77°F (25°C) FOR
24 HOURS FOLLOWED BY TWO HOURS AT 122°F (50°C). BEND
SAMPLE OVER A ½-INCH (13 MM) MANDREL. PAINT TO ADHERE
FIRMLY WITHOUT SHOWING CRACKING OR FLAKING.
- 2) WATER RESISTANCE. APPLY 15 MIL WET FILM THICKNESS TO A 4" BY
8" (102 MM BY 203 MM) GLASS PLATE. DRY AT 77°F (25°C) FOR 72
HOURS. IMMERSE IN DISTILLED WATER AT 77°F (25°C) FOR 24
HOURS. AIR DRY FOR TWO HOURS ON A FLAT SURFACE. PAINT TO
NOT SHOW BLISTERING OR ADHESION LOSS.
- 3) SKINNING AND LUMPS. FILL A PINT (0.473 L) CONTAINER ¾ FULL
OF PAINT AND SEAL TIGHTLY. AFTER 72 HOURS, STRAIN PAINT
THROUGH A 100 MESH SCREEN. NO LUMPS OR SKIN RETAINED ON
THE SCREEN IS PERMISSIBLE.
- 4) SETTLING. FILL A CENTRIFUGE TUBE WITH PAINT AND REVOLVE FOR
TWO HOURS AT 1112 NEWTONS (250 FT/LBS). SEPARATION FROM
TOP OF VEHICLE TO TOP OF PIGMENT NOT TO EXCEED 13 MM

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(1/2- INCH).

- 5) SKINNING. FILL ½ PINT (0.236 L) CONTAINER HALF FULL OF PAINT AND SEAL. LET STAND FOR 24 HOURS. NO SKINNING TO BE VISIBLE.
 - 6) BLEEDING. WHEN TESTED UNDER ASTM D-969, PAINT TO NOT SHOW PERCEPTIBLE BLEEDING WHEN PAINTED ON A BITUMINOUS SURFACE.
 - 7) FREEZE-THAW STABILITY. WHEN TESTED UNDER ASTM D-2243, PAINT TO NOT SHOW COAGULATION OR VISCOSITY CHANGE EXCEEDING 10 KREBS UNITS.
 - 8) STATIC HEAT STABILITY. POUR PAINT INTO A PINT (473 ML) WITHIN 0.25 INCHES (6.4 MM) OF THE TOP, PUT THE LID ON AND SEAL WITH TAPE, AND PLACE THE CONTAINER IN AN OVEN HEATED TO 60°C ± 1°C (140°F ± 2°F) FOR SEVEN DAYS. EQUILIBRATE THE PAINT AT STANDARD CONDITIONS AND THOROUGHLY MIX BY STIRRING FOR AT LEAST FIVE MINUTES. ENSURE THE PAINT DOES NOT SHOW SIGNS OF LIVERING, HARD SETTLING, COAGULATION, LUMPS OR COARSE PARTICLES. PERFORM A CONSISTENCY TEST MEETING ASTM D-562 AT 25°C (77°F). PAINT VISCOSITY TO NOT VARY 10 K.U. FROM THE ORIGINAL VISCOSITY MEASURED AT 25°C (77°F).
- C. PACKAGING AND MARKING. MEET SUBSECTION 714.04.9 REQUIREMENTS.
- D. SAMPLING AND ACCEPTANCE. DRAW THREE SAMPLES MEETING SUBSECTION 714.04.8 REQUIREMENTS.
- E. RETRO-REFLECTIVE GLASS BEADS. USE SILENE-COATED MOISTURE RESISTANT GLASS BEADS MEETING SUBSECTION 714.05 REQUIREMENTS.
- F. APPLICATION. FOLLOW THE MANUFACTURER'S REQUIREMENTS FOR PAVEMENT CLEANING AND TRAFFIC PAINT APPLICATION OR AS FOLLOWS, WHICHEVER IS MORE RESTRICTIVE.
- 1) APPLY TO A DRY SURFACE.
 - 2) CLEAN THE PAVEMENT OF ALL LOOSE ROCK, DIRT, AND DEBRIS IMMEDIATELY BEFORE APPLYING THE TRAFFIC PAINT.
 - 3) DO NOT HEAT THE TRAFFIC PAINT TO EXCEED 110°F (43.3°C) BEFORE AND DURING APPLICATION.
 - 4) APPLY THE TRAFFIC PAINT WHEN THE AMBIENT TEMPERATURE IS 50°F (10°C) AND RISING. STOP APPLICATION WHEN THE TEMPERATURE IS 50°F (10°C) AND DROPPING AND WHEN RAIN OR OTHER WEATHER ADVERSE TO THE TRAFFIC PAINT DURING ITS DRYING TIME IS IMMINENT.
 - 5) APPLY TRAFFIC PAINT AT 15 MILS (0.38 MM) WET THICKNESS IN A SINGLE APPLICATION MEETING SUBSECTION 620.03.3(A).
 - 6) REMOVE AND REPLACE ALL DEFECTIVE PAVEMENT MARKING DAMAGED BY WEATHER AT CONTRACTOR EXPENSE.

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- 7) RE-PAINT, AT CONTRACTOR EXPENSE, ALL STRIPING REPRESENTED BY PAINT SAMPLES WHERE ANY SPECIFIED PROPERTY IS OUTSIDE 20% OF THE SPECIFIED VALUE.

G. REFLECTIVE GLASS BEADS

- 1) GLASS BEADS FOR USE IN REFLECTORIZING TRAFFIC PAINT MARKINGS ON PAVEMENT BY THE DROP-ON METHOD MUST BE SPHERICAL AND TRANSPARENT WITH SMOOTH, LUSTROUS SURFACES. THE BEADS, AS DELIVERED, MUST BE SPHERICAL AND TRANSPARENT WITH SMOOTH, LUSTROUS SURFACES. THE BEADS, AS DELIVERED, MUST BE FREE FROM EXTRANEIOUS MATERIAL AND CLUMPS OF BEADS THAT CANNOT BE BROKEN UP EASILY WHEN APPLYING TO THE STRIPE.
- 2) IMPERFECTIONS – THE GLASS BEADS CANNOT INCLUDE MORE THAN 25% IRREGULARLY SHAPED PARTICLES WHEN TESTED UNDER ASTM D1155. ASSURE THE BEADS ARE FREE OF SCRATCHES, PITS, MILKINESS, DARK PARTICLES, AND EXCESSIVE AIR BUBBLES.
- 3) COLOR – THE GLASS BEADS MUST BE COLORLESS TO THE EXTENT THAT THEY DO NOT IMPART A NOTICEABLE DAYTIME HUE TO WHITE PAVEMENT MARKINGS.
- 4) CHEMICAL STABILITY – THE BEADS MUST WITHSTAND REFLUXING IN DISTILLED WATER IN A SOXHLET EXTRACTOR FOR 90 HOURS WITHOUT NOTICEABLE DULLING OF SURFACE LUSTER AND NOT MORE THAN 2.5% LOSS IN WEIGHT.
- 5) INDEX OF REFRACTION – THE GLASS FROM WHICH THE BEADS ARE MADE MUST HAVE AN INDEX OF REFRACTION OF AT LEAST 1.50 BY THE IMMERSION METHOD USING TUNGSTEN LIGHT.
- 6) GRADATION – ASSURE THE GLASS BEADS MEET THE FOLLOWING GRADATION REQUIREMENTS WHEN TESTED UNDER THE STANDARD METHOD OF TEST FOR SIEVE ANALYSIS OF GLASS SPHERES, ASTM D1214.

<u>SIEVE NO.</u>	<u>TOTAL PERCENT</u>
20	100%
30	75-95%
50	15-35%
100	0-5%

- 7) PACKAGING AND MARKING – FURNISH GLASS BEADS IN BAGS CONTAINING 50 LB. (26 KG) NET. ASSURE THE SHIPPING BAGS ARE MOISTURE PROOF, PAPER-LINED BURLAP BAGS MEETING SPECIFICATION ICC-36-C UNDER INTERSTATE COMMERCE COMMISSION REGULATION SECTION 78-234. MARK EACH BAG WITH THE NAME OF CONTENTS, MANUFACTURER OF BEADS, AND NET WEIGHT.
- 8) CERTIFICATION – SUBMIT CERTIFICATION FROM A TESTING

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LABORATORY APPROVED BY THE ENGINEER CERTIFYING
THE BEADS MEET THESE EXPECTATIONS.

PART 3: EXECUTION

3.1 APPLICATION OF PLASTIC PAVEMENT MARKING MATERIAL.

- A. APPLY PLASTIC PAVEMENT MARKING MATERIALS ONLY TO CLEAN, DRY SURFACES FREE OF PAINT, DIRT, AND FOREIGN MATTER. ON NEWLY CONSTRUCTED SURFACES TO WHICH A SEALER HAS BEEN APPLIED, CLEAN THE SURFACE RECEIVING THE PLASTIC PAVEMENT MARKING TO NEUTRALIZE ANY ACID AND REMOVE THE SEALER.
- B. APPLY FOLLOWING THE MANUFACTURER'S RECOMMENDED PROCEDURES. APPLY PLASTIC PAVEMENT MARKING MATERIALS ONLY TO SURFACES AT TEMPERATURES WITHIN THE RANGE SPECIFIED BY THE MANUFACTURER FOR OPTIMUM ADHESION.
- C. WHEN ACTIVATORS ARE REQUIRED FOR THE ADHESIVE OR WHEN VARIOUS SPECIAL COATINGS ARE REQUIRED FOR DIFFERENT PAVEMENT SURFACES, SUPPLY SUCH INFORMATION TO THE ENGINEER, INDICATING SPECIAL APPLICATION PROCEDURES.
- D. ASSURE THE WIDTH AND LAYOUT OF STRIPES OR THE AREA OF APPLICATION OF PLASTIC PAVEMENT MARKINGS AND LEGENDS MEET THE DIMENSIONS SHOWN IN THE CONTRACT DOCUMENTS OR STANDARD DRAWINGS.
- E. BEFORE APPLYING THE PLASTIC STRIPING MATERIAL, THE ENGINEER WILL ESTABLISH CONTROL POINTS ON THE ROADWAY FOR STRIPING ALIGNMENT. THE ENGINEER WILL ESTABLISH CONTROL POINTS EVERY 100 FEET (30 METERS) ON TANGENT, AT LEAST EVERY 100 FEET (30 METERS) ON CURVES OF 2 DEGREES OR LESS, AND AT 50-FOOT (15 METERS) INTERVALS FOR CURVES OVER 2 DEGREES. THE ENGINEER WILL ALSO DESIGNATE OTHER PAVEMENT STRIPING LOCATIONS SUCH AS STOP BARS, CROSSWALKS, AND THE LIKE. MAINTAIN ALL LINES WITHIN 2" (50 MM) OF ESTABLISHED LINES.
- F. PLACE ASPHALTIC SURFACING ON THE ROADWAY JUST BEFORE FINAL COMPACTION AND ROLL INTO THE NEW SURFACE DURING FINAL COMPLETION. ASSURE PAVEMENT MARKINGS OR LEGENDS ARE FLUSH WITH THE FINISHED SURFACE.

3.2 PAINTING TRAFFIC LINES

- A. CLEAN THE SURFACE TO BE PAINTED FOR DIRT, ROCKS, GRAVEL, AND ANY OTHER FOREIGN MATTER. APPLY THE PAINT BY HAND OR MECHANICAL MEANS CONSISTENT WITH THE SCOPE OF THE JOB. ASSURE THE WIDTH AND LAYOUT OF STRIPES OR THE AREA TO BE PAINTED MEETS THE PLANS OR STANDARD DRAWINGS.
- B. PAINT THE TOP AND TRAFFIC SIDE OF CURBS AT THOSE LOCATIONS WHERE PARKING IS TO BE RESTRICTED, AS SHOWN IN THE CONTRACT DOCUMENTS OR IN THE PAVEMENT MARKING MANUAL. PAINT THE TOP AND TRAFFIC SIDES OF ALL ISLAND CURBS, MEDIAN CURB, AND OTHER SPECIFIED CURB. PAINT BY UNIFORMLY APPLYING ONE (1) COAT OF YELLOW TRAFFIC LINE PAINT MEETING THE REQUIREMENTS OF SECTION 02581.2.2.A.1 AS APPLICABLE. PAINT THE CURB AFTER IT HAS CURED AT LEAST 30 DAYS AFTER BEING CAST. APPLY THE PAINT AT A RATE THAT THE CURB SURFACE IS COMPLETELY COVERED AND HIDDEN. ASSURE SURFACES TO BE PAINTED ARE CLEAN AND FREE OF ALL FOREIGN MATTER BEFORE PAINTING.

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- C. BEFORE APPLYING PAINT, MARK THE ROADWAY BETWEEN CONTROL POINTS ESTABLISHED BY THE ENGINEER. THE ENGINEER WILL ESTABLISH SUCH CONTROL POINTS ON TANGENT EVERY 100 FEET (30 METERS) AND ON CURVES AT LEAST EVERY 100 FEET (30 METERS) FOR UNDER 2- DEGREE CURVES AND AT 50 FOOT (15 METERS) INTERVALS ON CURVES OVER 2-DEGREE CURVATURE. MAINTAIN THE LINE WITHIN 2" (50 MM) OF THE ESTABLISHED LINES. THE ENGINEER WILL ALSO DESIGNATE OTHER PAVEMENT STRIPING LOCATIONS SUCH AS STOP BARS, CROSSWALKS, AND THE LIKE.
- D. APPLY HIGHWAY TRAFFIC STRIPING DURING DAYLIGHT HOURS WHEN THE AIR AND PAVEMENT TEMPERATURES ARE 40° F (4° C) OR HIGHER, THE PAVEMENT SURFACE IS DRY AND THE WEATHER IS NOT FOGGY, RAINY, OR STORMY.
- E. APPLY PAINT AND GLASS BEADS WITH EQUIPMENT MANUFACTURED SPECIFICALLY FOR THAT PURPOSE AND USING WORKMEN EXPERIENCED IN OPERATING SUCH EQUIPMENT. LOCATE THE BEAD APPLICATOR DIRECTLY BEHIND AND SYNCHRONIZED WITH THE PAINT APPLICATOR. ASSURE BOTH DEVICES ARE SHIELDED TO AVOID SPRAYING OF PAINT OR LOSS OF BEADS OUTSIDE OF THE DESIGNATED WIDTH OF LINE. ASSURE THE EQUIPMENT IS ALSO CAPABLE OF PAINTING A STRIPE OR STRIPES OF THE SPECIFIED WIDTH WITH A TOLERANCE OF PLUS OR MINUS ¼ INCH (6.25 MM). IN "NO PASSING ZONES", THE MACHINE MUST BE ABLE TO PAINT THREE (3) STRIPES SIMULTANEOUSLY. FOR CENTERLINE PAINTING, ASSURE THE MACHINE IS EQUIPPED WITH AN AUTOMATIC SKIP CONTROL GIVING THE SPECIFIED BROKEN-LINE PATTERN WITHIN A TOLERANCE OF 6" (150 MM) OVER EACH CYCLE.
- F. USE HAND-OPERATED EQUIPMENT TO STRIPE STOP BARS, CROSSWALKS, AND OTHER AREAS NOT READILY ACCESSIBLE TO THE PAVEMENT STRIPING MACHINE.
- G. APPLY THE PAVEMENT STRIPING PAINT AT THE FOLLOWING RATES PER GALLON (LITER):
 - 1. FOUR-INCH STRIPE (100 MM) – AT LEAST 250 BUT NOT MORE THAN 275 LINEAR FEET (METERS) PER GALLON (LITER).
 - 2. FOUR-INCH (100 MM) DASHED STRIPE (9 FOOT [2.8 METER] STRIPE-15 FOOT [4.6 METER] GAP) – AT LEAST 665 BUT NOT MORE THAN 735 LINEAR FEET (METERS) PER GALLON (LITER).
 - 3. FOUR-INCH (100 MM) DASHED STRIPE (10 FOOT [3 METER] – 30 FOOT [9 METER] GAP) AT LEAST 1000 BUT NOT MORE THAN 1100 LINEAR FEET (METERS) PER GALLON (LITER).
 - 4. APPLY BEADS AT THE RATE OF 6 POUNDS (KG) PER GALLON (LITER) OF PAINT, PLUS OR MINUS 0.1 POUND.
- H. FOR QUALITY CONTROL, THE ENGINEER WILL CHECK THE APPLICATION AT THE BEGINNING OF EACH DAY'S PAINT STRIPING AND AS OFTEN AS CONSIDERED NECESSARY. IF EQUIPMENT SETTINGS FAIL TO PRODUCE QUALITY STRIPING WITHIN THE LIMITS SPECIFIED, STOP STRIPING WORK UNTIL CORRECTED.
- I. PROTECT ALL MARKINGS UNTIL DRY BY PLACING APPROVED GUARDING OR WARNING DEVICES AS NECESSARY. CORRECT ALL MARKINGS SMEARED OR OTHERWISE DAMAGED AT NO EXPENSE TO THE OWNER.
- J. SUFFICIENT QUANTITIES OF PAINT HAVE BEEN INCLUDED IN THE CONTRACT TO PROVIDE FOR AN INTERIM APPLICATION AND A FINAL APPLICATION OF TRAFFIC LINE PAINT. THE NEED FOR APPLYING AN INTERIM APPLICATION WILL BE DETERMINED BY THE ENGINEER.

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- K. WHEN PLASTIC PAVEMENT MARKINGS ARE SPECIFIED, USE PAINT FOR THE INTERIM MARKINGS OF THE SPECIFIED COLOR AND APPLY AS SPECIFIED IN THE CONTRACT DOCUMENTS. THE FINAL APPLICATION MUST BE PLASTIC.
- L. APPLY TWO (2) FULL APPLICATIONS OF THE SPECIFIED CENTERLINE AND SHOULDER LINE STRIPING ON OPEN GRADED FRICTION COURSE AND SEAL COAT PAVEMENT SURFACES MEETING THE FOLLOWING TABLE. APPLY THE SECOND APPLICATION A MINIMUM OF 30 DAYS AFTER THE FIRST APPLICATION.

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PAVEMENT STRIPING – OGFC AND SEAL COATED SURFACES

PAVEMENT SURFACE TYPE		NUMBER OF APPLICATIONS*	STRIPING APPLICATION – DIRECTION OF TRAVEL	
			FIRST APPLICATION	SECOND
APPLICATION				
OGFC AND SEAL COATED SURFACES	2 LANE	2	NOT SPECIFIED	APPLY IN OPPOSITE DIRECTION OF FIRST APPLICATION
	2-WAY			
	4-WAY	2	APPLY IN SAME DIRECTION AS TRAFFIC FLOW.	APPLY IN SAME DIRECTION AS TRAFFIC FLOW.

*ALL TRANSVERSE LINES MUST RECEIVE TWO (2) APPLICATIONS APPLIED IN OPPOSITE DIRECTIONS.

3.3 REMOVAL OF PAVEMENT MARKINGS

- A. AS SHOWN IN THE CONTRACT DOCUMENTS OR DIRECTED BY THE ENGINEER, REMOVE TEMPORARY PAVEMENT MARKINGS OR MARKINGS THAT ARE NO LONGER APPROPRIATE TO THE ROADWAY.
- B. APPROVED METHODS OF REMOVING MARKINGS INCLUDE SAND BLASTING WITH AIR OR WATER; HIGH PRESSURE WATER; STEAM OR SUPERHEATED WATER; MECHANICAL GRINDERS, SANDERS, SCRAPERS, BRUSHES, BURNING, AND THE LIKE.
- C. CHOOSE, SUBJECT TO ENGINEER APPROVAL, THE REMOVAL METHOD BEST SUITED TO THE EXISTING CONDITION OF THE PAINT AND PAVEMENT SURFACE.
- D. NO OTHER METHODS OF REMOVAL OTHER THAN THOSE SPECIFIED HERE WILL BE ALLOWED. THE CONTRACTOR MAY MAKE WRITTEN REQUEST TO THE ENGINEER FOR APPROVAL TO USE OTHER METHODS, MATERIALS, OR EQUIPMENT. THE ENGINEER MAY SUBSEQUENTLY DISAPPROVE ANY PRIOR APPROVED METHOD SHOULD IT PROVE DETRIMENTAL TO THE PAVEMENT SURFACE OR INADEQUATE IN REMOVING THE MARKINGS.
- E. REMOVE SAND OR OTHER MATERIAL DEPOSITED ON THE PAVEMENT RESULTING FROM REMOVING TRAFFIC MARKINGS AS THE WORK PROGRESSES. IF THE STRIPING REMOVAL RESULTS IN LIGHT OR DISCOLORED LINES ON THE ROADWAY, COVER THE AREAS WITH A THIN ASPHALT FOG COAT. REPAIR ALL DAMAGE TO THE PAVEMENT OR SURFACING CAUSED BY PAVEMENT MARKING REMOVAL AT NO COST TO THE OWNER.

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PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. PLASTIC PAVEMENT STRIPING IS MEASURED FOR PAYMENT BY THE NUMBER OF LINEAR FEET (METERS) OF LINE OF THE SPECIFIED WIDTH AND THICKNESS IN PLACE AND ACCEPTED. LENGTH OF DASHED, LONGITUDINAL PAVEMENT LINE IS THE ACTUAL LENGTH PLACED, E.G. 25% OF THE TOTAL ROADWAY LENGTH WHERE 10-30 LINES GAP RATIO IS USED.
- B. PLASTIC PAVEMENT MARKING WORDS AND SYMBOLS ARE MEASURED FOR PAYMENT BY THE NUMBER OF SQUARE FEET OF WORDS AND SYMBOLS IN PLACE AND ACCEPTED.
- C. PAINTED TRAFFIC LINES, WORDS, AND SYMBOLS ARE MEASURED FOR PAYMENT BY THE NUMBER OF GALLONS (LITERS) OF PAINT USED AND ACCEPTED.
- D. UNLESS OTHERWISE PROVIDED IN THE CONTRACT, REMOVAL OF PAVEMENT MARKINGS IS MEASURED FOR PAYMENT BY THE LINEAR FOOT (METER). WORDS AND SYMBOLS ARE MEASURED BY THE SQUARE FOOT (SQUARE METER) AND CONVERTED TO THE EQUIVALENT LINEAR FOOT (METER) OF 4" (100 MM) WIDE LINE.
- E. PAINT AND PAINTING OF CURBS, ISLAND CURBS, AND MEDIAN CURBS IN ACCORDANCE WITH SECTION 02581.3.2 ARE MEASURED BY THE ACTUAL GALLONS (LITERS) OF PAINT USED AND ACCEPTED.
- F. PLASTIC PAVEMENT STRIPING IS PAID FOR AT THE CONTRACT UNIT PRICE PER LINEAR FOOT (METER) OF STRIPING OF THE SPECIFIED WIDTH AND THICKNESS.
- G. PLASTIC PAVEMENT MARKING WORDS AND SYMBOLS ARE PAID FOR AT THE CONTRACT UNIT PRICE PER SQUARE FOOT (SQUARE METER) OF PLASTIC WORDS AND AT THE CONTRACT UNIT PRICE PER SQUARE FOOT (SQUARE METER) OF PLASTIC WORDS AND SYMBOLS. PAYMENT FOR PLASTIC LINES, WORDS, AND SYMBOLS IS FULL COMPENSATION FOR FURNISHING ALL NECESSARY MATERIALS AND EQUIPMENT AND DOING ALL REQUIRED WORK.
- H. PAINTING OF TRAFFIC LINES AND WORDS AND SYMBOLS IS PAID FOR AT THE CONTRACT UNIT PRICE PER GALLON (LITER) FOR "HIGHWAY TRAFFIC STRIPING" COMPLETE IN PLACE, INCLUDING THE FURNISHING AND APPLICATION OF BEADS. PAYMENT IS FULL COMPENSATION FOR ALL WORK NECESSARY TO COMPLETE THE ITEM.
- I. REMOVAL OF PAVEMENT MARKINGS IS PAID FOR AT THE CONTRACT UNIT PRICE PER LINEAR FOOT (METER).
- J. THE COST OF PAINT AND THE PAINTING OF CURBS, ISLAND CURBS, AND MEDIAN CURBS IN ACCORDANCE WITH SECTION 02581.3.2 ARE PAID FOR AT THE CONTRACT UNIT PRICE PER GALLON (LITER) FOR CURB MARKING.

END OF SECTION 02581

SECTION 02660 - WATER DISTRIBUTION

PART 1: GENERAL

1.1 DESCRIPTION

- A. FURNISH ALL WATER MAIN PIPE AND FITTINGS MEETING THE CONTRACT DOCUMENTS OR SPECIFIED AS FOLLOWS.
- B. FURNISH AND INSTALL VALVES AND FIRE HYDRANTS FOR WATER MAINS, TOGETHER WITH RELATED APPURTENANCES.
- C. CONSTRUCT WATER SERVICES, INCLUDING WATER SERVICE PIPING, TAPPING MAINS, CORPORATION STOPS, CURB STOPS AND RELATED ITEMS.

1.2 CERTIFICATION BY MANUFACTURER:

- A. FURNISH A MANUFACTURER'S CERTIFICATION COVERING ALL PIPE AND FITTINGS FURNISHED, CERTIFYING THAT THE PIPE AND FITTINGS MEET APPLICABLE SPECIFICATIONS.

1.3 REFERENCES

ANSI B16.1	TAPPING SLEEVES
ASTM B88-62	COPPER PIPE
ASTM PE3406-3408	POLYETHYLENE PRESSURE PIPE
AWWA B300	HYPOCHLORITE FOR
DISINFECTING	
AWWA B301	LIQUID CHLORINE FOR DISINFECTING
AWWA C104	DUCTILE IRON CEMENT-MORTAR LINING
AWWA C110	DUCTILE IRON FITTINGS
AWWA C111	DUCTILE IRON JOINTS
AWWA C151	DUCTILE IRON PIPE
AWWA C153	DUCTILE IRON COMPACT FITTINGS
AWWA C301	CONCRETE CYLINDER PIPE
AWWA C500	GATE VALVES
AWWA C502	FIRE HYDRANTS
AWWA C504	BUTTERFLY VALVES
AWWA C509	GATE VALVES
AWWA C651	DISINFECTING WATER MAINS
AWWA C900	PVC WATER MAIN PIPE

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1.4 STANDARD DRAWINGS:

A. STANDARD DRAWINGS IN APPENDIX A APPLICABLE TO THIS SECTION ARE AS FOLLOWS:

STANDARD DRAWING NO. 02660-1	THRUST BLOCKING FOR WATER MAIN FITTINGS
STANDARD DRAWING NO. 02660-2	WATER AND SEWER MAIN SEPARATION
STANDARD DRAWING NO. 02660-3	THRUST BLOCKING FOR WATER MAIN VALVES
STANDARD DRAWING NO. 02660-4	FIRE HYDRANT SETTING
STANDARD DRAWING NO. 02660-5	HYDRANT LOCATION
DETAIL STANDARD DRAWING NO. 02660-6	WATER SERVICE LINE
STANDARD DRAWING NO. 02660-7	BLOWOFF VALVE

PART 2: PRODUCTS

2.1 GENERAL

- A. FURNISH WATER MAIN PIPE AND FITTINGS AS SPECIFIED IN THE CONTRACT DOCUMENTS AND MEETING THE MATERIAL AND TESTING REQUIREMENTS OF THIS SECTION. FURNISH FITTINGS AND SERVICE LINE PIPING OF THE SAME MATERIAL AND DESIGN AS THE WATER MAIN PIPE UNLESS SPECIFIED OTHERWISE. PIPE STRENGTH CLASSIFICATIONS ARE SHOWN ON PLAN DRAWINGS AND/OR ARE LISTED IN THE CONTRACT DOCUMENTS.
- B. REFERENCES MADE TO ASTM, ANSI, AWWA, USASI OR AASHTO DESIGNATIONS ARE THE LATEST REVISION AT THE TIME OF CALL FOR BIDS.

2.2 PIPE MATERIALS

A. GENERAL

- 1. FURNISH THE PIPE SPECIFIED IN THE CONTRACT DOCUMENTS MEETING THE MATERIALS AND TESTING REQUIREMENTS AS OUTLINED IN THIS SECTION.
- 2. ASSURE ALL PIPE IS CLEARLY MARKED SHOWING TYPE, CLASS AND/OR THICKNESS. LETTERING MUST BE LEGIBLE AND PERMANENT UNDER NORMAL HANDLING AND STORAGE CONDITIONS.

B. DUCTILE IRON PIPE

- 1. FURNISH CLASS 51 WALL THICKNESS MEETING AWWA C151, AMERICAN NATIONAL STANDARD FOR DUCTILE IRON PIPE.
- 2. USE UNDERGROUND PIPE AND FITTINGS HAVING MECHANICAL OR PUSH-ON JOINTS MEETING AWWA C 111.

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3. ASSURE THE PIPE INTERIOR IS CEMENT MORTAR LINED MEETING AWWA C104 REQUIREMENTS. ASSURE THE OUTSIDE PIPE SURFACE FOR UNDERGROUND SERVICE IS BITUMINOUS COAL TAR BASE COATED 1 MIL THICK.
4. FITTINGS
 - A. FURNISH FITTINGS MEETING ONE OF THE FOLLOWING;
 - 1) CLASS 250 FITTINGS MEETING AWWA C110, LATEST EDITION, GRAY-IRON AND DUCTILE IRON FITTINGS FOR WATER AND OTHER LIQUIDS
 - 2) COMPACT FITTINGS MEETING AWWA C153.
5. JOINTS
 - A. ASSURE JOINTS ARE MECHANICAL OR PUSH-ON JOINTS MEETING AWWA C111. ASSURE THE FITTING INTERIOR IS CEMENT MORTAR LINED MEETING AWWA C104. ASSURE THE FITTING EXTERIOR IS BITUMINOUS TAR COATED 1 MIL THICK. USE COMPACT FITTINGS HAVING A RATED WORKING PRESSURE OF 350 PSI (2410 KPA) FOLLOWING MANUFACTURER RECOMMENDED LAYING LENGTHS.
6. COUPLINGS
 - A. USE PIPE COUPLINGS MEETING ONE OF THE FOLLOWING:
 - 1) CAST TYPE WITH CAST IRON OR DUCTILE IRON SLEEVES AND MALLEABLE OR DUCTILE IRON FLANGES.
 - 2) GRAY IRON OR DUCTILE IRON, MECHANICAL JOINT SOLID SLEEVES, WITH A MINIMUM 12 INCH LENGTH (30 CM).
 - 3) LIMIT USE OF THE FIRST TYPE TO A MAXIMUM 16 INCH (40 CM) DIAMETER. USE THE MANUFACTURERS' STANDARD GASKET FOR USE IN POTABLE WATER SYSTEMS. USE STAINLESS STEEL BOLTS AND NUTS. COATING TO BE "MANUFACTURERS' STANDARD".
- C. POLYVINYL CHLORIDE (PVC) PRESSURE PIPE
 1. FURNISH PVC WATER MAIN PIPE MEETING AWWA C900 REQUIREMENTS, MADE TO DUCTILE IRON O.D.'S FOR "PUSH-ON" JOINTS. ASSURE PIPE JOINTS ARE BELL AND SPIGOT HAVING AN ELASTOMERIC GASKET. USE DR 25 CLASS 165 PIPE.
- D. CONCRETE CYLINDER PIPE
 1. FURNISH PRESTRESSED, REINFORCED CONCRETE WATER PIPE, STEEL CYLINDER TYPE MEETING AWWA C301 AND HAVING RUBBER GASKETED BELL AND SPIGOT JOINTS. FURNISH THE PIPE CLASS, MARKING, LENGTHS, ETC. SPECIFIED IN THE CONTRACT DOCUMENTS.
- E. WATER SERVICE PIPE
 1. USE COPPER OR POLYETHYLENE PIPE IN WATER SERVICE LINE CONSTRUCTION AS SPECIFIED IN THE CONTRACT DOCUMENTS AND MEETING THE FOLLOWING SPECIFICATIONS.

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- A. FURNISH SERVICE PIPE OF THE SIZE OR SIZES SPECIFIED. SERVICE LINES ARE CONSIDERED 2-INCH (51 MM) SIZE AND UNDER. SERVICE LINES OVER 2-INCH (51 MM) SIZE ARE CONSIDERED AS WATER MAINS AND ARE SPECIFIED UNDER THE APPLICABLE SECTIONS.
- B. FURNISH AND INSTALL THE SERVICE PIPE FROM THE MAIN TO THE PROPERTY LINE INSTALLING A CURB STOP AND CURB BOX AT THE PROPERTY LINE. MEET THE WATER SERVICE INSTALLATION REQUIREMENTS OF STANDARD DRAWING 02660-6.
- C. COPPER SERVICE PIPE
 - 1) USE COPPER, TYPE K, MEETING FEDERAL SPECIFICATION WW-T- 799 OR ASTM B88-62.
- D. POLYETHYLENE SERVICE PIPE
 - 1) USE PIPE MEETING AWWA SPECIFICATION C901, "POLYETHYLENE (PE) PRESSURE PIPE, TUBING AND FITTINGS, 1/2 INCH THROUGH 3 INCH FOR WATER" AND ASTM PE3406-3408. PE PIPE TO BE PRESSURE TUBING MEETING TABLE 6 REQUIREMENTS OF SAID SPECIFICATION. USE CLASS 200 WITH A DR OF 7 POLYETHYLENE PIPE.

2.3 TAPPING SLEEVES AND VALVES:

- A. USE TAPPING SLEEVES MEETING EITHER:
 - 1. GRAY IRON OR DUCTILE IRON, SPLIT-SLEEVE, MECHANICAL JOINT TYPE WITH END AND SIDE GASKETS,
 - 2. SPLIT-BODY TYPE WITH CIRCULAR GASKET FORMING A SEAL AROUND THE CIRCUMFERENCE OF THE OUTLET.
 - 3. ASSURE BOTH TYPES HAVE A CLASS 125, ANSI B16.1 OUTLET FLANGE, ARE RATED FOR A MINIMUM 150 PSI (1030 KPA) WORKING PRESSURE AND CONTAIN A THREADED TEST PLUG ON THE NECK OR BODY OF THE TAPPING SLEEVE. ASSURE GASKETS ARE MANUFACTURERS' STANDARD FOR USE IN POTABLE WATER SYSTEMS. USE STAINLESS STEEL BOLTS AND NUTS. ASSURE MECHANICAL JOINT TYPE IS FUSION- BONDED, 12-MIL THICKNESS, AND EPOXY COATED. LIMIT THE USE OF MECHANICAL JOINT TYPE TO METAL PIPE. ASSURE TAPPING VALVES MEET THE APPLICABLE REQUIREMENTS FOR GATE VALVES, AS OUTLINED IN THIS SECTION, WITH FLANGED INLETS COMPATIBLE WITH THE FLANGE OF THE TAPPING SLEEVE AND MECHANICAL JOINT OUTLET.

2.4 CORPORATION STOPS

- A. FURNISH BRASS CORPORATION STOPS WITH INLET END TO MEET TAPPING REQUIREMENTS AND FLARED OUTLET FOR COPPER TUBING OR PRESSURE COUPLING FOR POLYETHYLENE TUBING.

2.5 SERVICE CLAMPS

- A. FURNISH FLAT, DOUBLE STRAP, BRONZE METAL SERVICE CLAMPS WITH NEOPRENE GASKETS AND CORPORATION STOP THREADS. ASSURE SERVICE CLAMPS FOR PVC PROVIDE FULL SUPPORT AROUND THE PIPE CIRCUMFERENCE WITH A BEARING AREA OF THE WIDTH ALONG THE AXIS OF THE PIPE SO THE PIPE IS NOT DISTORTED WHEN THE CLAMP IS TIGHTENED.

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2.6 CURB STOPS

- A. FURNISH CURB STOPS WITH BRONZE PLUG, TEE HEAD KEY WITH MINNEAPOLIS PATTERN AND SCREW BOX MOUNT.

2.7 CURB BOXES

- A. FURNISH EXTENSION TYPE CURB BOXES HAVING A 6- 1/2 FOOT (2 METERS) EXTENDED LENGTH.

2.8 VALVES

A. GATE VALVES

1. FURNISH IRON BODY GATE VALVES, RESILIENT SEAT OR DOUBLE DISC GATE VALVES WITH NON-RISING STEMS WITH DESIGN, CONSTRUCTION AND PRESSURE RATING MEETING AWWA C500 OR AWWA C509 REQUIREMENTS AND THE FOLLOWING.
2. ASSURE STEM SEALS ARE DOUBLE "O" RING SEALS CAPABLE OF REPLACING THE SEAL ABOVE THE STEM COLLAR WITH THE VALVE UNDER PRESSURE IN FULL OPEN POSITION.
3. FURNISH GATE VALVES FOR UNDERGROUND INSTALLATION EQUIPPED WITH A 2-INCH (31 MM) SQUARE OPERATING NUT FOR KEY OPERATION. ALL VALVES TO OPEN COUNTERCLOCKWISE. VALVES TO BE EQUIPPED WITH PUSH-ON JOINTS OR MECHANICAL JOINTS FOR PIPE CONNECTIONS.

B. BUTTERFLY VALVES

1. FURNISH CLASS 150, RUBBER SEATED, BUTTERFLY VALVES FOR WATER DISTRIBUTION SYSTEMS MEETING AWWA C504 REQUIREMENTS. VALVES TO BE EQUIPPED WITH MECHANICAL JOINT ENDS AND LUBRICATED SCREW TYPE OPERATORS DESIGNED FOR UNDERGROUND SERVICE.
2. RUBBER VALVE SEATS TO BE REPLACEABLE WITHOUT DISASSEMBLING THE VALVE AND NOT INTERRUPTED BY THE SHAFTING. RUBBER SEATS MAY BE RETAINED ON THE DISC EDGE BY STAINLESS STEEL CLAMPING INSTEAD OF BONDING TO THE VALVE BODY. ASSURE SHAFT PACKING IS THE SELF-ADJUSTING, PERMANENT TYPE.
3. ASSURE UNDERGROUND SERVICE OPERATORS ARE PERMANENTLY LUBRICATED, SCREW TYPE, TOTALLY ENCLOSED AND WATERTIGHT CONSTRUCTED. ASSURE OVERLOAD PROTECTION IS INCORPORATED IN THE OPERATOR ALLOWING 450 FOOT-POUNDS (610 J) INPUT TORQUE AT FULL-OPEN AND FULL-CLOSED POSITIONS WITHOUT DAMAGING THE OPERATOR OR VALVE. PROVIDE A 2-INCH (51MM) SQUARE OPERATING NUT AND VALVE BOX FOR OPERATING THE VALVE. VALVES TO OPEN COUNTER CLOCKWISE. FURNISH PERFORMANCE CERTIFICATION, LEAKAGE AND HYDROSTATIC TESTS AS SPECIFIED IN AWWA C504. ASSURE VALVE MANUFACTURER HAS AT LEAST FIVE YEARS EXPERIENCE MANUFACTURING WATERWORKS AND DISTRIBUTION VALVES.

2.9 VALVE BOXES

- A. FURNISH CAST IRON VALVE BOXES, 5-1/4-INCH (13 CM) DIAMETER, ADJUSTABLE VALVE BOXES WITH THE REQUIRED BASE FOR THE VALVE SIZE USED. ASSURE VALVE BOXES ARE SCREW TYPE AND OF THE SPECIFIED LENGTH FOR THE PIPE BURY. ASSURE THE VALVE BOX CAST IRON COVER HAS AN ARROW INDICATING THE OPENING DIRECTION AND STAMPED

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WITH THE WORD "WATER".

2.10 FIRE HYDRANTS

- A. FURNISH FIRE HYDRANTS MEETING AWWA C502; "STANDARD SPECIFICATIONS FOR FIRE HYDRANTS FOR ORDINARY WATER WORKS SERVICE", AND THE CONTRACT REQUIREMENTS.
- B. FURNISH HYDRANTS WITH 5-1/4-INCH (13 CM) VALVE OPENINGS, 6-INCH (15 CM) MECHANICAL JOINT, FLANGED OR PUSH-ON INLET, ONE PUMPER CONNECTION AND TWO, 2-1/2-INCH (63 CM) HOSE CONNECTIONS. ASSURE HOSE NOZZLE THREADS MEET ASA SPECIFICATION B26 FOR NATIONAL STANDARD FIRE HOSE COUPLING SCREW THREADS, 7 1/2 THREADS PER INCH. ASSURE PUMPER NOZZLE SIZE AND THREADS MATCH OWNERS EXISTING PATTERN. FURNISH NATIONAL STANDARD OPERATING NUT. FURNISH HYDRANTS OPENING COUNTERCLOCKWISE AND HAVING AN ARROW ON THE HYDRANT TOP DESIGNATING THE OPENING DIRECTION.
- C. FURNISH "COMPRESSION" TYPE HYDRANTS WITH SAFETY FLANGE AND SAFETY STEM COUPLING ABOVE THE GROUND LINE PERMITTING REPAIR WITHOUT SHUTTING OFF THE WATER. ASSURE HYDRANTS ARE OF THE DRY TOP DESIGN WITH TWO OR MORE "O" RINGS SEALING THE WATER FROM THE OPERATING MECHANISM. ASSURE THE OPERATING MECHANISM IS AUTOMATICALLY LUBRICATED FROM A SEALED, SELF-CONTAINED LUBRICATING RESERVOIR.
- D. PAINT THE HYDRANT PORTION ABOVE THE GROUND LINE MEETING THE OWNER'S STANDARDS. FURNISH HYDRANTS FOR 6.5 FOOT (2 METERS) BURY.

2.11 SPECIAL FITTINGS

- A. FURNISH SPECIAL FITTINGS MEETING THE CONTRACT DOCUMENTS. THE ENGINEER WILL SPECIFY GASKET MATERIALS FOR CONTAMINATED SOIL OR SPECIAL GROUNDWATER SITUATIONS.

2.12 POLYETHYLENE ENCASEMENT

- A. FURNISH POLYETHYLENE ENCASEMENT IN ACCORDANCE WITH AWWA C105, "POLYETHYLENE ENCASEMENT FOR FRAY AND DUCTILE CAST – IRON PIPE FOR WATER AND OTHER LIQUIDS".

PART 3: EXECUTION

3.1 TRENCH EXCAVATION AND BACKFILL FOR WATER MAINS

- A. THIS WORK INCLUDES ALL EXCAVATION, BACKFILLING, DISPOSAL OF SURPLUS AND UNSUITABLE MATERIAL, AND ALL OTHER WORK INCIDENTAL TO TRENCH CONSTRUCTION, INCLUDING EXCAVATION FOR VALVES, FITTINGS, HYDRANTS, THRUST BLOCKS OR OTHER PIPELINE STRUCTURES AND NOT CLASSIFIED AS "STRUCTURAL EXCAVATION."
- B. PERFORM THIS WORK IN ACCORDANCE WITH SECTION 02221: TRENCH EXCAVATION AND BACKFILL FOR PIPELINES & APPURTENANT STRUCTURES.

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3.2 PIPE INSTALLATION FOR WATER MAINS

A. GENERAL

1. INSTALL PIPE FOLLOWING THE MANUFACTURER'S SPECIFICATIONS AND INSTRUCTIONS. PROVIDE ALL TOOLS AND EQUIPMENT REQUIRED TO INSTALL EACH TYPE OF PIPE USED.
2. THE CONTRACTOR IS RESPONSIBLE FOR ALL CONTRACTOR FURNISHED MATERIAL. REPLACE ALL DEFECTIVE MATERIAL OR MATERIAL DAMAGED BY HANDLING AFTER DELIVERY BY THE MANUFACTURER. THIS INCLUDES THE FURNISHING OF ALL MATERIALS AND LABOR REQUIRED TO REPLACE INSTALLED MATERIAL DISCOVERED DAMAGED OR DEFECTIVE BEFORE FINAL ACCEPTANCE OF THE WORK, OR DURING THE GUARANTEE PERIOD.
3. STORE ALL MATERIAL SAFELY AND TO PREVENT DAMAGE. KEEP PIPE INTERIOR AND OTHER ACCESSORIES FREE FROM DIRT AND FOREIGN MATTER AT ALL TIMES.
4. DELIVER AND DISTRIBUTE ALL CONTRACTOR FURNISHED PIPE AT THE SITE. LOAD AND UNLOAD PIPE, FITTINGS, SPECIALS, VALVES AND ACCESSORIES TO PREVENT DAMAGE. DO NOT PERMIT PIPE HANDLED ON SKIDWAYS TO SKID OR ROLL AGAINST PIPE ALREADY ON THE GROUND.
5. WHEN DISTRIBUTING MATERIAL AT THE WORK SITE, LAY EACH PIECE ADJACENT TO ITS INSTALLATION POINT. REPAIR OR REPLACE ALL DAMAGED PIPE AT CONTRACTOR'S EXPENSE ON THE JOBSITE.

B. DEWATERING OF TRENCH

1. REMOVE ALL WATER IN THE TRENCH DURING PIPE LAYING AND MAINTAIN A DRY TRENCH UNTIL THE PIPE ENDS ARE SEALED. DO NOT PERMIT THE PIPE TO FLOAT. DO NOT ALLOW ANY TRENCH WATER TO ENTER THE PIPE AT ANY TIME.

C. LAYING OF PIPE

1. INSPECT THE PIPE AND PIPE COATING FOR DAMAGE OR DEFECTS BEFORE INSTALLATION. LAY PIPE WITHOUT DAMAGING THE PIPE COATING. REPAIR ALL PIPE COATING DAMAGE FOLLOWING THE MANUFACTURER'S INSTRUCTIONS BEFORE LAYING THE PIPE. WHEN USING BELT SLINGS TO LOWER THE PIPE INTO THE TRENCH, REMOVE THE SLINGS WITHOUT DAMAGING THE PIPE COATING.
2. LAY PIPE TO THE SPECIFIED LINES AND GRADES WITH FITTINGS AND VALVES AT THE REQUIRED LOCATIONS. PLUMB ALL VALVE STEMS.
3. GRADE AND ALIGNMENT ON UN-GRADED STREETS WILL BE PROVIDED USING HUBS SET PARALLEL TO THE PIPE LINE, AND ON GRADED STREETS FROM ESTABLISHED POINTS ON THE EXISTING CURBS OR SIDEWALKS, WHEN DIRECTED BY THE ENGINEER. EXCAVATE PIPE TRENCHES TO THE LINES AND GRADES GIVEN OR TO THE STANDARD COVER DEPTH SPECIFIED. TRANSFER LINES AND GRADES TO THE PIPE FROM HUBS OR FROM EXISTING CONCRETE CURBS OR SIDEWALKS AS AN INCIDENTAL PART OF THIS WORK.
4. USE IMPLEMENTS, TOOLS AND FACILITIES SATISFACTORY TO THE ENGINEER FOR THE SAFE AND CONVENIENT PROSECUTION OF THE WORK. CAREFULLY

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LOWER ALL PIPE, FITTINGS AND VALVES INTO THE TRENCH USING A DERRICK, ROPE OR OTHER TOOLS OR EQUIPMENT, WITHOUT DAMAGING PIPE MATERIALS AND PROTECTIVE COATINGS AND LININGS. DO NOT DROP OR DUMP MATERIALS INTO THE TRENCH.

5. TAKE EVERY PRECAUTION TO PREVENT FOREIGN MATERIAL FROM ENTERING THE PIPE AS IT IS PLACED IN THE LINE. DURING LAYING OPERATIONS, DO NOT PERMIT DEBRIS, TOOLS, CLOTHING OR OTHER MATERIALS TO BE PLACED IN THE PIPE. AT TIMES WHEN PIPE LAYING IS NOT IN PROGRESS, CLOSE THE OPEN ENDS OF THE PIPE USING A WATERTIGHT PLUG OR OTHER APPROVED METHODS TO PREVENT MATERIAL ENTERING THE PIPE.
6. PLACE PIPE BEDDING IN THE BOTTOM OF THE TRENCH MEETING SECTION 02221; TRENCH EXCAVATION AND BACKFILL FOR PIPELINES & APPURTENANT STRUCTURES. VOIDS MAY BE LEFT IN THE BEDDING MATERIAL TO REMOVE PIPE SLINGS AND FOR PIPE BELLS TO ALLOW SUPPORT ALONG THE FULL LENGTH OF THE PIPE BARREL.
7. LONG RADIUS CURVES, EITHER HORIZONTAL OR VERTICAL, MAY BE LAID WITH STANDARD PIPE WITH DEFLECTIONS AT THE JOINTS WHERE APPROVED. IF THE PIPE IS SHOWN CURVED ON THE PLANS AND NO SPECIAL FITTINGS ARE SHOWN, ASSUME THAT THE CURVES CAN BE MADE BY DEFLECTION OF THE JOINTS WITH STANDARD LENGTHS OF PIPE. IF SHORTER LENGTHS ARE REQUIRED, THE PLAN WILL INDICATE MAXIMUM LENGTHS THAT CAN BE USED.
8. THE ENGINEER WILL DETERMINE THE METHOD OF DEFLECTION OR CURVING WHERE REQUIRED BUT NOT SPECIFIED. NO ADDITIONAL PAYMENT WILL BE MADE FOR LAYING PIPE ON PLANNED CURVES, NOR FOR FIELD CHANGES INVOLVING STANDARD PIPE LENGTHS DEFLECTED AT THE JOINTS.
9. DO NOT EXCEED THE APPLICABLE MATERIAL AND JOINT SPECIFICATIONS OF AWWA OR THE PIPE MANUFACTURER'S RECOMMENDATIONS AT PIPE JOINTS FOR VARIOUS TYPES OF PIPE. WHEN RUBBER GASKETED PIPE IS LAID ON A CURVE, JOINT THE PIPE IN A STRAIGHT ALIGNMENT AND THEN DEFLECT TO THE CURVED ALIGNMENT. EXCAVATE TRENCHES TO ACCOMMODATE DEFLECTIONS AND CURVES.
10. CONSTRUCT REACTION OR THRUST BLOCKS AT ALL TEES, PLUGS, VALVES, REDUCERS, CAPS AND AT BENDS DEFLECTING 22-1/2 DEGREES OR MORE. CONSTRUCT THRUST BLOCKS AT TAPPING SLEEVES WHERE THE OUTLET DIAMETER EXCEEDS ONE-HALF THE DIAMETER OF THE MAIN BEING TAPPED. LIMIT USING METAL RODS OR STRAPS FOR THRUST RESTRAINT TO THOSE SPECIFIED ON THE PLANS, OR WHERE THE USE OF CONCRETE THRUST BLOCKS WOULD BE IMPRACTICAL. DO NOT USE METAL RODS OR STRAPS WITHOUT THE ENGINEER'S APPROVAL. CONSTRUCT REACTION BLOCKS FROM CONCRETE HAVING A MINIMUM COMPRESSIVE STRENGTH OF 2,000 POUNDS PER SQUARE INCH (14,000 KPA) AT 28 DAYS. PLACE BLOCKING BETWEEN UNDISTURBED GROUND AND THE FITTING TO BE ANCHORED, AS SHOWN ON STANDARD DRAWING 02660-1. PLACE THE BLOCKING SO THAT THE PIPE AND FITTING JOINTS ARE ACCESSIBLE FOR REPAIR.
11. CUT PIPE FOR INSERTING VALVES, FITTINGS OR CLOSURE PIECES IN A NEAT AND WORKMANLIKE MANNER WITHOUT DAMAGING THE PIPE OR COATING AND LEAVING A SMOOTH END AT RIGHT ANGLES TO THE PIPE AXIS. DO NOT CUT PIPE USING AN OXYACETYLENE TORCH.

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D. PIPE JOINTING

1. RUBBER GASKET, "PUSH-ON" JOINTS

- A. FOLLOW THE MANUFACTURER'S RECOMMENDATIONS FOR JOINTING OF PIPE AND FITTINGS WITH A RUBBER GASKET, "PUSH-ON" TYPE. WIPE THE RUBBER GASKET AND GASKET SEAT INSIDE THE BELL CLEAN WITH A CLOTH. WIPE THE PLAIN END OF THE ADJOINING PIPE CLEAN, LUBRICATE AND INSERT INTO THE BELL TO MAKE CONTACT WITH THE GASKET. FORCE THE PLAIN END "HOME" USING A CROW BAR, FORK TOOL, OR JACK ASSEMBLY.

2. MECHANICAL JOINTS

- A. THOROUGHLY BRUSH THE BELL AND THE OUTSIDE OF THE SPIGOT OF THE MECHANICAL JOINT FITTING WITH A WIRE BRUSH TO REMOVE ALL LOOSE RUST OR OTHER FOREIGN MATERIAL JUST BEFORE ASSEMBLY. BRUSH THE CLEANED SURFACES WITH SOAPY WATER JUST BEFORE SLIPPING THE GASKET OVER THE SPIGOT END AND INTO THE BELL.
- B. CENTER THE SPIGOT END OF THE PIPE OR FITTING IN THE BELL BEFORE JOINTING IS BEGUN. ONCE THE GASKET IS IN PLACE, BRING THE GLAND UP TOWARD THE PIPE FLANGE EVENLY, MAINTAINING APPROXIMATELY THE SAME DISTANCE BETWEEN THE GLAND AND THE FACE OF THE FLANGE AT ALL POINTS AROUND THE SOCKET. PARTIALLY TIGHTEN THE BOLTS, ALTERNATELY AROUND THE SOCKET, MAINTAINING APPROXIMATELY EQUAL TENSION UNTIL THE FINAL TENSION IS REACHED.

- C. USE THE FOLLOWING BOLT TORQUE RANGE FOR THE JOINTS:

<u>BOLT SIZE</u>		<u>RANGE OF</u>	
<u>TORQUE INCH</u>	<u>(MILLIMETERS)</u>		<u>FT.</u>
<u>- LB. (JOULES)</u>			
5/8	(16)	40 - 60	(54-81)
3/4	(19)	60 - 90	(81-122)
1	(25)	70 - 100	(95-135)
1-1/4	(32)	90 - 120	(122-163)

- D. APPLY THE TORQUE LOADS WITH TORQUE MEASURING OR INDICATING WRENCHES, OR APPLY USING REGULAR SOCKET WRENCHES, CHECKED WITH TORQUE WRENCHES.
- E. IF THE JOINT IS NOT SEALED USING THE MAXIMUM TORQUE INDICATED ABOVE, DISASSEMBLE AND RE ASSEMBLE THE JOINT AFTER THOROUGH CLEANING. DO NOT OVERSTRESS BOLTS TO PROVIDE THE SEAL.

3. CONNECTIONS TO EXISTING MAINS

- A. MAKE ALL CONNECTIONS TO EXISTING WATER MAINS IN USE UNLESS OTHERWISE SPECIFIED. FURNISH THE SPECIAL FITTINGS, AS SHOWN ON THE PLANS, AND ALL OTHER MATERIAL REQUIRED. MAKE ALL NECESSARY EXCAVATIONS TO ASSURE GRADUAL TRANSITION BETWEEN THE NEW AND EXISTING WATER MAIN, AND PERFORM ALL NECESSARY BACKFILLING.

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- B. WHERE THE CONNECTION OF NEW WORK TO OLD REQUIRES A SERVICE INTERRUPTION AND CUSTOMER NOTIFICATION, THE ENGINEER AND THE CONTRACTOR ARE TO MUTUALLY AGREE UPON A DATE FOR CONNECTIONS TO PERMIT ADEQUATE TIME TO ASSEMBLE LABOR AND MATERIALS, AND TO NOTIFY ALL AFFECTED CUSTOMERS. ALL NOTIFICATIONS ARE THE CONTRACTOR'S RESPONSIBILITY.

3.3 POLYETHYLENE ENCASEMENT

- A. WRAP ALL DIRECT BURY CAST IRON OR DUCTILE IRON PIPE AND FITTINGS INCLUDING HYDRANTS, VALVE BOXES, CURB BOXES, AND ALL OTHER METAL PARTS AND SURFACES, IN POLYETHYLENE ENCASEMENT.

3.4 TESTING, CLEANING & DISINFECTING WATER MAINS, VALVES & FITTINGS:

A. HYDROSTATIC AND LEAKAGE TESTING

1. PERFORM HYDROSTATIC AND LEAKAGE TESTING IN ACCORDANCE WITH AWWA C600. ONCE THE PIPE IS LAID AND BACKFILLED, TEST FOR AT LEAST 2 HOURS, ALL NEWLY LAID PIPE, OR ANY VALVED SECTION, TO A HYDROSTATIC PRESSURE OF AT LEAST 1.5 TIMES THE NORMAL OPERATING PRESSURE AT THE TEST POINT OR 1.25 TIMES THE NORMAL OPERATING PRESSURE AT THE HIGHEST POINT ALONG THE TEST SECTION.
2. SLOWLY FILL THE PIPE WITH WATER, PURGING ALL AIR, AND APPLY THE TEST PRESSURE USING A PUMP HOOKED UP SO THAT THE PRESSURE AND LEAKAGE CAN BE MEASURED. TO PURGE THE PIPE OF AIR DURING THE TEST, IT IS NECESSARY TO TAP THE PIPE AT ITS HIGHEST POINTS IF PERMANENT AIR VENTS, WATER SERVICES, HYDRANTS, ETC. ARE NOT LOCATED AT THE HIGH POINTS. USE CORPORATION STOPS FOR THIS PURPOSE. FURNISH THE PUMP CONNECTIONS, GAUGES, STOPS, AND ALL NECESSARY APPARATUS FOR TESTING.
3. DISASSEMBLE AND REASSEMBLE ALL JOINTS SHOWING LEAKAGE AFTER THOROUGH CLEANING. REMOVE AND REPLACE ALL CRACKED OR DEFECTIVE PIPES OR FITTINGS DISCOVERED IN DURING THE PRESSURE TEST WITH SOUND MATERIAL AND REPEAT THE TEST.
4. CONDUCT THE LEAKAGE TEST CONCURRENTLY WITH THE PRESSURE TEST FOR 2 HOURS. LEAKAGE IS DEFINED AS THE QUANTITY OF WATER SUPPLIED INTO THE PIPE, OR ANY VALVED SECTION THEREOF, NECESSARY TO MAINTAIN PRESSURE WITHIN 5 PSI OF THE PRESSURE TEST AFTER THE PIPE HAS BEEN FILLED WITH WATER AND PURGED OF AIR.
5. THE PIPE INSTALLATION WILL BE REJECTED IF THE LEAKAGE EXCEEDS THAT DETERMINED BY THE FOLLOWING FORMULA:

$$L = \frac{SD(P)^{1/2}}{148,000}$$

6. IN WHICH L EQUALS THE ALLOWABLE LEAKAGE IN GALLONS PER HOUR; S IS THE LENGTH OF PIPE TESTED, IN FEET; D IS THE NOMINAL DIAMETER OF THE PIPE, IN INCHES; AND P IS THE AVERAGE TEST PRESSURE DURING THE LEAKAGE TEST, IN POUNDS PER SQUARE INCH GAUGE.
7. SHOULD ANY TEST OF PIPE LAID DISCLOSE LEAKAGE EXCEEDING THAT SPECIFIED

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ABOVE, LOCATE AND REPAIR THE DEFECTIVE JOINTS UNTIL THE LEAKAGE IS WITHIN THE SPECIFIED ALLOWANCE.

8. CONDUCT THE PRESSURE AND LEAKAGE TESTS WITH THE ENGINEER PRESENT.
9. WHEN TESTING AGAINST CLOSED METAL-SEATED VALVES, AN ADDITIONAL LEAKAGE PER CLOSED VALVE OF 0.0078 GALLON PER HOUR PER INCH OF NOMINAL VALVE SIZE IS ALLOWED. REPAIR ALL VISIBLE LEAKS REGARDLESS OF THE AMOUNT OF LEAKAGE.
10. PRESSURE TEST TAPPING SLEEVES AFTER INSTALLATION AND BEFORE TAPPING.

B. CLEANING WATER MAINS

1. BEFORE CHLORINATION, EXCEPT WHEN HYPOCHLORITE TABLETS ARE USED, FLUSH THE MAINS THOROUGHLY AFTER THE PRESSURE AND LEAKAGE TEST ARE COMPLETED.
2. IT IS UNDERSTOOD THAT SUCH FLUSHING REMOVES ONLY THE LIGHTER SOLIDS AND CANNOT BE RELIED UPON TO REMOVE HEAVY MATERIAL ALLOWED TO GET INTO THE MAIN DURING LAYING. USE A MINIMUM FLUSHING VELOCITY IN THE MAIN OF 2.5 FEET PER SECOND (0.7 METERS/SECOND). IF NO HYDRANT IS INSTALLED AT THE END OF THE MAIN, PROVIDE A TAP OF THE SIZE TO PRODUCE A VELOCITY IN THE MAIN OF AT LEAST 2.5 FEET PER SECOND (0.7 METERS/SECOND). TABLE 2 SHOWS THE RATES OF FLOW REQUIRED TO PRODUCE A VELOCITY OF 2.5 FEET PER SECOND (0.7 METERS/SECOND) IN VARIOUS SIZE PIPES.

TABLE 1
REQUIRED FLOW AND OPENINGS TO FLUSH PIPELINES¹/
(40 PSI (276 KPA) RESIDUAL PRESSURE IN WATER MAIN)

PIPE DIAM. <u>INCHES (CM)</u>	FLOW REQUIRED TO PRODUCE 2.5 FPS (APPROX.) VELOCITY IN MAIN, <u>GPM (EPM)</u>	SIZE OF TAP (INCH)(MM) 1 (25) 1-1/2 (38) 2 (51) NUMBER OF TAPS		<u>HYDRANT OUTLET</u>	
		<u>ON PIPE²/</u>		<u>NUMBER</u>	<u>SIZE IN. (MM)</u>
4 (10)	100 (380)	1		1	2-1/2 (63)
6 (15)	200 (760)		1	1	2-1/2 (63)
8 (20)	400 (1510)	2	1	1	2-1/2 (63)
10 (25)	600 (2270)	3	2	1	2-1/2 (63)
12 (30)	900 (3400)		2	2	2-1/2 (63)
16 (41)	1600 (6060)		4	2	2-1/2 (63)

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1. WITH A 40 PSI (267 KPA) PRESSURE IN THE MAIN WITH THE HYDRANT FLOWING TO ATMOSPHERE, A 2-1/2-INCH (63MM) HYDRANT OUTLET WILL DISCHARGE APPROXIMATELY 1000 GPM(3786 EPM) AND A 4-1/2-INCH (114MM) HYDRANT NOZZLE WILL DISCHARGE APPROXIMATELY 2500 GPM (9463 EPM).
2. NUMBER OF TAPS ON PIPE BASED ON DISCHARGE THROUGH 5 FEET (1.5 METERS) OF GALVANIZED IRON (GI) PIPE WITH ONE 90 • ELBOW.
3. EXERCISE EXTREME CARE AND CONDUCT A THOROUGH INSPECTION DURING THE WATER MAIN LAYING TO PREVENT AND DETECT SMALL STONES, PIECES OF CONCRETE, PARTICLES OF MATERIAL, OR OTHER FOREIGN MATERIAL THAT MAY HAVE ENTERED THE MAINS. TO REMOVE THIS MATERIAL, FLUSH AND INSPECT ALL HYDRANTS ON THE LINES TO ASSURE THAT THE ENTIRE VALVE OPERATING MECHANISM OF EACH HYDRANT IS IN GOOD CONDITION.
4. IN 24-INCH (61 CM) OR LARGER DIAMETER MAINS, IN ADDITION TO FLUSHING, BROOM-SWEEP THE MAIN, REMOVING ALL SWEEPINGS BEFORE CHLORINATING THE MAIN.

C. DISINFECTING WATER MAINS

1. GENERAL

- A. DISINFECT THE WATER MAINS SUBJECT TO THE ENGINEER'S APPROVAL IN ACCORDANCE WITH AWWA C651, "DISINFECTING WATER MAINS", AND THESE SPECIFICATIONS, BEFORE PLACING THE MAIN IN SERVICE. KEEP THE INTERIOR OF ALL PIPE, FITTINGS AND APPURTENANCES FREE FROM DIRT, HEAVY AND FOREIGN PARTICLES.

2. FORMS OF CHLORINE

- A. THE FORMS OF CHLORINE THAT MAY BE USED, SUBJECT TO THE APPROVAL OF THE ENGINEER, ARE:

- 1) LIQUID CHLORINE CONTAINING 100 PERCENT AVAILABLE CHLORINE UNDER PRESSURE IN STEEL CONTAINERS. MEET AWWA B301 REQUIREMENTS AND USE ONLY IN COMBINATION WITH APPROPRIATE GAS-FLOW CHLORINATORS AND EJECTORS.
- 2) SODIUM HYPOCHLORITE IN LIQUID FORM CONTAINING APPROXIMATELY 5 TO 15 PERCENT AVAILABLE CHLORINE. MEET AWWA B300 REQUIREMENTS.
- 3) CALCIUM HYPOCHLORITE IN GRANULAR FORM OR IN 5G TABLETS CONTAINING APPROXIMATELY 65 PERCENT AVAILABLE CHLORINE BY WEIGHT. MEET AWWA B300 REQUIREMENTS.

3. METHODS OF CHLORINATION

- A. THREE (3) METHODS OF CHLORINATION MAY BE USED. THE TABLET METHOD GIVES AN AVERAGE CHLORINE DOSE OF APPROXIMATELY 25 MG./L; THE CONTINUOUS FEED METHOD GIVES A 24 HOUR CHLORINE RESIDUAL OF NOT LESS THAN 10 MG./L; AND THE SLUG METHOD PROVIDES A THREE

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HOUR EXPOSURE OF NOT LESS THAN 50 MG./L FREE CHLORINE.

- 1) TABLET METHOD
 - A) THIS METHOD MAY BE USED IF THE PIPES AND APPURTENANCES ARE KEPT CLEAN AND DRY DURING CONSTRUCTION.
 - B) DURING CONSTRUCTION, PLACE CALCIUM HYPOCHLORITE GRANULES AT THE UPSTREAM END OF THE FIRST SECTION OF PIPE, AT THE UPSTREAM END OF EACH BRANCH MAIN, AND AT 500-FOOT (150 METER) INTERVALS. USE THE QUANTITY OF GRANULES SHOWN IN TABLE 2.
 - C) WARNING: DO NOT USE THIS PROCEDURE ON SOLVENT WELDED PLASTIC OR ON SCREWED JOINT STEEL PIPE BECAUSE OF FIRE OR EXPLOSION HAZARD FROM THE REACTION OF THE JOINT COMPOUNDS WITH THE CALCIUM HYPOCHLORITE.

TABLE 2
OUNCES OF CALCIUM HYPOCHLORITE GRANULES TO BE PLACED AT BEGINNING OF MAIN AND AT EACH 500-FOOT (150 METER) INTERVAL

PIPE DIAMETER		CALCIUM HYPOCHLORITE GRANULES
INCHES	(CM)	OZ
4	(10)	0.5
6	(15)	1.0
8	(20)	2.0
12	(30)	4.0
16 AND LARGER	(41)	8.0

- D) DURING CONSTRUCTION, PLACE 5G CALCIUM HYPOCHLORITE TABLETS IN EACH SECTION OF PIPE AND ALSO PLACE ONE TABLET IN EACH HYDRANT, HYDRANT BRANCH AND OTHER APPURTENANCE. USE THE NUMBER OF 5G TABLETS FOR EACH PIPE SECTION REQUIRED TO PROVIDE A MINIMUM CHLORINE CONCENTRATION OF 25 MG/L. APPENDIX B PROVIDES INFORMATION ON THE NUMBER OF TABLETS REQUIRED FOR COMMONLY USED SIZES OF PIPE. ATTACH TABLETS TO THE INSIDE OF THE PIPE USING AN ADHESIVE SUCH AS PERMATEX NO.1 OR EQUAL. ASSURE NO ADHESIVE IS ON THE TABLET EXCEPT ON THE BROAD SIDE ATTACHED TO THE SURFACE OF THE PIPE. ATTACH ALL THE TABLETS AT THE INSIDE TOP OF THE MAIN, WITH APPROXIMATELY EQUAL NUMBERS OF TABLETS AT EACH END OF A GIVEN PIPE LENGTH. IF THE TABLETS ARE ATTACHED BEFORE THE PIPE SECTION IS PLACED IN THE TRENCH, MARK THEIR POSITION ON THE SECTION SO IT CAN BE READILY DETERMINED THAT THE PIPE IS INSTALLED WITH THE TABLETS AT THE TOP.

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- E) WHEN INSTALLATION HAS BEEN COMPLETED, FILL THE MAIN WITH WATER AT A VELOCITY NOT EXCEEDING 1 FPS(0.3 MPS). TAKE PRECAUTIONS TO ASSURE THAT AIR POCKETS ARE ELIMINATED. LEAVE THIS WATER IN THE PIPE FOR AT LEAST 24 HOURS. IF THE WATER TEMPERATURE IS LESS THAN 41° F (5°C), LEAVE THE WATER IN THE PIPE FOR AT LEAST 48 HOURS. POSITION VALVES SO THAT THE CHLORINE SOLUTION IN THE MAIN BEING TREATED WILL NOT FLOW INTO WATER MAINS IN ACTIVE SERVICE.
- 2) CONTINUOUS FEED METHOD
- A) BEFORE CHLORINATING, FILL THE MAIN WITH WATER TO ELIMINATE AIR POCKETS AND FLUSH AS SPECIFIED ABOVE.
 - B) USE WATER FROM THE EXISTING DISTRIBUTION SYSTEM OR OTHER APPROVED SOURCE OF SUPPLY TO FLOW AT A CONSTANT, MEASURED RATE INTO THE NEWLY LAID WATER MAIN. AT A POINT NOT MORE THAN 10 FEET (3 METERS) DOWNSTREAM FROM THE BEGINNING OF THE NEW MAIN, ASSURE WATER ENTERING THE NEW MAIN RECEIVES CHLORINE FED AT A MINIMUM 25 MG/L FREE CHLORINE. TO ASSURE THAT THIS CONCENTRATION IS PROVIDED, MEASURE THE CHLORINE CONCENTRATION AT REGULAR INTERVALS.
 - C) APPENDIX B PROVIDES INFORMATION ON THE AMOUNTS OF CHLORINE COMPOUND REQUIRED FOR VARIOUS PIPE SIZES.
 - D) DURING CHLORINE APPLICATION, POSITION VALVES SO THAT THE CHLORINE SOLUTION IN THE MAIN BEING TREATED DOES NOT FLOW INTO WATER MAINS IN ACTIVE SERVICE. DO NOT STOP CHLORINE APPLICATION UNTIL THE ENTIRE MAIN IS FILLED WITH CHLORINATED WATER. RETAIN THE CHLORINATED WATER IN THE MAIN FOR AT LEAST 24 HOURS, OPERATING ALL VALVES AND HYDRANTS IN THE SECTION TREATED TO DISINFECT THE APPURTENANCES. AT THE END OF THE 24- HOUR PERIOD, THE TREATED WATER IN ALL PORTIONS OF THE MAIN MUST HAVE A MINIMUM FREE CHLORINE RESIDUAL OF 10 MG/L FREE CHLORINE.
 - E) THE PREFERRED EQUIPMENT FOR APPLYING LIQUID CHLORINE IS A SOLUTION FEED VACUUM OPERATED CHLORINATOR TO MIX THE CHLORINE GAS IN SOLUTION WATER, IN COMBINATION WITH A BOOSTER PUMP FOR INJECTING THE CHLORINE GAS SOLUTION WATER INTO THE MAIN TO BE DISINFECTED. IT IS RECOMMENDED THAT DIRECT FEED CHLORINATORS NOT BE USED. HYPOCHLORITE SOLUTIONS MAY BE APPLIED TO THE WATER MAIN WITH A CHEMICAL FEED PUMP DESIGNED FOR FEEDING CHLORINE SOLUTIONS.
 - F) IF APPROVED, AN OPTIONAL CONTINUOUS FEED METHOD UTILIZING CALCIUM HYPOCHLORITE GRANULES MAY BE USED. PLACE THE GRANULES IN THE PIPE SECTIONS AS SPECIFIED UNDER THE TABLET METHOD.

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3) SLUG METHOD

- A) BEFORE CHLORINATING, PRELIMINARY FLUSH THE MAIN AS SPECIFIED HEREIN.
- B) USE WATER FROM THE EXISTING DISTRIBUTION SYSTEM OR OTHER APPROVED SOURCE OF SUPPLY TO FLOW AT A CONSTANT MEASURED RATE INTO THE NEWLY LAID WATER MAIN.
- C) NOT MORE THAN 10 FEET (3 METERS) DOWNSTREAM FROM THE BEGINNING OF THE NEW MAIN, ADD CHLORINE TO THE WATER ENTERING THE NEW MAIN AT A CONSTANT RATE THAT THE WATER WILL HAVE A MINIMUM 100 MG/L FREE CHLORINE. MEASURE THIS CONCENTRATION AT REGULAR INTERVALS. APPLY THE CHLORINE CONTINUOUSLY AND FOR THE TIME REQUIRED TO DEVELOP A SOLID COLUMN OR "SLUG" OF CHLORINATED WATER THAT WILL, AS IT MOVES THROUGH THE MAIN, EXPOSE ALL INTERIOR SURFACES TO A 100 MG/L FOR AT LEAST 3 HOURS.
- D) MEASURE THE FREE CHLORINE RESIDUAL IN THE SLUG AS IT MOVES THROUGH THE MAIN. IF AT ANY TIME IT DROPS BELOW 50 MG/L STOP THE FLOW AND RELOCATE THE CHLORINATION EQUIPMENT AT THE HEAD OF THE SLUG, AND AS FLOW IS RESUMED, ADD CHLORINE TO RESTORE THE FREE CHLORINE IN THE SLUG TO NOT LESS THAN 100 MG/L.
- E) AS THE CHLORINATED WATER FLOWS PAST FITTINGS AND VALVES, OPERATE RELATED VALVES AND HYDRANTS TO DISINFECT APPURTENANCES AND PIPE BRANCHES.

4. FINAL FLUSHING

- A. AFTER THE RETENTION PERIOD, FLUSH THE CHLORINATED WATER FROM THE MAIN UNTIL CHLORINE MEASUREMENTS SHOW THAT THE CONCENTRATION IN THE WATER LEAVING THE MAIN IS NO HIGHER THAN THAT IN THE SYSTEM, OR IS ACCEPTABLE FOR DOMESTIC USE.

D. BACTERIOLOGICAL TESTS

- 1. AFTER FINAL FLUSHING AND BEFORE THE WATER MAIN IS PLACED IN SERVICE, TEST A SAMPLE, OR SAMPLES, COLLECTED FROM THE MAIN(S) FOR TURBIDITY AND ORGANISMS. COLLECT AT LEAST ONE SAMPLE FROM THE NEW MAIN AND ONE FROM EACH BRANCH.
- 2. REDISINFECTION
 - A. IF THE INITIAL DISINFECTION FAILS TO PRODUCE APPROVED BACTERIOLOGICAL OR TURBIDITY SAMPLES, RE-FLUSH AND RESAMPLE THE MAIN. IF CHECK SAMPLES SHOW BACTERIAL CONTAMINATION, RE-CHLORINATE THE MAIN UNTIL APPROVED RESULTS ARE OBTAINED.

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3. SWABBING

- A. WHERE CONNECTIONS ARE MADE TO EXISTING PIPING AND THE CONNECTIONS ARE NOT DISINFECTED ALONG WITH THE NEWLY INSTALLED MAIN, SWAB OR SPRAY THE INTERIOR OF ALL PIPE AND FITTINGS USED IN MAKING THE CONNECTIONS WITH A 1 PERCENT HYPOCHLORITE SOLUTION BEFORE INSTALLATION.

3.5 WATER AND SEWER MAIN SEPARATION

- A. MAINTAIN HORIZONTAL AND VERTICAL SEPARATION BETWEEN WATER MAINS AND SEWER MAINS IN ACCORDANCE WITH STANDARD DRAWING NO. 02660-2.

3.6 VALVES

- A. SET AND JOINT GATE VALVES AND BUTTERFLY VALVES TO THE PIPE AS SPECIFIED FOR PIPE LAYING AND JOINTING. SET VALVES WITH OPERATING NUT VERTICAL. CENTER AND PLUMB VALVE BOXES OVER THE OPERATING NUT TO PREVENT SHOCK OR STRESS BEING TRANSMITTED TO THE VALVE.
- B. VALVE BOXES
 - 1. CENTER AND PLUMB VALVE BOXES OVER THE VALVE OPERATING NUT. SET VALVE BOX TOPS FLUSH WITH THE GROUND SURFACE OR STREET SURFACING.
 - 2. PLACE BEDDING GRAVEL AROUND ALL WATER MAIN VALVES AND UNDER THE VALVE BOX BOTTOM TO DRAIN ANY WATER ENTERING THE VALVE BOX.
- C. VALVE THRUST BLOCKS
 - 1. WHEN SPECIFIED, INSTALL VALVES WITH THRUST BLOCKS AND ANCHOR RODS MEETING STANDARD DRAWING 02660-3 REQUIREMENTS.

3.7 FIRE HYDRANTS

- A. SET ALL HYDRANTS PLUMB WITH THE PUMPER NOZZLE FACING THE STREET. SET THE HYDRANT WITH THE GROUND LINE AT THE LOCATION INDICATED BY THE HYDRANT MANUFACTURER.
- B. PROVIDE DRAINAGE AT THE HYDRANT BASE BY PLACING CLEAN GRAVEL UNDER AND AROUND IT. PLACE GRAVEL AT LEAST 1 FOOT (30 CM) ON ALL SIDES FROM THE BASE OF THE HYDRANT TO AT LEAST 6 INCHES (15 CM) ABOVE THE DRAIN OPENING. BRACE THE HYDRANT AGAINST UNEXCAVATED EARTH AT THE TRENCH END WITH CONCRETE BACKING AS DETAILED ON THE PLANS. FURNISH HYDRANTS WITH THE SPECIFIED GATE VALVES. INSTALL HYDRANTS MEETING STANDARD DRAWING NO. 02660-4 OR 02660-5 AS SPECIFIED BY THE OWNER.

3.8 SERVICE LINE INSTALLATION

- A. PROVIDE ALL WORK AND MATERIALS FOR THE COMPLETE SERVICE LINE INSTALLATION, INCLUDING TRENCH EXCAVATION AND BACKFILL; MAKING THE WATER MAIN TAP; FURNISHING AND INSTALLING THE CORPORATION STOP, CURB STOP AND BOX, SERVICE CLAMP WHERE NECESSARY, AND SERVICE LINE WITH FITTINGS TO MAKE THE CONNECTIONS TO THE STOPS. BEND THE SERVICE LINE ADJACENT TO THE WATER MAIN INTO A FIGURE "S" IN A HORIZONTAL OR VERTICAL PLANE TO AVOID A RIGID CONNECTION. ASSURE ALL SERVICES HAVE A MINIMUM 6-1/2 FEET (2 METERS) OF COVER MEASURED AS SPECIFIED IN STANDARD

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DRAWING NO.02660-6.

- B. MARK THE WATER SERVICE LINE END AT THE PROPERTY LINE USING A STEEL FENCE POST, 5 FEET LONG (1.5 METERS), BURIED IN 3 FEET (1 METER) IN THE GROUND. PAINT THE POST BLUE. WHERE APPLICABLE, MARK THE CONCRETE CURB TO IDENTIFY THE SERVICE LOCATIONS.

3.9 TAPPING:

- A. TAP THE NEWLY INSTALLED WATER MAINS UNLESS SPECIFIED OTHERWISE. THE OWNER WILL TAP ANY EXISTING WATER MAINS NOT INSTALLED BY THE CONTRACTOR. IF OWNER TAPPED, BE RESPONSIBLE FOR SCHEDULING AND COORDINATING WITH THE OWNER. THE CONTRACTOR WILL BE CHARGED A FEE FOR EACH OWNER MADE TAP.
- B. PERFORM TAPPING USING AN APPROVED TAPPING MACHINE USING CLEAN, SHARP DRILL TAPS AND/OR SHELL CUTTERS. DO NOT TAP DIRECTLY INTO AWWA C900 PVC PIPE. 3/4-INCH (19 MM) AND 1-INCH (25 MM) TAPS MAY BE MADE DIRECTLY INTO THE BARREL OF DUCTILE IRON PIPE WITHOUT USING SERVICE SADDLES. DIRECT TAP INTO THE PIPE BARREL TO THE DEPTH EXPOSING A MAXIMUM THREE THREADS OF THE CORPORATION STOP. USE MAXIMUM DIRECT TAP SIZES OF 1-1/2-INCH (38 MM) FOR 6-INCH (15 CM) DIAMETER MAINS AND 2-INCH (51 MM) FOR LARGER MAINS.

PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. THE FOLLOWING ITEMS ARE PAY ITEMS FOR THE WORK COVERED UNDER THIS SECTION. PAYMENT FOR THESE ITEMS IS FULL COMPENSATION FOR PROVIDING ALL MATERIALS, TOOLS, LABOR AND EQUIPMENT NECESSARY TO COMPLETE THE ITEM AND ALL INCIDENTAL WORK RELATED THERETO, WHETHER SPECIFICALLY MENTIONED HEREIN OR NOT.

4.2 WATER MAINS

- A. MEASUREMENT OF WATER MAINS IS MADE IN LINEAL FEET (METERS) ALONG THE CENTERLINE OF PIPE THROUGH ALL VALVES, FITTINGS AND APPURTENANCES. PAYMENT FOR WATER MAIN WILL BE MADE AT THE CONTRACT UNIT PRICE BID PER LINEAL FOOT (METERS) OF THE VARIOUS SIZES CALLED FOR, WHICH INCLUDES FURNISHING AND INSTALLING PIPE, FURNISHING AND PLACING TYPE 1 PIPE BEDDING, TRENCH EXCAVATION AND BACKFILL, CLEANING, TESTING AND DISINFECTING THE WATER MAIN AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.

4.3 FITTINGS

- A. MEASUREMENT OF WATER MAIN FITTINGS IS BY NUMERICAL COUNT OF THE VARIOUS TYPES AND SIZES LISTED IN THE CONTRACT DOCUMENTS. PAYMENT FOR FITTINGS IS MADE AT THE CONTRACT UNIT PRICE BID FOR EACH FITTING, AND INCLUDES FURNISHING AND INSTALLING THE FITTINGS AS REQUIRED, THRUST BLOCKING AND ANY OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.

4.4 WATER SERVICE CONNECTIONS

- A. THIS ITEM IS MEASURED BY NUMERICAL COUNT OF WATER SERVICES OF THE VARIOUS SIZES LISTED IN THE CONTRACT DOCUMENTS. PAYMENT FOR WATER SERVICE CONNECTIONS IS MADE AT THE CONTRACT UNIT PRICE BID PER EACH, WHICH INCLUDES FURNISHING AND

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INSTALLING THE WATER SERVICE LINE FROM THE MAIN TO THE PROPERTY LINE, TAPPING THE MAIN, FURNISHING AND INSTALLING ALL FITTINGS, CORPORATION STOPS, CURB STOPS AND BOXES AND TAPPING SADDLES IF REQUIRED, TRENCH EXCAVATION, BACKFILL, PIPE BEDDING, SHORING, AND DEWATERING, CLEANUP AND ALL OTHER WORK NECESSARY OR INCIDENTAL TO COMPLETE THE ITEM.

4.5 WATER SERVICE LINE

- A. PAYMENT FOR WATER SERVICE LINE IS MADE AT THE CONTRACT UNIT PRICE BID PER EACH, WHICH INCLUDES FURNISHING AND INSTALLING THE WATER SERVICE LINE FROM THE MAIN TO THE PROPERTY LINE, TRENCH EXCAVATION, BACKFILL, PIPE BEDDING, SHORING, AND DEWATERING, CLEANUP AND ALL OTHER WORK NECESSARY OR INCIDENTAL TO COMPLETE THE ITEM. NO SEPARATE MEASUREMENT AND PAYMENT IS MADE FOR TRENCH EXCAVATION AND BACKFILL FOR WATER SERVICE LINES. INCLUDE THE COST OF THIS WORK IN THE PRICE BID FOR SERVICE LINES.

4.6 VALVES

- A. MEASUREMENT OF WATER VALVES IS MADE BY NUMERICAL COUNT OF THE SIZES AND TYPES OF VALVES LISTED IN THE CONTRACT DOCUMENTS. PAYMENT FOR WATER VALVES IS MADE AT THE CONTRACT UNIT PRICE BID EACH; WHICH INCLUDES FURNISHING AND INSTALLING THE VALVE AND VALVE BOX, ALL EXCAVATION, BACKFILL, AND SPECIAL COMPACTION REQUIRED FOR THE INSTALLATION, THRUST AND ANCHOR BLOCKING (IF REQUIRED), AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.

4.7 FIRE HYDRANTS

- A. MEASUREMENT OF FIRE HYDRANT ASSEMBLIES IS BY NUMERICAL COUNT. PAYMENT IS MADE AT THE CONTRACT UNIT PRICE BID EACH; WHICH INCLUDES FURNISHING AND INSTALLING THE FIRE HYDRANT AND AUXILIARY GATE VALVE, PIPING FROM MAIN WATERLINE TO HYDRANT, ALL EXCAVATION, BACKFILL, AND SPECIAL COMPACTION REQUIRED FOR THE INSTALLATION, THRUST AND ANCHOR BLOCKING, DRAIN GRAVEL, AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.

END OF SECTION 02660

SECTION 02720 - STORM DRAIN SYSTEMS

PART 1: GENERAL

1.1 DESCRIPTION

- A. FURNISH AND INSTALL ALL STORM DRAINS, INCLUDING MANHOLES, INLETS, SERVICE LINES AND OTHER APPURTENANT STRUCTURES AS SPECIFIED IN THE CONTRACT AND THIS SECTION. PIPE STRENGTH CLASSIFICATIONS ARE SPECIFIED ON THE PLANS, LISTED IN THE CONTRACT DOCUMENTS OR HEREIN.

1.2 CERTIFICATION BY MANUFACTURER

- A. FURNISH A MANUFACTURER'S CERTIFICATION ON ALL PIPE, CERTIFYING THAT THE PIPE AND FITTINGS MEET THE CONTRACT REQUIREMENTS.

1.3 REFERENCES

AASHTO M36	CORRUGATED GALVANIZED STEEL PIPE AND PIPE ARCHES
AASHTO M196	CORRUGATED ALUMINUM PIPE AND PIPE ARCHES
AASHTO M245	PRE-COATED GALVANIZED, CORRUGATED STEEL PIPE AND PIPE ARCHES
AASHTO M274	TYPE II ALUMINIZED CORRUGATED STEEL PIPE AND PIPE ARCHES
AASHTO M294	CORRUGATED POLYETHYLENE PIPE (HDPE)
ASTM C76	REINFORCED CONCRETE PIPE
ASTM D361	LOW HEAD PRESSURE RCP
ASTM C443	O-RING RUBBER GASKETS
ASTM C478	PRECAST REINFORCED CONCRETE MANHOLE SECTIONS
ASTM C506	RCP - ARCH PIPE
ASTM C507	RCP - ELLIPTICAL PIPE
ASTM C655	RCP - TONGUE & GROOVE PIPE
ASTM C665	RCP - D-LOAD PIPE
ASTM C789	RCP - CONCRETE BOX SECTION
ASTM C850	RCP - CONCRETE BOX SECTIONS
ASTM D1784	RIGID POLYVINYL CHLORIDE COMPOUNDS
ASTM D3034	POLYVINYL CHLORIDE SEWER PIPE AND FITTINGS
ASTM 3350	HIGH DENSITY POLYETHYLENE PIPE
AWWA C151	BITUMINOUS COATED DUCTILE IRON PIPE
ASTM F949	PVC OPEN PROFILE PIPE

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1.4 STANDARD DRAWINGS

A. STANDARD DRAWINGS IN APPENDIX A APPLICABLE TO THIS SECTION ARE AS FOLLOWS:

STANDARD DRAWING NO. 02720-1	30" (76 CM) STANDARD STORM DRAIN INLET
STANDARD DRAWING NO. 02720-2	24" (61 CM) STANDARD RISER INLET STANDARD
DRAWING NO. 02720-3	SANITARY SEWER AND STORM DRAIN
MANHOLE STANDARD DRAWING NO. 02720-4	STANDARD STRAIGHT MANHOLE
STANDARD DRAWING NO. 02720-5	48" (122 CM) STANDARD MANHOLES SHOWING
	TWO TYPES OF CONE SECTIONS
STANDARD DRAWING NO. 02720-6	PRE-CAST MANHOLE BASES
STANDARD DRAWING NO. 02720-7	TYPICAL MANHOLE CHANNEL DETAILS
STANDARD DRAWING NO. 02720-8	STANDARD CAST IRON COVER
STANDARD DRAWING NO. 02720-9	STANDARD 24" (61 CM) CAST IRON RING
	MANHOLE FRAME
STANDARD DRAWING NO. 02720-10	STORM DRAIN SERVICE LINE

PART 2: PRODUCTS

2.1 GENERAL

- A. FURNISH ALL STORM DRAIN PIPING AS SPECIFIED IN THE CONTRACT DOCUMENTS AND MEETING THE MATERIALS AND TESTING REQUIREMENTS OF THIS SECTION. FURNISH WYE AND TEE BRANCHES OF THE SAME MATERIAL AND DESIGN AS THE SPECIFIED STORM DRAIN PIPE. FURNISH THE PIPE SIZES AND STRENGTH CLASSIFICATIONS SHOWN IN THE CONTRACT DOCUMENTS.
- B. REFERENCES TO ASTM, ANSI OR AASHTO DESIGNATION, MEANS THE LATEST REVISION AT THE TIME OF CALL FOR BIDS.
- C. ASSURE ALL PIPE IS CLEARLY MARKED WITH TYPE, CLASS AND/OR THICKNESS AS APPLICABLE. ASSURE LETTERING IS LEGIBLE AND PERMANENT UNDER NORMAL HANDLING AND STORAGE CONDITIONS.
- D. FURNISH THE JOINT TYPE, CLASS, THICKNESS DESIGNATION, CASTING, LINING, MARKING, TESTING, ETC. AS SPECIFIED.

2.2 PIPE MATERIALS

A. CONCRETE PIPE

- 1. FURNISH CONCRETE STORM DRAIN AND CULVERT PIPE MEETING ASTM C76 OR C655. USE ROUND REINFORCED PIPE HAVING O-RING RUBBER GASKET JOINTS MEETING ASTM C443 WITH THE O-RING GASKET CONFINED IN THE PIPE TONGUE GROOVE.

B. POLYVINYL CHLORIDE (PVC) PIPE

- 1. FURNISH PVC PIPE PRODUCED BY A CONTINUOUS EXTRUSION PROCESS EMPLOYING A PRIME GRADE OF UNPLASTICIZED POLYVINYL CHLORIDE. ASSURE THE GRADE USED IS HIGHLY RESISTANT TO HYDROGEN SULFIDE, SULFURIC ACID, GASOLINE, OIL, DETERGENTS AND OTHER CHEMICALS FOUND IN SEWAGE AND INDUSTRIAL WASTES. ASSURE THE MATERIAL MEETS "RIGID POLYVINYL CHLORIDE COMPOUNDS", ASTM D1784 REQUIREMENTS. ASSURE THE PIPE HAS SELF-EXTINGUISHING FLAMMABILITY CHARACTERISTICS. ASSURE THE PIPE MEETS ASTM D3034, "STANDARD SPECIFICATIONS FOR POLYVINYL CHLORIDE SEWER PIPE AND FITTINGS", WITH AN SDR OF 35 4"-15" (10 CM

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- 38 CM) ASTM F679, "STANDARD SPECIFICATION FOR PVC LARGE DIAMETER PLASTIC GRAVITY SEWER PIPE AND FITTINGS: 18" – 36" (46 CM – 91 CM), OR ASTM F949, "STANDARD SPECIFICATION FOR PVC CORRUGATED (OPEN PROFILE) SEWER PIPE WITH A SMOOTH INTERIOR AND FITTINGS", 12" – 36" (10 CM – 91 CM).

2. THE NOMINAL LAYING LENGTH IS A MINIMUM 12.5 FEET (3.8 METERS), 13 FEET (4 METERS) OR 20 FEET (6.1 METERS) EXCEPT SHORTER LENGTHS ARE PERMITTED ADJACENT TO MANHOLES, LAMPHOLES OR OTHER APPURTENANCES. ASSURE EACH PIPE LENGTH IS MARKED WITH SIZE, SDR, "SEWER PIPE" AND CODE NUMBER. ASSURE EACH PIPE LENGTH HAS A BELL PROVIDING A WATERTIGHT JOINT WHEN JOINTING THE BELL AND SPIGOT WITH A RUBBER RING. MAKE THE RUBBER GASKET JOINT USING A RUBBER GASKET COMPRESSED BETWEEN THE OUTER SURFACE OF THE SPIGOT AND THE INNER SURFACE OF THE BELL. ASSURE THE JOINT IS COMPLETELY SEALED BY THE GASKET PROVIDING A WATERTIGHT JOINT UNDER ALL SERVICE CONDITIONS, INCLUDING EXPANSION, CONTRACTION, SETTLEMENT AND PIPE DEFORMATION. ASSEMBLE THE RUBBER RING JOINT ASSEMBLY FOLLOWING THE MANUFACTURER'S RECOMMENDATIONS.
 3. FURNISH WYE OR TEE FITTINGS OF THE SAME MATERIAL, CONSTRUCTION AND JOINT DESIGN AS THE MAIN SEWER PIPE.
- C. AN OWNER MAY ALLOW 'ULTRA FLO' OR APPROVED EQUIVALENT STEEL PIPE. CONNECTIONS MUST BE MADE WITH MINIMUM COUPLING BAND WIDTH OF 10-1/2" AND APPROPRIATE GASKETING MATERIAL. WHEN SPECIFIED BY THE ENGINEER, MATERIALS SHALL MEET THE FOLLOWING STANDARDS:
- | | |
|-------------------------|--|
| ASTM A760 (AASHTO M36) | SPECIFICATIONS FOR CORRUGATED STEEL PIPE, METALLIC-COATED FOR SEWERS AND DRAINS |
| ASTM A762 (AASHTO M245) | SPECIFICATIONS FOR CORRUGATED STEEL PIPE, POLYMER PRE-COATED FOR SEWERS AND DRAINS |
| ASTM A742 (AASHTO M246) | SPECIFICATIONS FOR STEEL SHEET, COATED AND POLYMER METALLIC CORRUGATED STEEL PIPE C PRE-COATED FOR |
| ASTM A929 (AASHTO M274) | SPECIFICATIONS FOR STEEL SHEET METALLIC COATED BY THE HOT DIP PROCESS FOR CORRUGATED STEEL PIPE. |

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D. OTHER PIPE MATERIAL

1. AN OWNER MAY SELECT OTHER MATERIALS AS APPROPRIATE FOR APPLICATIONS WHERE AN ENGINEER HAS REVIEWED THE CIRCUMSTANCES AND PROVIDED SPECIFICATIONS FOR INSTALLATION. WHEN SPECIFIED BY AND ENGINEER, MATERIALS SHALL MEET THE FOLLOWING STANDARDS:

ASTM C 76	REINFORCED CONCRETE PIPE – TONGUE & GROVE JOINT
ASTM C 506	REINFORCED CONCRETE PIPE – ARCH PIPE
ASTM C 507	REINFORCED CONCRETE PIPE – ELLIPTICAL PIPE
ASTM C 665	REINFORCED CONCRETE PIPE – D-LOAD PIPE ASTM
C 789	PRECAST REINFORCED CONCRETE BOX SECTIONS
ASTM C 850	PRECAST REINFORCED CONCRETE BOX SECTIONS
ASTM 3350	HIGH DENSITY POLYETHYLENE PIPE (HDPE)
AASHTO M 36	CORRUGATED GALVANIZED STEEL PIPE AND PIPE ARCHES
AASHTO M 196	CORRUGATED ALUMINUM PIPE AND PIPE ARCHES AASHTO M
245	PRE-COATED GALVANIZED, CORRUGATED STEEL PIPE AND
	PIPE ARCHES
AASHTO M 274	TYPE II ALUMINIZED CORRUGATED STEEL PIPE AND PIPE
	ARCHES
AASHTO M 294	CORRUGATED POLYETHYLENE PIPE (HDPE)

E. MANHOLES

A. GENERAL

1. FURNISH MANHOLES CONSTRUCTED OF PRECAST CONCRETE SECTIONS WITH FRAMES, COVERS AND STEPS MEETING STANDARD DRAWING DETAILS.

B. PRECAST CONCRETE SECTIONS

1. FURNISH MANHOLES MEETING ASTM C478: "PRECAST REINFORCED CONCRETE MANHOLE SECTIONS".

C. STEPS

1. FURNISH NON-CORROSIVE TYPE, 12 INCHES (30 CM) IN WIDTH, OF 1/2-INCH (13 MM) STEEL ROD ENCASED WITH POLYPROPYLENE. ASSURE STEPS WITHSTAND 400 POUND (180 KG) VERTICAL LOADS AND 1,000 POUND (450 KG) PULL-OUT RESISTANCE.

D. FRAMES AND COVERS

1. FURNISH FRAMES AND COVERS MEETING STANDARD DRAWINGS 02720-8 AND 02720-9. FURNISH 2 HOLE TYPE COVERS UNLESS NOTED OR SPECIFIED OTHERWISE.

E. CONCRETE BASES

1. CONCRETE BASES MAY BE PRECAST OR FIELD-POURED ON UNDISTURBED EARTH. USE CONCRETE MEETING SECTION 03310: STRUCTURAL CONCRETE.

F. INLETS AND CATCH BASINS

- A. FURNISH STANDARD CAST IRON INLET FRAMES AND GRATES MEETING STANDARD DRAWING REQUIREMENTS OR AS SPECIFIED.

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PART 3: EXECUTION

3.1 PIPE AND SERVICE LINE INSTALLATION

A. EXCAVATION AND BACKFILL

1. EXCAVATE AND BACKFILL PIPELINES MEETING THE APPLICABLE PORTIONS OF SECTION 02221: TRENCH EXCAVATION AND BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES.

B. RESPONSIBILITY FOR MATERIALS

1. BE RESPONSIBLE FOR ALL MATERIAL FURNISHED. REPLACE ALL MATERIAL FOUND DEFECTIVE IN MANUFACTURE OR DAMAGED IN HANDLING AFTER DELIVERY BY THE MANUFACTURER. THIS INCLUDES FURNISHING ALL MATERIAL AND LABOR REQUIRED FOR THE REPLACEMENT OF INSTALLED MATERIAL DISCOVERED DEFECTIVE BEFORE FINAL ACCEPTANCE OF THE WORK OR DURING THE GUARANTEE PERIOD.
2. BE RESPONSIBLE FOR THE SAFE STORAGE OF MATERIAL FOR THE WORK UNTIL IT HAS BEEN INCORPORATED IN THE COMPLETED PROJECT.

C. HANDLING OF PIPE

1. DELIVER AND DISTRIBUTE ALL CONTRACTOR FURNISHED PIPE. LOAD AND UNLOAD PIPE, FITTINGS AND ACCESSORIES BY LIFTING WITH HOISTS OR SKIDDING SO AS TO AVOID SHOCK OR DAMAGE. DO NOT DROP THE MATERIALS. DO NOT SKID OR ROLL PIPE HANDLED ON SKIDWAYS AGAINST PIPE ALREADY ON THE GROUND.
2. IN DISTRIBUTING THE MATERIAL AT THE WORK SITE, UNLOAD EACH PIECE OPPOSITE OR NEAR THE PLACE WHERE IT IS TO BE LAID IN THE TRENCH. KEEP THE PIPE INTERIOR AND OTHER ACCESSORIES FREE FROM DIRT AND FOREIGN MATTER AT ALL TIMES.
3. HANDLE PIPE TO PREVENT COATING OR LINING DAMAGE. REPAIR OR REPLACE ALL COATING OR LINING DAMAGE IN A MANNER SATISFACTORY TO THE ENGINEER.

D. LAYING PIPE

1. LAY AND MAINTAIN ALL PIPE TO THE SPECIFIED LINES AND GRADES WITH FITTINGS, TEES AND MANHOLES AT THE SPECIFIED LOCATIONS.
2. INSTALL WYE OR TEE FITTINGS IN THE MAINLINE SEWER FOR SERVICE LINE CONNECTIONS. FURNISH WYE OR TEE FITTINGS OF THE SAME MATERIAL, DESIGN AND SPECIFICATIONS AS THE SEWER MAIN PIPE. JOINT SERVICE PIPE TO TEE BRANCHES OR MAIN LINE PIPE OTHER THAN PVC USING SPECIAL JOINT ADAPTERS MANUFACTURED SPECIFICALLY FOR JOINTING THE TWO TYPES OF PIPE.
3. USE TOOLS AND EQUIPMENT MEETING ENGINEER APPROVAL FOR THE SAFE AND CONVENIENT PROSECUTION OF THE WORK. CAREFULLY LOWER ALL PIPE AND FITTINGS INTO THE TRENCH PREVENTING DAMAGE TO PIPE MATERIALS AND PROTECTIVE COATINGS AND LININGS. DO NOT DUMP OR DROP MATERIALS INTO THE TRENCH.
4. EXERCISE CARE TO PREVENT FOREIGN MATERIAL FROM ENTERING THE PIPE AS IT IS INSTALLED. WHEN PIPE LAYING IS NOT IN PROGRESS, CLOSE THE OPEN ENDS OF PIPE USING A PLUG OR OTHER MEANS APPROVED BY THE ENGINEER. REMOVE AND CLEAN

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ALL SAND, GRAVEL, CONCRETE AND CEMENT GROUT THAT HAS ENTERED THE LINES DURING CONSTRUCTION.

E. TOLERANCES

1. INSTALL PIPE WITHIN 1/2-INCH (13 MM) OF THE SPECIFIED ALIGNMENT AND WITHIN 1/4-INCH (6 MM) OF THE SPECIFIED GRADE FOR PIPE 15-INCH (38 CM) IN DIAMETER AND SMALLER AND 1/2-INCH (13 MM) OF SPECIFIED GRADE FOR PIPE LARGER THAN 15-INCH (38 CM) DIAMETER. THESE TOLERANCES APPLY TO ANY POINT ALONG THE ENTIRE PIPE LENGTH.

3.2 MANHOLES

A. CONSTRUCTION

1. CONSTRUCT MANHOLES TO THE SPECIFIED DIMENSIONS. ASSURE INVERT CHANNELS ARE SMOOTH AND SEMI-CIRCULAR IN SHAPE CONFORMING TO THE INSIDE OF THE ADJACENT PIPE SECTION. MAKE FLOW DIRECTION CHANGES WITH A SMOOTH CURVE OF AS LARGE A RADIUS AS THE SIZE OF THE MANHOLE WILL PERMIT. MAKE CHANGES IN CHANNEL SIZE AND GRADE GRADUALLY AND EVENLY. FORM THE INVERT CHANNELS DIRECTLY IN THE MANHOLE BASE CONCRETE OR BY LAYING A HALF-PIPE IN THE CONCRETE. SMOOTH AND SLOPE THE MANHOLE FLOOR OUTSIDE THE CHANNEL TOWARD THE CHANNEL AT ONE INCH PER FOOT (8 CM PER METER).
2. JOINT ALL CONNECTIONS BETWEEN MANHOLE WALLS AND BASE AND BETWEEN WALL SECTIONS MAKING THE MANHOLE WATERTIGHT.
3. INSTALL ADJUSTING RINGS ON EACH MANHOLE TO ADJUST THE MANHOLE TOP ELEVATION TO THE EXISTING OR SPECIFIED GROUND ELEVATIONS, WITH THE TOTAL RING HEIGHT OF 2-INCH (5 CM) MINIMUM AND 12-INCH (30 CM) MAXIMUM. ASSURE ADJUSTING RINGS ARE REINFORCED WITH THE SAME PERCENTAGE OF STEEL AS THE RISER AND TOP.

3.3 INLETS AND CATCH BASING

- A. CONSTRUCT INLETS AND CATCH BASINS MEETING THE STANDARD DRAWING FOR THE TYPE SPECIFIED.
- B. CONSTRUCT INLET STRUCTURES TO THE LINE, CROSS-SECTION AND DIMENSIONS SPECIFIED. FURNISH CONCRETE AND REINFORCING STEEL MEETING SECTION 03310: STRUCTURAL CONCRETE AND SECTION 03210: REINFORCING STEEL. INLET STRUCTURES MAY BE PRECAST OR CAST-IN-PLACE.

3.4 STORM DRAIN SERVICE LINES

- A. CONSTRUCT SERVICE LINES MEETING STANDARD DRAWING 02720-10. INSTALL THE SERVICE LINE TO THE PROPERTY LINE. PLUG THE END OF THE SERVICE LINE WITH A STOPPER AND GASKET, USING A GASKET OF THE SAME TYPE USED FOR PIPE JOINTING. DO NOT GROUT THE PLUGS.
- B. MARK THE SANITARY SEWER AND STORM DRAIN SERVICE LINE ENDS AT THE PROPERTY LINE USING A STEEL FENCE POST 5 FEET (1.5 M) LONG, BURIED AT LEAST 2 FEET (0.6 M). PLACE A 2" X 2" (5CM X 5 CM) WOOD MARKER EXTENDING FROM THE PIPE INVERT TO GROUND LINE. WIRE THE 2" X 2" (5CM X 5 CM) MARKER TO THE STEEL FENCE POST. WHERE APPLICABLE, MARK THE CONCRETE CURB TO IDENTIFY THE SERVICE LOCATIONS. PAINT SANITARY SEWER SERVICE MARKERS GREEN AND STORM DRAIN SERVICE MARKERS GRAY.

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3.5 TESTS

A. LIGHT TEST (VISUAL)

1. ONCE THE TRENCH IS BACKFILLED, PERFORM A LIGHT TEST BETWEEN MANHOLES TO CHECK ALIGNMENT AND GRADE FOR PIPE DISPLACEMENT. EXCEPT FOR SPECIFIED CURVED ALIGNMENTS, THE COMPLETED PIPELINE MUST PERMIT A TRUE CIRCLE OF LIGHT TO BE SEEN FROM MANHOLE TO MANHOLE.
2. IF ALIGNMENT OR GRADE DOES NOT MEET SPECIFICATIONS, CORRECT ALIGNMENT OR GRADE AT CONTRACTOR EXPENSE.

B. LEAKAGE TEST

1. UNLESS SPECIFIED, A LEAKAGE TEST WILL NOT BE REQUIRED. OBVIOUS AND CONCENTRATED LEAKS, SUCH AS OPEN JOINTS, PINCHED GASKETS, CRACKED BARRELS OR BELLS, ARE NOT ALLOWED.

C. DEFLECTION TEST

1. THE ENGINEER MAY REQUIRE DEFLECTION TESTING OF ALL FLEXIBLE PIPE INSTALLATIONS TO ASSURE THE CONSTRUCTION QUALITY.
2. CONDUCT DEFLECTION TESTS MEETING ASTM D3034 AND SATISFY EITHER OF THE FOLLOWING DEFLECTION LIMITATIONS:

**TABLE 3.1 DEFLECTION TESTING
LIMITATIONS**

MINIMUM PERIOD BETWEEN TRENCH BACKFILLING & TESTING	MINIMUM MANDREL DIAMETER AS A PERCENT OF INSIDE PIPE DIAMETER
7 DAYS	95.0
30 DAYS	92.5

3. MANDRELS MUST HAVE AT LEAST NINE ARMS. PERFORM THE MANDREL TEST WITHOUT MECHANICAL PULLING DEVICES.

PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. THE FOLLOWING ARE PAY ITEMS FOR THE WORK COVERED UNDER THIS SECTION. PAYMENT FOR THESE ITEMS IS FULL COMPENSATION FOR PROVIDING ALL MATERIALS, TOOLS, LABOR AND EQUIPMENT NECESSARY TO COMPLETE THE ITEM AND ALL INCIDENTAL WORK RELATED THERETO, WHETHER SPECIFICALLY MENTIONED HEREIN OR NOT.

4.2 STORM DRAINS

- A. MEASUREMENT OF STORM DRAIN PIPE IS IN LINEAL FEET (METERS) OF THE VARIOUS SIZES AND CLASSES ALONG THE CENTERLINE OF PIPE FROM CENTER TO CENTER OF MANHOLES, OR CENTER OF INLET TO CENTER OF MANHOLE. PAYMENT FOR STORM DRAIN PIPE IS MADE AT THE CONTRACT UNIT PRICE BID PER LINEAL FOOT (METERS) OF THE VARIOUS SIZES AND CLASSES CALLED FOR, WHICH INCLUDES FURNISHING AND INSTALLING PIPE, TRENCH EXCAVATION AND BACKFILL, FURNISHING AND PLACING TYPE 1 PIPE BEDDING, SPECIALS

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REQUIRED FOR CONNECTION TO MANHOLES AND INLETS, TESTING AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.

4.3 MANHOLES

- A. MEASUREMENT OF EACH MANHOLE FOR PAYMENT IS MADE IN TWO PARTS: (1) FOR A BASIC MANHOLE, AND (2) FOR ANY ADDITIONAL VERTICAL HEIGHT OVER AND ABOVE THE BASIC DEPTH. A BASIC MANHOLE IS DEFINED AS 5 FEET (1.5 M) DEEP FROM THE LOWEST INVERT TO THE TOP OF THE MANHOLE FRAME AND COVER. ANY MANHOLE LESS THAN 5 FEET (1.5 M) DEEP IS CONSIDERED AS ONE BASIC MANHOLE. ANY MANHOLE OVER 5 FEET (1.5 M) DEEP IS CONSIDERED AS ONE BASIC MANHOLE PLUS A VERTICAL HEIGHT MEASUREMENT TO THE NEAREST 0.1 FOOT (0.03 M). BASIC MANHOLES ARE MEASURED BY NUMERICAL COUNT AND THE ADDITIONAL VERTICAL FEET (METERS) OF MANHOLE. THE MEASUREMENT OF THE ADDITIONAL VERTICAL HEIGHT OF MANHOLE IS THE VERTICAL HEIGHT OF THE MANHOLE FROM THE LOWEST INVERT TO THE TOP OF THE CAST IRON FRAME MINUS 5 FEET (1.5 M).
- B. PAYMENT FOR FURNISHING AND INSTALLING A BASIC MANHOLE COMPLETE, IS MADE AT THE CONTRACT UNIT PRICE BID PER EACH FOR "BASIC MANHOLES", 5.0 FEET DEEP (1.5 METERS). PAYMENT INCLUDES BASE, MANHOLE SECTIONS, STEPS, CAST IRON RING AND COVER, JOINT SEALER AND ALL OTHER INCIDENTALS REQUIRED TO COMPLETE THE ITEM.
- C. PAYMENT FOR FURNISHING AND INSTALLING MANHOLES DEEPER THAN THE BASIC MANHOLE DEPTH IS MADE AT THE CONTRACT UNIT PRICE BID PER VERTICAL FOOT (METERS) FOR "ADDITIONAL MANHOLE DEPTH" AND INCLUDES MANHOLE SECTIONS, STEPS, JOINT SEALER AND ALL OTHER INCIDENTALS TO COMPLETE THE ITEM.
 - 1. PAYMENT IS MADE UNDER:
 - A. BASIC MANHOLE, 5'0" (1.5 M) DEPTH - PER EACH
 - B. ADDITIONAL MANHOLE DEPTH - PER VERTICAL FOOT (METER)

4.4 STORM DRAIN INLETS

- A. STORM DRAIN INLETS SHALL BE MEASURED AND PAID FOR BY THE NUMBER OF DRAIN INLETS INSTALLED, COMPLETE IN PLACE, AT THE CONTRACT UNIT PRICE BID FOR THE VARIOUS TYPES OF INLETS LISTED IN THE CONTRACT DOCUMENTS, WHICH PRICE AND PAYMENT SHALL CONSTITUTE FULL COMPENSATION FOR ALL EXCAVATION AND BACKFILL, FURNISHING AND INSTALLING ALL MATERIALS REQUIRED (INCLUDING GRATES), COMPACTION, LABOR, TOOLS AND INCIDENTALS NECESSARY TO COMPLETE THE ITEM.

4.1 STORM DRAIN SERVICE LINES

- A. MEASUREMENT IS MADE ALONG THE PIPE FROM THE TEE OR WYE OF THE MAIN SEWER THROUGH TEES, WYES AND OTHER FITTINGS TO THE STREET MARGIN OR RIGHT-OF-WAY MARGIN. MEASUREMENT IS TO THE NEAREST FOOT (0.3M).
 - 1. PAYMENT FOR SERVICES IS BASED ON THE FOLLOWING BID ITEMS AS SPECIFIED IN THE CONTRACT:
 - A. TRENCH EXCAVATION AND BACKFILL IS INCLUDED IN THE LINEAR FOOT PRICE BID FOR SEWER SERVICE PIPE.
 - B. (SIZE) (CLASS) SEWER SERVICE PIPE IN PLACE," PER LINEAR FOOT.

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4.2 GENERAL

- A. THE CONTRACT BID PRICES ARE FULL PAYMENT FOR ALL LABOR, MATERIALS, TOOLS AND OTHER INCIDENTALS AS MAYBE REQUIRED TO COMPLETE THE ITEMS OF WORK IN THE CONTRACT.

END OF SECTION 02720

**SECTION 02730 - SANITARY SEWER COLLECTION
SYSTEMS**

PART I: GENERAL

1.1 DESCRIPTION

- A. FURNISH AND INSTALL SEWER PIPE AND FITTINGS INCLUDING MANHOLES, SERVICE LINES AND OTHER APPURTENANT STRUCTURES AS SPECIFIED IN THE CONTRACT AND THIS SECTION. PIPE STRENGTH CLASSIFICATIONS ARE SHOWN ON THE PLANS, LISTED IN THE CONTRACT DOCUMENTS OR SPECIFIED HEREIN.

1.2 CERTIFICATION BY MANUFACTURER

- A. FURNISH A MANUFACTURER'S CERTIFICATION FOR ALL PIPE AND FITTINGS, CERTIFYING THAT THE PIPE AND FITTINGS MEET THE CONTRACT REQUIREMENTS.

1.3 REFERENCES

ASTM C76	REINFORCED CONCRETE PIPE
ASTM C361	LOW HEAD PRESSURE RCP
ASTM C443	O-RING RUBBER GASKETS
ASTM C478	PRECAST REINFORCED CONCRETE MANHOLE SECTIONS
ASTM C655	D-LOAD RCP
ASTM D1784	RIGID POLYVINYL CHLORIDE COMPOUNDS
ASTM D2241	PVC PRESSURE PIPE
ASTM D3034	POLYVINYL CHLORIDE SEWER PIPE AND FITTINGS
ASTM F679	LARGE DIAMETER PVC PIPE
ASTM F714	HDPE PIPE-DIMENSIONS
ASTM 3350	HIGH DENSITY POLYETHYLENE PIPE
ASTM F949	PVC OPEN PROFILE PIPE

1.4 STANDARD DRAWINGS

- A. STANDARD DRAWINGS IN APPENDIX A APPLICABLE TO THIS SECTION ARE AS FOLLOWS:

STANDARD DRAWING NO. 02660-2	WATER AND SEWER MAIN SEPARATION
STANDARD DRAWING NO. 02720-3	SANITARY SEWER AND STORM DRAIN
MANHOLE STANDARD DRAWING NO. 02720-4	STANDARD STRAIGHT MANHOLE
STANDARD DRAWING NO. 02720-5	48" (122 CM) STANDARD MANHOLE SHOWING TWO TYPES OF CONE
SECTIONS STANDARD DRAWING NO. 02720-6	PRECAST MANHOLE BASES
STANDARD DRAWING NO. 02720-7	TYPICAL MANHOLE CHANNEL DETAILS
STANDARD DRAWING NO. 02720-8	STANDARD CAST IRON COVER
STANDARD DRAWING NO. 02720-9	STANDARD 24" (61 CM) CAST IRON RING MANHOLE FRAME
STANDARD DRAWING NO. 02730-1	NOMOGRAPH FOR AIR TESTING GRAVITY SEWER MAINS
STANDARD DRAWING NO. 02730-2	SANITARY SEWER SERVICE LINE
STANDARD DRAWING NO. 02730-3	DEEP SANITARY SEWER SERVICE LINE

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SANITARY SEWER COLLECTION SYSTEM

PART 2: PRODUCTS

2.1 GENERAL

- A. FURNISH SEWER PIPE AND FITTINGS AS SPECIFIED IN THE CONTRACT DOCUMENTS AND MEETING THE MATERIALS AND TESTING REQUIREMENTS OF THIS SECTION. FURNISH WYE OR TEE BRANCHES AND SERVICE LINE PIPING OF THE SAME MATERIAL AND DESIGN AS THE SEWER PIPE UNLESS SPECIFIED OTHERWISE. PIPE STRENGTH CLASSIFICATIONS ARE SHOWN ON THE PLANS AND/OR ARE LISTED IN THE CONTRACT DOCUMENTS.
- B. REFERENCES MADE TO ASTM, ANSI OR AASHTO DESIGNATION ARE THE LATEST REVISION AT THE TIME OF CALL FOR BIDS.
- C. ASSURE ALL PIPE IS CLEARLY MARKED WITH TYPE, CLASS AND/OR THICKNESS AS APPLICABLE. ASSURE LETTERING IS LEGIBLE AND PERMANENT UNDER NORMAL CONDITIONS OF HANDLING AND STORAGE.
- D. FURNISH THE JOINT TYPE, CLASS, THICKNESS DESIGNATION, CASTINGS, LINING, MARKING, TESTING, ETC. AS SPECIFIED.

2.2 PIPE MATERIALS

A. POLYVINYL CHLORIDE (PVC) PIPE

1. GENERAL

- A. FURNISH PVC PIPE PRODUCED BY A CONTINUOUS EXTRUSION PROCESS, EMPLOYING A PRIME GRADE OF UN-PLASTICIZED POLYVINYL CHLORIDE. ASSURE THE GRADE USED IS HIGHLY RESISTANT TO HYDROGEN SULFIDE, SULFURIC ACID, GASOLINE, OIL, DETERGENTS AND OTHER CHEMICALS FOUND IN SEWAGE AND INDUSTRIAL WASTES. ASSURE THE MATERIAL MEETS "RIGID POLYVINYL CHLORIDE COMPOUNDS" - ASTM DESIGNATION D-1784 REQUIREMENTS. ASSURE THE PIPE HAS SELF-EXTINGUISHING FLAMMABILITY CHARACTERISTICS.

2. GRAVITY SEWER PIPE

- A. FURNISH GRAVITY SEWER PIPE MEETING ONE OF THE FOLLOWING REQUIREMENTS:
 - 1) ASTM D-3034, "STANDARD SPECIFICATIONS FOR POLYVINYL CHLORIDE SEWER PIPE AND FITTINGS", WITH AN SDR OF 35.4"- 15" (10 CM - 38 CM).
 - 2) ASTM F679, "STANDARD SPECIFICATIONS FOR PVC LARGE DIAMETER PLASTIC GRAVITY SEWER PIPE AND FITTINGS" 18"- 36"(46 CM - 76 CM).
 - 3) ASTM F949, "STANDARD SPECIFICATION FOR PVC CORRUGATED (OPEN PROFILE) SEWER PIPE WITH A SMOOTH INTERIOR AND FITTINGS" LARGER THAN 12" (10CM).

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- B. FURNISH PIPE HAVING NOMINAL 12.5 FEET (3.8 METERS), LAYING LENGTHS, EXCEPT SHORTER LENGTHS MAY BE USED ADJACENT TO MANHOLES, LAMPHOLES OR OTHER APPURTENANCES. ASSURE EACH PIPE SECTION IS MARKED, AS A MINIMUM, WITH SIZE, SDR, "SEWER PIPE" AND CODE NUMBER.
- 3. PRESSURE SEWER PIPE
 - A. FURNISH PRESSURE SEWER PIPE MEETING ASTM D2241, "STANDARD SPECIFICATION FOR POLYVINYL CHLORIDE PLASTIC PIPE (SDR-PR), WITH AN SDR OF 26 AND A PRESSURE RATING OF 160.
 - B. USE A NOMINAL LAYING LENGTH OF 20 FEET (6.1 METERS), EXCEPT SHORTER LENGTHS MAY BE USED ADJACENT TO BENDS OR OTHER APPURTENANCES. ASSURE EACH PIPE LENGTH IS MARKED, AS A MINIMUM, WITH SIZE, SDR, PRESSURE RATING OR BOTH, ASTM DESIGNATION AND MANUFACTURER'S NAME AND CODE.
- 4. PIPE JOINTING
 - A. FURNISH EACH PIPE LENGTH WITH A BELL DESIGNED TO PROVIDE A WATERTIGHT JOINT WHEN JOINTING THE BELL AND SPIGOT WITH A RUBBER RING.
 - B. MAKE A RUBBER GASKET JOINT FOR PVC PIPE AND FITTINGS USING A RUBBER GASKET COMPRESSED BETWEEN THE OUTER SURFACE OF THE SPIGOT AND THE INNER SURFACE OF THE BELL. ASSURE THE JOINT IS COMPLETELY SEALED BY THE GASKET SO THAT THE ASSEMBLY REMAINS WATERTIGHT UNDER ALL SERVICE CONDITIONS, INCLUDING EXPANSION, CONTRACTION, SETTLEMENT AND PIPE DEFORMATION. FOLLOW THE MANUFACTURER'S RECOMMENDATIONS WHEN ASSEMBLING THE RUBBER RING JOINT.
- 5. FITTINGS
 - A. ASSURE WYE OR TEE FITTINGS FOR CONNECTING SERVICE LINES ARE OF THE SAME MATERIAL, CONSTRUCTION AND JOINT DESIGN AS THE MAIN SEWER PIPE.
- B. CONCRETE PIPE
 - 1. GENERAL
 - A. FURNISH CONCRETE SEWER PIPE MEETING ASTM SPECIFICATIONS C76 OR C655, LATEST REVISION, EXCEPT AS NOTED HEREIN. ASSURE CEMENT USED TO MAKE CONCRETE PIPE IS TYPE II A MODIFIED, TYPE V OR OTHER APPROVED CEMENT CONTAINING LESS THAN 5 PERCENT TRICALCIUM ALUMINATE. THE PIPE STRENGTH CLASSIFICATIONS FOR C76 OR C655 SPECIFICATION PIPE IS LISTED IN THE PLANS OR CONTRACT DOCUMENTS.
 - B. FURNISH PIPE MEETING THE REFERENCED ASTM SPECIFICATIONS ON PERMISSIBLE VARIATIONS IN PIPE DIMENSIONS. ASSURE THE BARREL THICKNESS IS UNIFORM TO PROVIDING A CONSTANT FLOW AREA WITHOUT PROJECTIONS ACROSS JOINTS.

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2. FITTINGS
 - A. USE WYE OR TEE FITTINGS FOR CONNECTING SERVICE LINES OF THE SAME MATERIAL, CONSTRUCTION AND JOINT DESIGN AS THE MAIN SEWER PIPE.
 3. JOINTING MATERIAL
 - A. MAKE JOINTS FOR CONCRETE PIPE USING FLEXIBLE, WATERTIGHT, RUBBER- TYPE GASKETS MEETING TO ASTM C443, WITH AN O-RING GASKET CONFINED IN THE PIPE TONGUE GROOVE.
 4. PIPE JOINTING
 - A. THOROUGHLY CLEAN THE SPIGOT AND BELL ENDS OF THE PIPE BEFORE JOINT ASSEMBLY. FOLLOW THE PIPE AND JOINT MANUFACTURER'S RECOMMENDATIONS FOR PIPE JOINTING. CHECK THE POSITION OF THE RUBBER GASKETS AND PIPE ASSEMBLY USING A FEELER GAUGE BEFORE BACKFILLING THE TRENCH. VISUALLY INSPECT AND GAUGE PIPE AND JOINTS FROM INSIDE THE PIPE WHERE PIPE SIZE PERMITS TO ASSURE PROPER GASKET POSITION AND JOINT GAP TOLERANCES.
 5. MATERIAL TESTING
 - A. WHEN THE PIPE SUPPLIER IS NOT AN AMERICAN CONCRETE PIPE ASSOCIATION CERTIFIED PLANT, THE PIPE SUPPLIER SHALL FURNISH THE ENGINEER WITH CERTIFIED TEST RESULTS FROM AN INDEPENDENT TESTING LABORATORY ON THE FOLLOWING: (A) CRUSHING STRENGTH (3-EDGE BEARING METHOD), (B) ABSORPTION, AND (C) HYDROSTATIC TEST. FURNISH TEST RESULTS FOR EACH PIPE AS SPECIFIED IN ASTM C76 OR C655, OR A MINIMUM TWO PERCENT OF THE NUMBER OF PIPE SUPPLIED, WHICHEVER IS GREATER. COST OF THESE TESTS TO BE BORNE BY THE PIPE SUPPLIER. THE ENGINEER RETAINS THE OPTION TO WITNESS ALL TESTING COMPLETED AT THE PRODUCTION FACILITY.
- C. HIGH DENSITY POLYETHYLENE (HDPE) PIPE
1. PIPE
 - A. FURNISH NON-PROFILE WALL HDPE PIPE MEETING ASTM D3350, HAVING A CELL CLASSIFICATION OF PE 34-5434C. ASSURE DIMENSIONS AND WORKMANSHIP MEET ASTM F714 REQUIREMENTS.
 2. FITTINGS
 - A. USE WYE OR TEE FITTINGS FOR CONNECTING SERVICE LINES OF THE SAME MATERIAL CONSTRUCTION AND JOINT DESIGN AS THE MAIN SEWER PIPE.
 3. PIPE JOINTING
 - A. HEAT FUSION WELD ALL FIELD JOINTS TO MEET THE MANUFACTURER'S RECOMMENDATIONS.

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D. OTHER PIPE MATERIALS

1. OTHER PIPE MATERIALS MAY BE SPECIFIED AT THE DISCRETION OF THE ENGINEER AND OWNER.

2.3 MANHOLES

A. GENERAL

1. CONSTRUCT MANHOLES FROM PRECAST CONCRETE SECTIONS HAVING FRAMES, COVERS, AND STEPS MEETING STANDARD DRAWINGS.

B. PRECAST CONCRETE SECTIONS

1. FURNISH MANHOLES MEETING ASTM C478; "PRECAST REINFORCED CONCRETE MANHOLE SECTIONS", SPECIFICALLY INCLUDING MANDATORY REJECTION REQUIREMENTS.

C. STEPS

1. FURNISH NON-CORROSIVE STEPS, 12-INCHES (30 CM) IN WIDTH, OF 1/2-INCH (13 MM) STEEL ROD ENCASED WITH POLYPROPYLENE. ASSURE STEPS WITHSTAND 400 POUND (180 KG) VERTICAL LOADS AND 1,000 POUND (450 KG) PULL-OUT RESISTANCE.

D. FRAMES AND COVERS

1. FURNISH FRAMES AND COVERS MEETING STANDARD DRAWING NOS.02720-8 AND 02720-9. FURNISH 2-HOLE TYPE COVERS UNLESS SPECIFIED OTHERWISE.

E. CONCRETE BASE

1. FURNISH PRECAST CONCRETE BASES OR FIELD POURED ON UNDISTURBED EARTH. USE CONCRETE MEETING SECTION 03310: STRUCTURAL CONCRETE.

PART 3: EXECUTION

3.1 PIPE AND SERVICE LINE INSTALLATION

A. EXCAVATION AND BACKFILL

1. PERFORM PIPELINE EXCAVATION AND BACKFILL MEETING THE APPLICABLE REQUIREMENTS OF SECTION 02221: TRENCH EXCAVATION AND BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES.

B. RESPONSIBILITY FOR MATERIALS

1. BE RESPONSIBLE FOR ALL MATERIAL FURNISHED. REPLACE ALL MATERIAL FOUND DEFECTIVE IN MANUFACTURE OR DAMAGED IN HANDLING AFTER DELIVERY. THIS INCLUDES FURNISHING ALL MATERIAL AND LABOR REQUIRED FOR THE REPLACEMENT OF INSTALLED MATERIAL DISCOVERED DEFECTIVE BEFORE FINAL

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ACCEPTANCE OF THE WORK OR DURING THE GUARANTEE PERIOD.

2. BE RESPONSIBLE FOR THE SAFE STORAGE OF MATERIAL INTENDED FOR THE WORK UNTIL IT HAS BEEN INCORPORATED IN THE COMPLETED PROJECT.

C. HANDLING OF PIPE

1. DELIVER AND DISTRIBUTE ALL PIPE TO THE SITE. LOAD AND UNLOAD PIPE, FITTINGS AND ACCESSORIES BY LIFTING WITH HOISTS OR SKIDDING TO AVOID SHOCK OR DAMAGE. DO NOT DROP ANY MATERIALS. DO NOT ROLL OR SKID PIPE HANDLED ON SKIDWAYS AGAINST PIPE ALREADY ON THE GROUND.
2. IN DISTRIBUTING THE MATERIAL AT THE SITE OF THE WORK, UNLOAD EACH PIECE OPPOSITE OR NEAR THE PLACE WHERE IT IS TO BE LAID IN THE TRENCH. KEEP THE INTERIOR OF ALL PIPE AND OTHER ACCESSORIES FREE FROM DIRT AND FOREIGN MATTER AT ALL TIMES.
3. HANDLE PIPE TO PREVENT DAMAGING COATING OR LINING. IF ANY PART OF THE COATING OR LINING IS DAMAGED, MAKE ALL REPAIRS IN A MANNER SATISFACTORY TO THE ENGINEER.

D. LAYING PIPE

1. LAY AND MAINTAIN ALL PIPE TO THE SPECIFIED LINES AND GRADES WITH FITTINGS, TEES AND MANHOLES AT THE REQUIRED LOCATIONS. ESTABLISH LINE AND GRADE USING BATTER BOARDS AND STRING LINE, LASER EQUIPMENT OR OTHER APPROVED METHODS. WHEN BATTER BOARDS AND STRING LINE ARE USED, USE A MINIMUM OF THREE BATTERBOARDS AT ALL TIMES.
2. INSTALL WYE OR TEE FITTINGS IN THE MAINLINE SEWER FOR SERVICE LINE CONNECTIONS. FURNISH WYE OR TEE FITTINGS OF THE SAME MATERIAL, DESIGN AND SPECIFICATIONS AS THE SEWER MAIN PIPE. JOINT SERVICE PIPE TO TEE BRANCHES OR MAIN LINE PIPE OTHER THAN PVC USING SPECIAL JOINT ADAPTERS MANUFACTURED SPECIFICALLY FOR JOINTING THE TWO TYPES OF PIPE.
3. USE TOOLS AND EQUIPMENT, SATISFACTORY TO THE ENGINEER, FOR THE SAFE AND CONVENIENT PROSECUTION OF THE WORK. CAREFULLY LOWER ALL PIPE AND FITTINGS INTO THE TRENCH TO PREVENT DAMAGE TO PIPE MATERIALS AND PROTECTIVE COATINGS AND LININGS. DO NOT DROP OR DUMP ANY MATERIALS INTO THE TRENCH.
4. TAKE EVERY PRECAUTION TO PREVENT FOREIGN MATERIAL FROM ENTERING THE PIPE WHILE IT IS BEING INSTALLED. AT TIMES WHEN PIPE LAYING IS NOT IN PROGRESS, CLOSE THE OPEN ENDS OF PIPE USING A PLUG OR OTHER MEANS APPROVED BY THE ENGINEER. CLEAN AND REMOVE ALL SAND, GRAVEL, CONCRETE AND CEMENT GROUT THAT HAS ENTERED THE LINES DURING CONSTRUCTION.

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E. TOLERANCES

1. INSTALL THE PIPE WITHIN 1/2-INCH (13 MM) OF THE SPECIFIED ALIGNMENT AND WITHIN 1/4-INCH (6 MM) OF THE SPECIFIED GRADE.

3.2 MANHOLES

A. CONSTRUCTION

1. CONSTRUCT MANHOLES TO THE SPECIFIED DIMENSIONS. MAKE INVERT CHANNELS SMOOTH AND SEMI CIRCULAR IN SHAPE CONFORMING TO THE INSIDE OF THE ADJACENT SEWER SECTION. MAKE CHANGES IN FLOW DIRECTION WITH A SMOOTH CURVE OF AS LARGE A RADIUS AS THE MANHOLE SIZE WILL PERMIT. MAKE CHANGES IN CHANNEL GRADE AND SIZE GRADUALLY AND EVENLY. THE INVERT CHANNELS MAY BE FORMED DIRECTLY IN THE MANHOLE BASE CONCRETE OR BY LAYING HALF-PIPE IN THE CONCRETE. MAKE THE FLOOR OF THE MANHOLE OUTSIDE THE CHANNEL SMOOTH AND SLOPE TOWARD THE CHANNEL AT ONE INCH PER FOOT (8 CM PER METER).
2. JOINT ALL CONNECTIONS BETWEEN MANHOLE WALLS AND BASE AND BETWEEN WALL SECTIONS ADJUSTING RINGS AND FRAME MAKING THE MANHOLE WATERTIGHT. FOR ALL HORIZONTAL JOINTS LOCATED BELOW THE ESTABLISHED HIGH GROUNDWATER ELEVATION, INSTALL A PREFORMED RUBBER GASKET JOINT. THE ESTABLISHED HIGH GROUNDWATER LEVEL IS SHOWN ON THE PLANS OR NOTED IN THE SPECIAL PROVISIONS. FOR ALL SEWER PIPE TO MANHOLE JOINTS, USE GASKETED, FLEXIBLE, WATERTIGHT CONNECTIONS THAT WILL ACCOMMODATE DIFFERENTIAL SETTLEMENT. ACCEPTABLE OPTIONS FOR THESE CONNECTIONS TO THE MANHOLE ARE AS FOLLOWS:
 - A. ADJACENT JOINTS: BELL AND SPIGOT PIPE JOINTS WITH RUBBER SEALING RINGS LOCATED WITHIN 12 INCHES (30 CM) OF THE MANHOLE WALL.
 - B. COMPRESSION-TYPE FLEXIBLE CONNECTOR: A RESILIENT, FLEXIBLE CONNECTION, CAST INTO MANHOLE WALL, PROVIDING 10 DEGREES DEFLECTION.
 - C. BOOT-TYPE FLEXIBLE CONNECTOR: A FLEXIBLE, WATERTIGHT CONNECTION CONSISTING OF A RUBBER GASKET OR BOOT, METAL EXPANSION RING AND A METAL TAKE-UP CLAMP. ASSURE THE EXPANSION RING HOLDS THE GASKET IN THE MANHOLE WALL, WITH THE TAKE-UP CLAMP HOLDING THE GASKET TO THE PIPE.
 - D. OPTIONS (B) AND (C) ARE LIMITED TO PRECAST MANHOLE BASE INVERTS AND OTHER INSTALLATIONS WHERE THE FLEXIBILITY OF THE CONNECTION IS NOT COMPROMISED.
 - E. CONSTRUCT MANHOLES MEETING ASTM C478, AND THE REJECTION CRITERIA STATED THEREIN.
 - F. KEEP MANHOLE CONSTRUCTION WITHIN ONE MANHOLE DISTANT BEHIND SEWER PIPELINE CONSTRUCTION.

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3. INSTALL ADJUSTING RINGS ON EACH MANHOLE TO BRING THE MANHOLE TOP ELEVATION TO MATCH THE EXISTING OR SPECIFIED GROUND ELEVATIONS. USE MANHOLE RINGS WITH A 2-INCH MINIMUM (5 CM) AND 12-INCH (30 CM) MAXIMUM HEIGHT. FURNISH ADJUSTING RINGS REINFORCED WITH THE SAME PERCENTAGE OF STEEL AS THE RISER AND TOP.

3.3 SANITARY SEWER SERVICE LINES

- A. CONSTRUCT SERVICE LINES MEETING STANDARD DRAWING 02730-2. INSTALL THE SERVICE LINE TO THE PROPERTY LINE. PLUG THE END OF THE SERVICE LINE WITH A STOPPER AND GASKET, USING A GASKET OF THE SAME TYPE USED FOR PIPE JOINTING. DO NOT GROUT THE PLUGS.
- B. MARK THE SANITARY SEWER AND STORM DRAIN SERVICE LINE ENDS AT THE PROPERTY LINE USING A STEEL FENCE POST 5 FEET (1.5 M) LONG, BURIED AT LEAST 2 FEET (0.6 M). PLACE A 2" X 2" (5CM X 5 CM) WOOD MARKER EXTENDING FROM THE PIPE INVERT TO GROUND LINE. WIRE THE 2" X 2" (5CM X 5 CM) MARKER TO THE STEEL FENCE POST. WHERE APPLICABLE, MARK THE CONCRETE CURB TO IDENTIFY THE SERVICE LOCATIONS. PAINT SANITARY SEWER SERVICE MARKERS GREEN AND STORM DRAIN SERVICE MARKERS GRAY.

3.4 TESTS

- A. MAKE ALL TESTS AFTER BACKFILL IS COMPLETED, BUT BEFORE ANY SURFACE RESTORATION OR STREET SURFACING. BE RESPONSIBLE FOR FINDING AND REPAIRING ALL BREAKS AND LEAKS REVEALED BY THE TESTS. ADDITIONALLY, PERFORM ALL TESTS IN THE PRESENCE OF THE ENGINEER, RESIDENT INSPECTOR, OR THE OWNER'S OTHER DESIGNATED REPRESENTATIVE.
- B. LIGHT TEST (VISUAL)
 1. AFTER THE TRENCH HAS BEEN BACKFILLED AND COMPACTED AS SPECIFIED IN SECTION 02221, PERFORM A LIGHT TEST BETWEEN MANHOLES TO CHECK ALIGNMENT AND GRADE FOR PIPE DISPLACEMENT. EXCLUDING CURVED ALIGNMENTS SHOWN ON THE PLANS, THE COMPLETED PIPELINE IS TO PERMIT A TRUE CIRCLE OF LIGHT TO BE VISIBLE FROM ONE MANHOLE TO THE NEXT. IF ALIGNMENT OR GRADE IS NOT THAT SPECIFIED AND DISPLACEMENT OF PIPE IS FOUND, REMEDY ALL DEFECTS.
- C. LEAKAGE TEST
 1. NEW SEWER LINE WILL NOT BE FINALLY ACCEPTED UNTIL LEAKAGE TESTS ARE MADE ASSURING THE ENGINEER THAT PIPE LAYING AND JOINTING ARE SATISFACTORY.

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D. WATER TEST

1. WHERE GROUNDWATER IS AT LEAST 2 FEET (0.6 M) ABOVE THE SEWER LINE, MAKE TESTS BY SEALING OFF THE SECTION OF LINES BETWEEN MANHOLES AND MEASURING THE ACTUAL FLOW BY COLLECTING OR PUMPING THE DISCHARGE INTO BARRELS OR OTHER APPROVED METHODS. CONTINUE TESTS AT A MINIMUM OF 4 HOURS FOR EACH SECTION TESTED. ALLOW TIME TO SOAK LINES AND MANHOLES IN ADVANCE OF PERFORMING TESTS.
2. WHEN GROUNDWATER IS NOT 2 FEET (0.6 M) ABOVE THE PIPE, TEST AS FOLLOWS: ON FLAT SLOPES WHERE THE DEPTH OVER THE CENTERLINE OF THE PIPE IN THE LOWER MANHOLE OF THE SECTION BEING TESTED WILL BE NOT MORE THAN 10 FEET (3 M), FILL THE UPPER MANHOLE TO 2 FEET (0.6 M) OVER THE TOP OF THE PIPE OR 2 FEET (0.6 M) ABOVE THE GROUNDWATER ELEVATION (WHICHEVER IS HIGHER), AND BLOCK THE LOWER MANHOLE. WHEN THE ABOVE CONDITIONS CANNOT BE MET, THE ENGINEER MAY ORDER TESTING THE LINE IN SECTIONS BETWEEN MANHOLES. MEASURE THE LEAKAGE BY CHECKING THE WATER LEVEL DROP IN THE MANHOLE OVER A 4 HOUR PERIOD.
3. THE ALLOWABLE INFILTRATION OR EXFILTRATION, INCLUDING MANHOLES, CANNOT EXCEED 200 GALLONS PER DAY PER MILE OF SEWER PER INCH OF PIPE DIAMETER (185 LITERS PER DAY PER KILOMETER OF SEWER PER CENTIMETER OF PIPE DIAMETER). THIS DOES NOT EXCLUDE OBVIOUS AND CONCENTRATED LEAKS AND PHYSICAL DEFECTS, SUCH AS OPEN JOINTS, PINCHED GASKETS, CRACKED BARRELS OR BELLS, ETC. MAKE REPAIRS ON CONCENTRATED LEAKS, AND AS REQUIRED TO REDUCE INFILTRATION OR EXFILTRATION LEAKAGE BELOW THE SPECIFIED RATE.

E. AIR TEST (ALTERNATIVE)

1. AS AN ALTERNATE METHOD TO WATER TESTING, THE CONTRACTOR MAY UTILIZE LOW PRESSURE AIR TO TEST THE SEWER MAINS. USE THE TEST PROCEDURE DESCRIBED BELOW: PLUG BOTH ENDS OF THE PIPE UNDER TEST WITH AIRTIGHT PLUGS AND BRACE TO PREVENT SLIPPAGE AND BLOWOUT. FURNISH ONE PLUG WITH AN INLET TAP OR OTHER PROVISION FOR CONNECTING AN AIR HOSE.
2. EQUIP THE AIR SUPPLY HOSE, CONNECTED BETWEEN THE AIR COMPRESSOR AND THE PLUG, WITH A THROTTLING VALVE, AN AIR BLEED VALVE AND A HIGH PRESSURE SHUTOFF VALVE FOR CONTROL. EQUIP THE LOW PRESSURE SIDE OF THE THROTTLING VALVE WITH A TEE FOR A MONITORING PRESSURE GAUGE, PROTECTED BY A GAUGE COCK. THIS COCK IS KEPT CLOSED EXCEPT WHEN THE PRESSURE LOSS IS BEING TIMED.
3. IF THE PIPELINE IS SUBMERGED UNDER GROUNDWATER, THE BACK PRESSURE, CAUSED BY THE WATER HEAD, IS MEASURED AND ADDED TO THE STANDARD TEST PRESSURES TO COMPENSATE FOR THE GROUNDWATER EFFECT ON THE AIR TEST.
4. APPLY AIR SLOWLY TO THE PIPELINE UNTIL THE PRESSURE REACHES 4.0 PSIG (27.6 J). THROTTLE THE AIR SUPPLY TO MAINTAIN THE INTERNAL PRESSURE BETWEEN 4.0 AND 3.5 PSIG (27.6 -24.1 J) FOR AT LEAST 2 MINUTES. DURING THIS TIME CHECK THE PLUGS WITH SOAP SOLUTION TO DETECT ANY PLUG LEAKAGE.

1. WHEN THE PRESSURE REACHES EXACTLY 3.5 PSIG (24.1 J), DISCONNECT THE AIR
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SUPPLY, START A STOP WATCH AND RECORD THE TIME FOR THE PRESSURE TO DROP TO 2.5 PSIG (17.2 J). THE MINIMUM TIME ALLOWED FOR THE PRESSURE DROP IS COMPUTED ON AN AIR LOSS RATE OF 3.5 CFM (5.9M³ /MIN) OR AN AIR LOSS RATE OF 0.0030 CUBIC FEET PER MINUTE (CFM) PER SQUARE FOOT (0.055 M³ /MIN PER SQUARE METER) OF INNER PIPE SURFACE AREA UNDER TEST, WHICHEVER RATE YIELDS THE LEAST TIME FOR THE PRESSURE DROP. SHOULD THE TIME OF THE PRESSURE DROP BETWEEN 3.5 AND 2.5 PSIG (24.1 - 17.2 J) BE LESS THAN THE ALLOWABLE SPECIFIED TIME, MAKE THE NECESSARY LEAKAGE REPAIRS AND REPEAT THE AIR TEST.

2. STANDARD DRAWING 02730-1 PROVIDES A NOMOGRAPH WHICH MAY BE USED TO COMPUTE TESTING TIMES FOR AIR TESTING. THE NOMOGRAPH COMPUTES RESULTS BASED UPON ENGLISH (U.S. CUSTOMARY) UNITS.
3. FOR SINGLE PIPE SIZE TEST SECTIONS, THE LENGTH LIMITS FOR MINIMUM TEST TIMES OBTAINED FROM STANDARD DRAWING NO.02730-1 ENTITLED "NOMOGRAPH FOR AIR TESTING GRAVITY SEWER MAINS" ARE CONTAINED IN THE FOLLOWING TABLE.

**TABLE 3.1
LENGTH LIMIT FOR MINIMUM TESTTIMES**

PIPE DIAMETER, INCHES (CM)	TEST SECTION LENGTH, FOOT (M)	
	MINIMUM	MAXIMUM
4 (10)	642(196)	1124(343)
6 (15)	429(131)	751 (229)
8 (20)	322(98)	564 (172)
10(25)	257(78)	450 (137)
12(30)	215(66)	376 (115)
15(38)	172(52)	300 (91)
18(46)	43(44)	1250 (76)
21(53)	123(37)	215 (66)
24(61)	107(33)	188 (57)

4. FOR TEST SECTIONS THAT ARE SHORTER THAN THE MINIMUM LENGTHS, NEW TEST TIMES MUST BE CALCULATED. THIS IS DONE BY MULTIPLYING THE TEST TIME FROM THE NOMOGRAPH BY THE ACTUAL LENGTH OF THE TEST SECTION (IN FEET) AND THEN DIVIDING THE RESULTANT PRODUCT BY THE MINIMUM TEST SECTION LENGTH FROM THE PRECEDING TABLE.
5. FOR TEST SECTIONS EXCEEDING THE MAXIMUM LENGTHS, EITHER SHORTEN THE TEST SECTION TO AN ALLOWABLE LENGTH OR USE THE WATER TEST.

F. NUMBER OF TESTS

1. PERFORM THE NUMBER OF LEAKAGE TESTS DIRECTED BY THE ENGINEER TO ASSURE THAT MATERIALS AND WORKMANSHIP ARE ACCEPTABLE. REPAIR DEFECTIVE JOINTS USING ONLY APPROVED METHODS. REPLACE PIPE HAVING CRACKED OR BROKEN BARRELS. DO NOT EXCEED 800 FEET (240 M) OF SEWER LINE PER TEST UNLESS OTHERWISE APPROVED.

G. T.V. INSPECTION

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1. ALL SEWER MAINS SHALL BE INSPECTED USING A TELEVISION CAMERA BEFORE FINAL ACCEPTANCE. A SEWER LINE IS DEFICIENT AND UNACCEPTABLE IF (1) THE ALIGNMENT IS OUTSIDE THE SPECIFIED LIMITS, (2) WATER PONDS IN ANY SECTION ARE EQUAL TO OR GREATER THAN 2 TIMES THE GRADE TOLERANCE SPECIFIED HEREIN UNDER SECTION 02730.3.E.1, OR (3) THE PIPE HAS VISIBLE DEFECTS SUCH AS OPEN JOINTS, PINCHED GASKETS, CRACKED BARRELS OR BELL, OR SIMILAR DEFECTS.
 2. PAY ALL COSTS INCURRED IN ANY TELEVISION INSPECTION PERFORMED SOLELY FOR CONTRACTOR BENEFIT.
 3. RECORD ALL TELEVISION INSPECTIONS IN A FORMAT ACCEPTABLE TO THE OWNER. PULL THE CAMERA THROUGH THE SEWER AT 30 FEET PER MINUTE (9 METERS PER MINUTE MAXIMUM). IF THE CAMERA IS PULLED BY ATTACHING TO THE HOSE OF A HYDRAULIC SEWER CLEANER, ASSURE THE HOSE IS NOT ACTIVE DURING THE PULLING PROCESS.
- H. DEFLECTION TESTING
1. THE ENGINEER MAY REQUIRE DEFLECTION TESTING OF ALL OR ANY PORTION OF A FLEXIBLE PIPE INSTALLATION TO ASSURE THE CONSTRUCTION QUALITY. FLEXIBLE PIPE IS PIPE THAT WILL DEFLECT AT LEAST 2 PERCENT WITHOUT ANY SIGN OF STRUCTURAL DISTRESS.
 2. CONDUCT DEFLECTION TESTS, WHEN PERFORMED ON PVC PIPE, MEETING ASTM D3034 AND SATISFY EITHER OF THE FOLLOWING DEFLECTION LIMITATIONS:

TABLE 3.2 DEFLECTION TESTING LIMITATIONS

MINIMUM PERIOD BETWEEN TRENCH BACKFILLING & TESTING	MINIMUM MANDREL DIAMETER AS A PERCENT OF INSIDE PIPE DIAMETER
7 DAYS	95.0
30 DAYS	92.5

3. MANDRELS MUST HAVE AT LEAST NINE ARMS. PERFORM THE MANDREL TEST WITHOUT MECHANICAL PULLING DEVICES.
- I. MATERIAL AND EQUIPMENT FOR TESTING
1. FURNISH ALL LABOR, EQUIPMENT AND MATERIALS (INCLUDING WATER) NECESSARY FOR PERFORMING THE SEWER LINE TESTS AT CONTRACTOR EXPENSE.
- 3.5 WATER AND SEWER MAIN SEPARATION
- A. HORIZONTAL AND VERTICAL SEPARATION BETWEEN WATER AND SEWER MAINS IS DICTATED BY MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY.

PART 4: MEASUREMENT AND PAYMENT

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4.1 GENERAL

- A. THE FOLLOWING ITEMS ARE THE PAY ITEMS FOR THE WORK COVERED UNDER THIS SECTION. PAYMENT FOR THESE ITEMS IS FULL COMPENSATION FOR PROVIDING ALL MATERIALS, TOOLS, LABOR AND EQUIPMENT NECESSARY TO COMPLETE THE ITEM AND ALL INCIDENTAL WORK RELATED THERETO, WHETHER SPECIFICALLY MENTIONED HEREIN OR NOT.

4.2 SEWER MAINS

- A. MEASUREMENT OF SEWER MAINS ARE MADE IN LINEAL FEET (METERS) OF THE VARIOUS SIZES AND CLASSES ALONG THE CENTERLINE OF PIPE FROM CENTER TO CENTER OF MANHOLES. PAYMENT FOR SEWER MAIN IS MADE AT THE CONTRACT UNIT PRICE BID PER LINEAL FOOT (METERS) OF THE VARIOUS SIZES AND CLASSES CALLED FOR, WHICH INCLUDES FURNISHING AND INSTALLING PIPE, TRENCH EXCAVATION AND BACKFILL, FURNISHING AND PLACING TYPE 1 PIPE BEDDING, SPECIALS REQUIRED FOR CONNECTION TO MANHOLES, TESTING AND ALL OTHER WORK NECESSARY OR INCIDENTAL FOR COMPLETION OF THE ITEM.

4.3 MANHOLES

- A. MEASUREMENT OF EACH MANHOLE FOR PAYMENT IS MADE IN TWO PARTS: (1) FOR A BASIC MANHOLE, AND (2) FOR ANY ADDITIONAL VERTICAL HEIGHT OVER AND ABOVE THE BASIC DEPTH. A BASIC MANHOLE IS DEFINED AS BEING 5 FEET DEEP (1.5 M) FROM THE LOWEST INVERT TO THE TOP OF THE MANHOLE FRAME AND COVER. ANY MANHOLE LESS THAN 5 FEET DEEP (1.5 M) IS CONSIDERED AS ONE BASIC MANHOLE.
- B. ANY MANHOLE OVER 5 FEET DEEP (1.5 M) IS CONSIDERED AS ONE BASIC MANHOLE PLUS A VERTICAL HEIGHT MEASUREMENT TO THE NEAREST 0.1 FOOT (0.03 M). BASIC MANHOLES ARE MEASURED BY NUMERICAL COUNT AND THE ADDITIONAL VERTICAL HEIGHTS FEET (METERS) OF MANHOLE. THE MEASUREMENT OF THE ADDITIONAL VERTICAL HEIGHT OF MANHOLE IS THE VERTICAL HEIGHT OF THE MANHOLE FROM THE LOWEST INVERT TO THE TOP OF THE CAST IRON FRAME MINUS 5 FEET (1.5 M).
- C. PAYMENT FOR FURNISHING AND INSTALLING A BASIC MANHOLE, COMPLETE IN-PLACE, IS MADE AT THE CONTRACT UNIT PRICE BID PER EACH FOR "BASIC MANHOLES", 5.0 FEET DEEP. SUCH PAYMENT INCLUDES BASE, MANHOLE SECTIONS, STEPS, CAST IRON RING AND COVER, JOINT SEALER AND ALL OTHER INCIDENTALS REQUIRED TO COMPLETE THE ITEM.
- D. PAYMENT FOR FURNISHING AND INSTALLING MANHOLES DEEPER THAN THE BASIC MANHOLE DEPTH IS MADE AT THE CONTRACT UNIT PRICE BID PER VERTICAL FOOT (METER) FOR "ADDITIONAL MANHOLE DEPTH" AND INCLUDES MANHOLE SECTIONS, STEPS, JOINT SEALER AND ALL OTHER INCIDENTALS TO COMPLETE THE ITEM.
1. PAYMENT IS MADE UNDER:
- A. BASIC MANHOLE, 5'-0" (1.5 METER) DEPTH - PER EACH.
- B. ADDITIONAL MANHOLE DEPTH - PER VERTICAL FOOT (METER).

4.4 SANITARY SEWER SERVICE LINES

- A. MEASUREMENT IS MADE ALONG THE PIPE FROM THE TEE OR WYE OF THE MAIN SEWER THROUGH TEES, WYES AND OTHER FITTINGS TO THE STREET MARGIN OR RIGHT-OF-WAY MARGIN. MEASUREMENT IS TO THE NEAREST FOOT (0.3M).

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1. PAYMENT FOR SERVICES IS BASED ON THE FOLLOWING BID ITEMS AS SPECIFIED IN THE CONTRACT:
 - A. TRENCH EXCAVATION AND BACKFILL IS INCLUDED IN THE LINEAR FOOT PRICE BID FOR SEWER SERVICE PIPE.
 - B. (SIZE) (CLASS) SEWER SERVICE PIPE IN PLACE," PER LINEAR FOOT.

4.5 GENERAL

- A. THE CONTRACT BID PRICES ARE FULL PAYMENT FOR ALL LABOR, MATERIALS, TOOLS AND OTHER INCIDENTALS AS MAYBE REQUIRED TO COMPLETE THE ITEMS OF WORK IN THE CONTRACT.

END OF SECTION 02730

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SECTION 02 91 00 - SEEDING

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section includes ground surface preparation; furnishing and applying fertilizer; and furnishing and planting seed in areas described in the contract documents or directed by the engineer.
- B. Hydraulic seeding is not included in this section. Hydraulic seeding is covered in section 02920, hydraulic seeding.

1.2 SUBMITTALS

- A. Submit to the engineer applicable seed mixture certifications, fertilizer descriptions and mulch certifications. Furnish duplicate signed copies of the vendors statement certifying that each seed lot has been tested by a recognized seed testing laboratory within 6 months of date of delivery. Assure the statement includes: name and address of laboratory, date of test, lot number for each seed species and the test results including name, percentages of purity and of germination, percentage of weed content for each kind of seed furnished and, for seed mixes, the proportions of each kind of seed.

PART 2 PRODUCTS

2.1 SEED

- A. Furnish seed and seed mixture, free of all prohibited noxious weed seed or any other weed seed prohibited by state or local ordinance.
- B. Seal and label all seed containers to comply with Montana seed law and regulations or meeting U.S. department of agriculture and regulations under the federal seed act, if shipped in interstate commerce.
- C. Do not use wet, moldy, or otherwise damaged seed in the work.
- D. Furnish seed mixture of the species described in the contract documents. Furnish seed in standard containers labeled with the seed name, lot number, net weight, percentages of purity, germination, hard seed, and percentage of maximum weed seed content for each seed species.

2.2 TOPSOIL

- A. Use topsoil that is loose, friable, loamy soil, free of excess acid and alkali. Assure topsoil does not contain objectionable amounts of sod, hard lumps, gravel, sub-soil or other undesirable material that would form a poor seedbed. Before striping topsoil, assure it has supported the growth of healthy crops, grass or other vegetable growth.

2.3 LIME

- A. Furnish ground limestone or other material deemed suitable by the engineer containing a

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minimum 85 percent of total carbonate equivalent ground so that 90 percent will pass through a no. 100 mesh sieve. Coarser material may be acceptable, if the application rates are increased to provide at least the minimum quantities and depth specified using an approved dolomitic lime or a high magnesium lime containing at least 10 percent magnesium oxide.

2.4 FERTILIZER

- A. Furnish standard commercial fertilizers supplied separately or in mixtures containing the specified percentages of total nitrogen, available phosphoric acid, and water-soluble potash. Apply fertilizer at the specified rate and depth meeting the applicable state and federal laws. Furnish fertilizer in standard containers clearly labeled with name, weight, and guaranteed analysis of contents. No cyanamide compounds of hydrated lime are permitted in mixed fertilizers.
- B. Fertilizers may be supplied in one of the following forms:
 - 1. A dry, free-flowing fertilizer suitable for application by a common fertilizer spreader.
 - 2. A finely-ground fertilizer soluble in water, suitable for application by power sprayers; or
 - 3. A granular or pellet form suitable for application by blower equipment.

2.5 SOILS FOR REPAIRS

- A. Use soil for filling and top soiling repair areas of equal quality to the existing topsoil being repaired. Assure the soil is free of large stones, roots, stumps, or other materials that interfere with sowing, compacting, and establishing turf. Obtain approval from the engineer before placing topsoil.

PART 3: EXECUTION

3.1 TOPSOIL

- A. Place at least 6 inches (15 cm) of topsoil in all areas to be seeded. Import topsoil if sufficient topsoil is not available from excavated areas of the project.

3.2 ALLOWABLE SEEDING MONTHS

- A. Perform seeding when the temperature and moisture are favorable to germination and plant growth. Seed preferably before June 1st and after October 1st of each year. Seeding dates must be approved by the engineer.

3.3 SEEDBED PREPARATION AND SOWING

- A. Clear the areas to be seeded of all debris, vegetation, and other material determined by the engineer to be detrimental to the preparation of a seedbed. Once the area is cleared, disc, harrow, rake, or work the area by other suitable methods, into a smooth, even seedbed. Assure the prepared seedbed surface is firm enough to prevent seed loss from high winds or normal rainfall. If rolling is required, perform rolling before seeding using a suitable roller, of a weight appropriate to the soil conditions.
- B. Sow seed in the areas described in the contract documents at the specified

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application rates.

- C. Sow seed using a force feed drill having a grass seed attachment, except of slopes steeper than three to one or on areas too small to be seeded with a force feed drill. In these areas, seed may be sown by power sprayers, blowers or other effective methods. Use equipment in good working order.
- D. Seed Kentucky bluegrass at a depth of one-quarter inch or less and cultipack the seed.
- E. Do not sow seed in winds that prevent proper embedment into the surface.

3.4 FERTILIZER

- A. Spread and work fertilizer into the soil during the final seedbed preparation. Apply fertilizer at the rate described in the contract documents.

3.5 CARE OF SEEDED AREAS

- A. Keep the seeded area moist until it has germinated and it's continued growth is assured. Prevent erosion during watering. Water is incidental to the item "seeding".
- B. Protect all seeded areas from traffic or pedestrian use with warning barricades or other engineer approved methods.
- C. Maintain the seeded area, performing any required watering and mowing until the seed is firmly established. Prevent weeds and other undesirable vegetation from establishing in the seeded area. Mow weeds and rake and remove the clippings from the areas.
- D. Replace any seeded areas failing to germinate which have died or been damaged by construction activities. Replace such areas to meet the contract requirements. The contract warranty period applies to this item.

PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. Seeding is measured by the square yard (square meter) and paid for at the unit price bid including topsoil salvage and/or importing, topsoil placement, seedbed preparation, and seeding, complete in place and accepted by the engineer.
- B. Payment indicated to include complete compensation for all labor, equipment, materials and incidentals required for the completion of the work.

END OF SECTION

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SEEDING

02 91 00 - 3

SECTION 03 21 00 - REINFORCING STEEL

PART 1: GENERAL

1.1 DESCRIPTION

- A. This work is furnishing and placing reinforcing steel or wire fabric meeting the quality, type and size specified in the contract.

1.2 REFERENCES

ASTM A-615	
ASTM A-705	
AASHTO M 31	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
AASHTO M 32	Cold Drawn Steel Wire for Concrete Reinforcement
AASHTO M 55	Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement
AASHTO M 54	Fabric Deformed Steel Bar or Rod Mats for Concrete Reinforcement

PART 2: PRODUCT

2.1 Furnish all new material meeting the following requirements.

A. Bar Reinforcement

1. Furnish deformed reinforcement steel meeting ASTM A 615, (AASHTO M31) or ASTM A705, Grade 40 or Grade 60.
 - a. Small quantities purchased from warehouses may, at the Engineer's direction, be accepted if bend tested under ASTM A615 or AASHTO M31. The test specimen must cold bend around a pin without cracking on the outside of the bent portion.

B. Wire and Wire Mesh

1. Furnish wire meeting cold-drawn steel wire AASHTO M32 (ASTM A82) requirements.
2. Furnish wire mesh for concrete reinforcement meeting AASHTO M 55 (ASTM A 185).
3. Furnish bar mats meeting AASHTO M54 (ASTM A 184).

PART 3: EXECUTION

3.1 PROTECTION

- A. Protect steel reinforcement from damage at all times. Place steel free from dirt, detrimental scale, paint, oil and other foreign substance. Clean steel reinforcement having easily removed rust, loose scale, and dust using an approved method.

3.2 FABRICATION

- A. Furnish four copies of shop details and placing drawings for all reinforcing steel to the Engineer for approval. Once checked, the Engineer will return two marked-up sets of prints or drawings for correction. The Engineer's review is only for general conformity with the plans. Checking the detailed dimensions is the Contractor's responsibility. The Engineer's review does not relieve the Contractor's responsibility to furnish all material meeting the Contract requirements. Detail Reinforcing, steel meeting the ACI "Standard Details and Detailing of Concrete Structures" and the "Manual of Engineering and Placing Drawings for Reinforced Concrete Structures" published by the American Concrete Institute (ACI 315).
- B. Assure all bars are bent cold. Do not field bend any bar partially imbedded in concrete except as specified on the plans.
- C. Ship bar reinforcement in standard bundles, tagged and marked meeting the "Details and Detailing of Concrete Structures" (ACI 315) requirements.
- D. Concrete reinforcement and accessory details, not covered herein or on the drawings, must meet "Details and Detailing of Concrete Structures" and the "Manual of Engineering and Placing Drawings for Reinforced Concrete Structures" (ACI 315 and 315R) requirements.

3.3 PLACING AND FASTENING

- A. Accurately place and hold firm all steel reinforcement in the plan locations as concrete is being placed.
- B. Support and fasten together all reinforcement to prevent displacement due to construction loads. It is permissible to use on ground, where necessary, concrete support blocks having a minimum 4 square inches (2580 MM²) bearing area and having a compressive strength equal to the concrete being placed. Use approved bar chairs and spacers over form work. For concrete surfaces exposed to the weather in the finished structure, assure the portions of all accessories within ½-inch (12.7 mm) of the concrete surface are noncorrosive or protected against corrosion.
- C. Overlap welded wire fabric for successive mats or rolls providing an overlap measured between outermost cross wires of each fabric sheet at least 2 inches (50.8 mm). Extend the fabric across supporting beams and walls to within 4 inches (101.6 mm) of concrete edges. It may extend through contraction joints. Adequately support the fabric during concrete placement to maintain its position in the slab using the methods previously described or by laying the fabric on a concrete layer of the required depth before placing the upper slab layer.
- D. Offset vertical bars in columns at least one bar diameter at lap splices. Furnish templates for all column dowels.
- E. Obtain Engineer approval for all splices not shown on the plans. Mechanical connectors for reinforcing bars may be used if approved.
- F. Do not use pebbles, pieces of broken stone, concrete rubble, broken brick or building blocks, metal pipe, or wooden block to position the fabric.
- G. Follow the minimum concrete protective covering for reinforcement below.
 - 1. Concrete deposited against ground: 76.2 mm (3 inches)

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2. Formed surfaces exposed to weather or in contact with the ground:
- | | | |
|----|----------------------|------------------------|
| a. | #6 bars or larger | 50.8 mm (2 inches) |
| b. | Smaller than #6 bars | 38.1 mm (1-1/2 inches) |

3. Interior Surfaces:

- | | | |
|----|----------------------------|------------------------|
| a. | Beams, girders and columns | 38.1 mm (1-1/2 inches) |
| b. | Slabs, walls and joists: | |
| | 1) #11 bars or smaller | 19.05 mm (3/4-inch) 2) |
| | #14 and #18 bars | 38.1 mm (1-1/2 inches) |

- H. For corrosive atmospheres or fire protection, see special provisions for minimum covering requirements.
- I. Obtain Engineer approval of reinforcement placement before placing concrete. Remove and replace concrete placed without Engineer approval of reinforcing.
- J. Straighten fabric reinforcement shipped in rolls into flat sheets before placing it.

3.4 WELDING

- A. When specified or approved, weld reinforcing steel meeting "Reinforcing Steel Welding Code" (AWS D 1.1-4). Do not weld at bends in bars. Do not tack weld crossbars without Engineer approval.

PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. Reinforcing steel used in the work is not measured. The cost of furnishing and placing reinforcing steel is incidental and included in the unit price or lump sum price bid for various items of the work.

END OF SECTION

SECTION 03 31 00 – STRUCTURAL CONCRETE

PART 1: GENERAL

1.1 DESCRIPTION

- A. Furnish structural concrete meeting all specified requirements that is composed of Portland cement, aggregates, water. Furnish Ready-mixed concrete meeting ASTM C94 unless otherwise specified.

1.2 REFERENCES

ASTM C-94	Standard Specification for Ready-Mixed Concrete ASTM
C-150	Specification for Portland Cement
ASTM C-618	Specification for Coal Flyash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C-989	Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C-595	Specification for Blended Hydraulic Cements ASTM C-
157	Performance Specification for Hydraulic Cements ASTM
C-33	Specification for Concrete Aggregates
ASTM C-260	Specification for Air-Entraining Admixtures for Concrete ASTM C-
494	Specification for Chemical Admixtures for Concrete
ASTM C-1017	Specification for Chemical Admixtures for Use in producing Flowing Concrete
ASTM D-98	
ASTM C-138	Test Method for Density(Unit Weight), Yield, and Air Content(Gravimetric) of Concrete
ASTM C-173	Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C-231	Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C-31	Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C-39	Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C-172	Practice for Sampling Freshly Mixed Concrete
ACI 301	Standard Specification for Structural Concrete for Buildings ACI 305 Hot Weather Concrete
ACI 306	Cold Weather Concrete
ACI 318	Building Code Requirements for Reinforced Concrete

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1.3 QUALITY ASSURANCE

- A. Codes and Standards: The codes and standards referred to in this section are declared to be part of this specification as if fully set forth herein. In addition, the following ACI Standards are incorporated in their entirety, unless specifically required otherwise:
1. ACI Standard 301, "Specifications for Structural Concrete for Buildings," American Concrete Institute, Edition.
 2. ACI Standard 318, "Building Code Requirements for Reinforced Concrete", American Concrete Institute, current edition.
 3. Concrete Reinforcing Steel Institute, "Manual of Standard Practice".
 4. International Building Code of I.C.B.O.
- B. Concrete Testing: The Contractor shall employ at his expense a testing laboratory acceptable to the Engineer to perform material evaluation tests and/or perform the mix design prior to placing any concrete. The Engineer will perform all acceptance testing during the onsite placement of the concrete .. Retesting or additional testing of concrete or materials failing to meet the requirements of these specifications shall be done by the Contractor at no additional cost to the Owner.

PART 2: PRODUCT

2.1 CLASSIFICATION

- A. Concrete is classified as set forth below. Place the specified class of concrete for each structure element as specified. Concrete with prefixes "C" contain 1-1/2 inch (38.1 mm) size aggregate and those with "M" contain 3/4 inch (19.05 mm) size aggregate. Concrete with prefixes "M" may be substituted for concrete with prefixes "C."
1. Use M-4000 concrete for curb and gutter, sidewalks, driveways, approaches, curb turn fillets and valley gutters and structural concrete.
 2. Use M-3000 concrete for manholes, storm drain inlets and miscellaneous or C-3000 Concrete Construction class.
 3. M-3000 is concrete with 3/4 inch (19-05 mm) maximum aggregate and a 28-day compressive strength of 3000 pounds per square inch (psi) (20.7 Mpa).
 4. M-4000 is concrete with 3/4 inch (19-05 mm) maximum aggregate and a 28-day compressive strength of 4000 pounds per square inch (psi) (27.6 Mpa).
 5. C-3000 is concrete with 1-1/2 inch (38.1 mm) maximum aggregate and a 28-day compressive strength of 3000 psi (20.7 Mpa).
- B. If concrete strength or durability requirements established by design exceed the above strength classifications, the Engineer may specify additional concrete classifications to meet those requirements.

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2.2 COMPOSITION OF CONCRETE

- A. Upon receipt of the notice of award of the contract, furnish the Engineer with names of suppliers and locations of sources of materials proposed for use.
1. Materials
- a. Cementitious Material: Cementitious material consists of Portland cement meeting ASTM C 150, with or without the addition of cementitious or pozzolanic mineral admixtures meeting, ASTM C618 or ASTM C989, or blended hydraulic cement meeting ASTM C595 or hydraulic cement meeting ASTM 1157. Unless otherwise specified, assure cementitious material meets ASTM C 150 Type I or Type II. Assure cementitious material used in concrete is the same brand and type and from the same plant of manufacture as the cementitious material used in the concrete represented by the submitted field test data or used in the trial mixtures.
- b. Aggregates: Assure aggregates meet ASTM C33. When a single size or a combination of two or more sizes of coarse aggregates are used, assure the final gradation meets the grading requirements of ASTM C33. Obtain concrete aggregates from the same source and use the same size ranges as the aggregates used in the concrete represented by submitted historical data, or used in trial mixtures.
- c. Water and Ice: Use concrete mixing water and water to make ice meeting requirements of ASTM C94.
- d. Admixtures: Use admixtures meeting the following requirements:
- | | |
|--|------------|
| 1) Air entraining, admixtures - | ASTM C260 |
| 2) Chemical admixtures- | ASTM C494 |
| 3) Chemical admixtures for use in producing, flowing concrete- | ASTM C1017 |
| 4) Calcium Chloride - | ASTM D98 |
| 5) Use admixtures in the concrete that are the same as those used in the concrete represented by submitted field test data or in trial mixtures. | |
2. Change of materials
- a. When brand, type, size, or source of cementitious materials, aggregates, water, ice or admixtures are requested to be changed, submit new field data or data from new trial mixtures or furnish evidence that indicates that the change will not adversely affect the relevant properties of the concrete for acceptance before using the concrete.
- B. Performance and Design Requirements
1. Assure the cementitious material content is adequate to meet the specified requirements for strength, water-cement ratio and finishing requirements. For concrete used in floors, assure the cement content is at least that indicated in Table 2.1. For concrete exposed to freezing and thawing or concrete exposed to deicers, assure a maximum water-cement ratio of 0.45.

TABLE 2.1
MINIMUM CEMENT CONTENT REQUIREMENTS

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Nominal Maximum size
of aggregate, in(mm)

Minimum cement content
lb/yd³ (kg/m³)

1-1/2 (38-1)	470* (163.0)
1 (25.4)	520 (180.3)
3/4 (19-05)	540 (187-3)
3/8 (9-5)	641 (222.3)

* Minimum cement content is 520 lb/yd³ (180.3 kg/m³) and maximum H₂O/cement ratio of 0.45 if concrete will be exposed to freezing and thawing and/or in the presence of deicing chemicals.

- Furnish concrete at the point of delivery having a slump of 4 inches (max) (100 mm) determined by ASTM C 143. Meet slump tolerances in ACI 117. When a plasticizing admixture is used meeting ASTM C 10 17 or when a Type F or G high range water reducing admixture meeting ASTM C494 is approved to increase the concrete slump, assure the concrete has a slump of 2 to 4 inches (50-100mm) before the admixture is added and a maximum slump of 8 inches (200 mm) at the point of delivery after the admixture is added.
- Assure the nominal maximum size of coarse aggregate does not exceed three fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms or one-third of the thickness of slabs or toppings.
- Concrete must be air entrained. Measure air content under ASTM C 138, C 173 or C231. Unless otherwise specified, ASTM C231 shall be used.

TABLE 2.2
TOTAL AIR CONTENT* OF CONCRETE FOR VARIOUS SIZES OF
COARSE AGGREGATE

Nominal maximum Size of aggregate mm, (in.)	Total air content, percent		
	Severe exposure	Moderate exposure	Mild exposure
Less than 9.53(3/8)	9	7	8
9.53 (3/8)	7.5	6	4.5
12.5(1/2)	7	5.5	4
19 (3/4)	6	5	3.5
25.4(1)	6	4.5	3
12.7(1-1/2)	5.5	4.5	3
50.8(2)	5	3.5	1.5
76.2(3)	4.5	3.5	1.5
152.4(6)	4	3	1

* Measure in accordance with ASTM C 138, C 173, or C 231.
Air content tolerance is +/- 1 1/2 percent

- When admixtures are specified in the Contract documents for particular parts of the work, use types specified. Use of calcium chloride or other admixtures

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containing chloride ions is subject to the limitations in Table 2.3 Chloride Ion Concentration. When approved, use calcium chloride in solution form only, when introduced into the mixture.

- 1) Assure the maximum water soluble chloride ion concentrations in hardened concrete at ages from 28 to 42 days attributed to the ingredients including water, aggregates, cementitious materials and admixtures do not exceed the limits of Table 2.3. Use tests to determine water soluble chloride ion content meeting AASHTO T260. The type of member described in Table 2.3 applies to the work as indicated in the Contract Documents.

**TABLE 2.3
MAXIMUM ALLOWABLE CHLORIDE ION CONTENT**

Type of Member	Maximum water soluble chloride (Cl) Content in concrete, percent by weight of cement
Prestressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from moisture in service	1.00
Other reinforced concrete construction	.30

- b. When the average of the highest and lowest temperature during the period from midnight to midnight is expected to drop below 40°F (40°C) for more than three successive days, deliver concrete in accordance with ASTM C-94.
- c. Furnish the compressive strength and the water-cement or water cementitious, material ratio of concrete for each portion of the work as specified in the Contract documents.
 - 1) If cementitious or pozzolanic mineral admixtures meeting, ASTM C618 or ASTM C989 are used, the cement portion of the water-cement ratio must be the total weight of cementitious material.
 - 2) The maximum weight of fly ash, pozzolan or ground granulated blast-furnace slag included in the calculation of water-cementitious material ratio cannot exceed the following percentages of the total weight of portland cement plus fly ash, pozzolan and ground granulated blast- furnace slag:
 - 3) The combined weight of fly ash and pozzolan meeting ASTM C618 cannot exceed limits in ACI 318.. The fly ash and pozzolan present in an ASTM Type IP or IPM blended cement meeting ASTM C595 must be included in the calculated percentage.
 - 4) The weight of ground granulated blast-furnace slag meeting ASTM C989 cannot exceed 50 percent of the total weight

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of cementitious material. The slag used in manufacture of a Type IS or ISM blended hydraulic cement meeting ASTM C595 must be included in the calculated percentage.

- 5) If fly ash or pozzolan is used in concrete with ground granulated blast-furnace slag, the portland cement constituent meeting ASTM C 150 cannot be less than 50 percent of the total weight of cementitious material. Fly ash or pozzolan must not constitute more than 25 percent of the total weight of cementitious material.
- 6) Strength requirements are based on the 28-day compressive strength determined on 6" x 12" (150mm x 300mm) cylindrical specimens made and tested under ASTM C31 and C39 respectively.

2.3 PROPORTIONING AND DESIGN OF MIXES

- A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If trial batch method used, use an independent testing facility acceptable to the Engineer for preparing and reporting proposed mix designs.
- B. Submit written reports of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed and approved.

PART 3: EXECUTION

3.1 CONCRETE MIXES

- A. Job-Site Mixing: Mix materials for concrete in appropriate drum type batch match mixer. For mixers of one cu. Yd., or small capacity, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released. For mixers of capacity larger than one cu. Yd., increase minimum 1-1/2 minutes of mixing time by 2.5 minutes for each additional cu. yd., or fraction thereof.
- B. Provide batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mix type, mix time, batch quantities, and amount of water introduced.
- C. Ready-Mix Concrete: Comply with requirements of ASTM C94, and as herein specified.
- D. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ANSI/ASTM C94 may be required.
- E. When air temperature is between 85°F (30°C) and 90°F (32°C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90°F (32°C), reduce mixing and delivery time to 60 minutes.

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3.2 CONSISTENCY

- A. Assure concrete is of such consistency that it will flow around reinforcing steel, but individual particles of the coarse aggregate, when isolated, show a coating of mortar containing its proportionate quantity of sand. The consistency of the concrete will be gauged by the ability of the equipment to properly place the concrete in its final position and not by the difficulty in mixing or transporting. Use the minimum quantity of mixing water necessary to provide workability within the ranges of slump specified.

3.3 MIXING

- A. Thoroughly mix concrete to assure a uniform distribution of the materials throughout the mass. Mix concrete only in quantities required for immediate use and place it within the time limits specified. Waste all concrete which initial set has begun. Retempering of concrete is prohibited. Aggregates, or bags of cement containing lumps or crusts of hardened material shall not be used. Mix concrete in an approved truck mixer meeting the requirements of ASTM C94 herein.
- B. The capacity of the plant and the transportation equipment must ensure delivery at a rate that will permit proper handling, placement and finishing at the point of delivery. Maintain the concrete delivery rate to provide for the continuous operation of placing, handling and finishing concrete as is practical. Maintain the interval between delivery of loads so that layers or lifts of concrete in place do not harden before succeeding layers or lifts are placed. In general, no lift or layer of concrete can remain exposed for more than 20 minutes before being covered by fresh concrete.
- C. The volume of mixed concrete in the mixing drum shall not exceed the manufacturer's rating, on the capacity plate.
- D. During freezing weather, other approved methods of measuring water will be permitted.
- E. A recording water metering device is always required at the primary point of the batching operation.
- F. Do not add water to concrete in transit. Water may be introduced into the mixer at the job site under direction of the Engineer, if the specified water-cement ratio is not exceeded. Water must be added in accordance with ASTM C94, Assure the drum revolves continuously after the introduction of the cement and water until the concrete is discharged.
- G. Begin mixing immediately after introduction of the cement and water and continue for at least 70 revolutions of the drum at mixing speed. This minimum revolution count will be waived when the concrete is produced at a central mixing plant. Not more than 100 drum revolutions can exceed 6 revolutions per minute. All other revolutions must be at agitating speed of not less than 2 or more than 6 revolutions per minute.
- H. Discharge the concrete at the job and place in its final position within 1- 1/2 hours after the introduction of the mixing water and cement. When the air temperature is 90°F (30°C) or above, place the concrete in its final position within 1 hour after the introduction of the mixing, water and cement. Concrete mixes with an approved set retarding admixture may be held an additional ½ hour beyond limits specified above.
- I. No mixed or agitated concrete that has remained in the drum of the truck mixer more than 10 minutes without agitation can be used. If the Engineer determines the

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concrete has not suffered any detrimental effects. It may be used, after remixing for a minimum of 20 revolutions of the drum at mixing speed, if it can still be placed in the forms within the specified time limits.

- J. Provide a revolution counter on each truck that registers the number of revolutions of the drum.
- K. Mount the counter so it can be easily read by both the operator and the Engineer.

3.4 PLACING CONCRETE

- A. Thoroughly compact concrete into its final position. Assure it is thoroughly consolidated around fittings and embedded items. Assure all reinforcement and embedded items are accurately placed as shown on the plans and are clean and free from coatings of dried mortar, detrimental rust, scale, oil or foreign matter. Place concrete meeting the applicable requirements of Sections 02528 and 02529.

3.5 CURING CONCRETE

- A. Thoroughly cure concrete surfaces subject to premature drying by covering as soon as possible with canvas, plastic sheets with sealed joints, burlap and sand or other satisfactory materials and keep concrete moist. If the concrete surfaces are not covered, keep them moist by flushing or sprinkling. Continue curing for at least 7 days after placing the concrete. Concrete surfaces placed against forms may be cured by leaving the forms in place for at least 7 days, when approved.
- B. Protect concrete against freezing or other conditions detrimental to strength development meeting the applicable requirements of this specification.
- C. To aid finishing, side forms on ornamental work, curbs and sidewalks, railing and parapets may be removed after 12 hours, not to exceed 48 hours, depending on weather conditions. Continue moist curing during the concrete finishing operation.
- D. Untreated forms and existing concrete must be kept continuously wet for at least 1 hour before any concrete is placed. Keep wet until covered with concrete except that adequately treated forms must be thoroughly washed with a water spray immediately before placing the concrete.
- E. The curing of concrete, by either water curing or membrane curing, must be as follows unless otherwise approved by the Engineer.

1. Water Curing

- a. Keep all concrete top surfaces continuously moist after finishing, with a fine water spray, until the concrete has set. Cover the moist concrete with water or an approved curing covering.
- b. Cure concrete deck slabs and concrete floors for at least 7 days. Cure by placing burlap, cotton mats or other absorptive material as close behind the finishing operation as possible without marring the finished surface. Keep the absorptive material continuously moist for the full time it is used. The absorptive material may be kept in place for the entire curing period or it may be removed as soon as practical and the entire surface covered with approximately 1-1/2 inches (38.1 mm) of sand, kept continuously moist for the entire curing period.

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- c. Remove forms and repair surface irregularities without interfering with any of the curing requirements. As soon as the vertical forms have been removed and the surface irregularities repaired, cover the concrete with absorptive material, kept continuously wet for the balance of the curing a period.

2. Impervious Membrane Curing

- a. Assure membrane curing compounds are delivered to the job in the manufacturer's original container, clearly labeled to show the name of the manufacturer and the contents. The clear curing compound must be sufficiently transparent and free from permanent color that would change the color of the natural concrete. Use clear compound containing a fugitive dye having color sufficient to render the film visible on the concrete for at least 4 hours after application. The concrete surface must maintain its natural color after curing.
- b. Use a compound ready for use as shipped by the manufacturer. Dilute following the manufacturer's recommendations. Use curing compound only with written approval. Sampling will not be required if manufacturer's certification is available. Apply the curing compound under pressure with a spray nozzle to cover the entire exposed surface thoroughly and completely with a uniform film not exceeding manufacturer's specifications. Maintain the required pressure in the spray machine to force the material to leave the nozzle in a fine mist. Keep all concrete surfaces moist with a fine water spray or with wetted burlap until the sealing compound is applied. Keep the curing compound application close to the finishers of the top surface of concrete at all times. Seal the concrete immediately after the finishing operations have been completed, to the satisfaction of the Engineer.
- c. If it is necessary to allow workers or equipment on the surface before the 7 day curing period is completed, cover the top surface of sealed concrete with a protective cushion for runways. Use a cushion consisting of a moist, 1 -inch (25mm) minimum thick layer of fine sand, or layers of moist burlap that will prevent damage to the finished concrete. Cover the approved cushion with four by eight foot sheets of 3/4 inch (19mm) plywood laid over the cushion. Do not place the cushion material for at least 8 hours after the final application of the curing compound. Obtain the Engineer's written approval for any other proposed cushion material before use. Layers of plastic, visqueen or canvas are not an acceptable cushion material.
- d. Keep concrete, which has not completed its curing period, continuously moist during the stripping and surface repair operations. Remove all surface irregularities, repair all depressions, voids or holes, including those formed by trapped air, to the satisfaction of the Engineer. Immediately apply the curing compound before the surface has had an opportunity to dry out. Keep concrete, from which forms have been stripped, continuously moist until surface repair and finishing are completed and the impervious membrane curing has been applied.

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3.6 WEATHER AND NIGHT LIMITATIONS

A. General

1. Stop concreting operations when darkness prevents obtaining the specified placing, and finishing work. Night operations may be conducted with written approval and when approved artificial lighting is provided.
2. Cold weather concreting is governed by ACI 306 unless otherwise specified herein. Hot weather concreting methods is governed by ACI 305 unless otherwise specified herein. Except by specific written authorization, stop concreting operations when a descending air temperature in the shade and away from artificial heat falls below 40°F (4°C), or do not resume until an ascending air temperature in the shade and away from artificial heat reaches frozen foundation course or subgrade.
3. Assume all risk of placing concrete in cold weather. Placing concrete during cold weather does not relieve the Contractor of the responsibility for obtaining the specified results. Remove and replace all concrete injured by frost at Contractor expense.
4. Before any concrete is placed, remove all ice, snow and frost completely from the formwork receiving the concrete.
5. Heating and Placing Concrete
 - a. When concreting is authorized during cold weather, assure concrete temperature meets ASTM C94.
6. Protection of Concrete
 - a. During the curing period, if the air temperature is anticipated to fall below 32°F (0°C), provide an approved blanket type insulating material along the work for covering all concrete that has been in place for 7 days or less. If, at any time, the ambient temperature drops to 32°F (0°C) or less, protect the concrete using a method approved by the Engineer. The minimum method of protection under such conditions is as follows: between two layers of plastic sheeting, the insulating materials, with the exception of commercial blankets, must be spread loosely to a minimum depth of 6 inches (150mm), but in all cases, to the depth required to prevent freezing of, or frost damage to, the concrete. Maintain the blanketing material at least until the end of the regular specified curing, period which is not less than 7 days. The Engineer may direct leaving the blanketing material in place for an additional period if the recorded temperatures indicate that additional curing may be necessary. If during the construction period the mean daily temperature is expected to fall below 40°F (4°C) for 3 consecutive days, furnish approved heating enclosures and devices capable of maintaining the surface temperature of the concrete in place between 55°F (13°C) and 80°F (26°C). The curing, period under these conditions is 7 days when Type I-II cement is used and 5 days when a pre-approved "high early strength" mix is used. At the close of the curing period, the heat may be reduced so that the temperature inside the housing does not decrease faster than 15° per hour until the temperature inside the housing is the same as outside.

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- b. A Contractor may, at their own expense, field cure concrete cylinders with their in-place concrete and discontinue protection when those field cylinders reach 70 percent of design strength as indicated by the 28 day requirement of these specifications.
- c. Perform all concrete protection using methods consistent with ACI-306-1-87 and approved by the Engineer.

3.7 TESTING

- A. All concrete must be tested by an ACI Grade I or equivalent certified testing technician. Unless otherwise specified, the engineer shall be responsible for all acceptance testing during the on-site placement of the concrete.
 - 1. Materials
 - a. The Engineer or their representative must have access to the ready mix production facility for sampling constituent materials during production to assure the materials meet these specifications and represent those stated on the approved mix design.
 - 2. Standard Slump Tests
 - a. The Engineer shall , during each day's placement, check the consistency of the concrete by slump test. A slump test will also be made each time that strength specimens are made . Slump tests are performed meeting ASTM C143"Method of Test for the Slump of Portland Cement Concrete".
 - 3. Compression Tests
 - a. A minimum of three specimens, 6 inch (150 mm) in diameter or 4 inch(100 mm) , shall be made and tested for every concrete placement. Mold and test one set of test cylinders for every 100 yards (76.5 cubic meters) of concrete or fraction thereof placed each day. On a given project, if the total volume of concrete is such that frequency of testing required above would generate less than 5 strength tests for a given class of concrete, make tests from at least 5 randomly selected batches or from each batch if fewer than 5 batches are used. Cure these cylinders under laboratory conditions except that additional test cylinders cured entirely under field conditions may be required by the Engineer to check the adequacy of curing and protection of the concrete.
 - b. Take samples for strength tests in accordance with ASTM C172, entitled " _ _".
 - c. Mold test cylinders and laboratory-cure in accordance with ASTM C31. Test cylinders in accordance with ASTM C39, entitled " "Method of Test for Compressive Strength of Cylindrical Concrete Specimens", ASTM C39, using an independent testing laboratory, as approved by the Engineer.
 - d. Of each of the 3 cylinders take for a pour, test 1 for information strength at 7 days and test 2 for acceptance strength at 28 days. To meet this

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specification, average strength of two cylinders from the same sample, tested at 28 days or the specified earlier age, is required for each strength test. Strength level of an individual class of concrete is considered satisfactory if both of the following requirements are met:

- 1) The average of all sets of 3 consecutive tests equal or exceed the specified strength.
 - 2) No individual strength test (average of two cylinders) falls below specified strength by more than 500 psi (3400 kPa).
- e. Cure field cured cylinders under field conditions meeting Section 7.4 of "Method of Making and Curing Concrete Test Specimens in the Field" (ASTM C31).
- f. Mold field cured test cylinders at the same time and from the same samples as laboratory cured test cylinders. Improve procedures for protecting and curing concrete when strength of field cured cylinders at the test age designated for measuring specified strength is less than 85 percent of that of companion laboratory cured cylinders. When laboratory cured cylinder strengths are appreciably higher than the specified strength, field cured cylinder strengths need not exceed the specified strength by more than 500 psi (3400 kPa) even though the 85 percent criterion is met.
- g. The strengths of any specimens cured on the job are to indicate the adequacy of protection and curing of the concrete and may be used to determine when the forms may be stripped, shoring removed or the structure placed in service. When the strengths of the job cured specimens are below those specified above, the Contractor must improve the procedures for protecting and curing the concrete.
- h. When concrete fails to meet the requirements above or when tests of field cured cylinders indicate deficiencies in protection and curing, the Owner's representative may order tests on the hardened concrete under Chapter 17.3 of ACI-301-84 or order load tests in Chapter 20 of the ACI Building Code (ACI 318-83) for that portion of the structure where the questionable concrete has been placed. In the event the load or core tests indicate that the structure is unsatisfactory, make all modifications as directed by the Engineer to make the structure sound. If the load or core tests indicate the concrete is satisfactory, all cost of testing shall be paid by Owner.
4. Air Content Tests
- a. The Engineer shall during each strength test, check the air content by either the "Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method" (ASTM C23 1), "Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method" (ASTM C173) or "Method of Test for Unit Weight, Yield and Air Content (Gravimetric) of Concrete" (ASTM C138)
5. Temperature
- a. Test hourly when air temperature is 40°F (4°C) and below, and when 80°F (27°C) and above; and each time a set of compression test specimens is made.

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PART 4: MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. The method of measurement and basis of payment is as outlined in the specifications for the various items of concrete work.

4.2 REQUIRED SUBMITTALS

- A. The following are submittals required to become an approved source of supply for Portland Cement concrete placed in the City right-of-way:
1. Complete concrete mix design meeting all specification requirements. Meet the Mix proportions specified in ACI 301, Chapter 3. Submittals will include the following:

MIX PROPORTIONS

-cement in lbs (kgs)	Type and source of supply
-coarse aggregate	Size and source of supply
-fine aggregate	Source of supply
-water, gallons(liters)	City or well
-admixtures,oz/yd3(g/M3)	Brand and description*

*description as retarder, accelerator, air entraining, etc.

B. MATERIALS INFORMATION

1. Specific gravity (bulk s.s.d. Basis) of coarse and fine aggregate and 1 percent absorption-coarse aggregate unit weight (dry-rodded)-ASTM C33 quality tests including the following:

a. Fine aggregate

- 1) gradation AASHTO, T27 and T11 deleterious substances
soundness (AASHTO T104) organic impurities (AASHTO T21)
mortar-making properties (AASHTO T71)

b. Coarse aggregate

- 1) deleterious substances gradation (AASHTO T27 and T11)
soundness (AASHTO T104) percentage of wear (AASHTO T96)

c. Current chemical analysis of mixing water (if well)

d. Current cement mill analysis

2. CONCRETE MIX DATA

a. slump

b. % air

c. unit weight

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d. 7 and 28 day compressive strength

3. VARIATIONS

a. The following variations will be cause for submittal of a new mix design.

- 1) Change of aggregate source
- 2) Change of cement content
- 3) Addition or exclusion of certain admixtures including, but not limited to, pozzolans, accelerators, retarders and water reducers
- 4) Change in aggregate size
- 5) Change in type of cement
- 6) Failure to attain strength requirements as outlined in ACI 214 or ASTM C94

b. A variation in any of the following will require 'Informing the City Engineer and possibly data indicating acceptability for use in existing mix designs.

- 1) Change of cement supplier
- 2) Change of admixture brands or dosages (not types)
- 3) Minor adjustments of aggregate proportions accompanying materials changes or to accommodate placement conditions (same w/c ratio)

C. Certification of Ready Mixed Concrete Production Facilities

1. Concrete producers are to allow access to their facilities by Engineer or their representatives for inspecting their facilities and/or sampling materials. All facilities should meet the requirements of the "National Ready-Mix Concrete Association" check list for concrete production facilities.
2. Items directly affecting a facility's ability to properly proportion, transport and deliver concrete may be reason for disqualifying that facility as a source of supply until such deficiencies are corrected. Examples would include cement and aggregate scales that will not accurately weight materials or mixer units that will not thoroughly mix concrete materials.

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- D. The following chart indicates the submittal frequency for each item required for approval as a source of supply.

**TABLE 4.1 SUBMITTAL
FREQUENCY**

SUBMITTAL	FREQUENCY		
	Monthly	Twice Yearly	Other
1- Complete mix design			(See Item 1, No 4)
2. Aggregate gradations	X		With mix design
3. L.A. Abrasion			With mix design
4. Soundness			With mix design
5. Deleterious substances			With mix design
6. Water quality (if well)		X	
6a. Cube strengths and time of set			With mix design
7. Cement mill certificates	X		
8. Organic Impurities			With mix design
9. Inspection of facilities			As indicated

Note: The above chart applies to the first year of this program. Frequency of submittals may change as dictated by variations of test data.

END OF SECTION

SECTION 328400 - PLANTING IRRIGATION

Part 1 - General

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Piping.
 - 2. Manual valves.
 - 3. Automatic control valves.
 - 4. Automatic drain valves.
 - 5. Transition fittings.
 - 6. Dielectric fittings.
 - 7. Miscellaneous piping specialties.
 - 8. Drip irrigation specialties.
 - 9. Controllers.
 - 10. Boxes for automatic control valves.

1.3 DEFINITIONS

- A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.
- B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
- C. ET Controllers: Evapo Transpiration Controllers. Irrigation controllers which use some method of weather-based adjustment of irrigation. These adjusting methods include use of historical monthly averages of ET; broadcasting of ET measurements; or use of on-site sensors to track ET.
- D. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 PERFORMANCE REQUIREMENTS

- A. Irrigation zone control shall be automatic operation with controller and automatic control valves.
- B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.

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- C. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- D. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
 - 1. Irrigation Main Piping: 200 psig
 - 2. Circuit Piping: 200 psig

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions such as signs and light standards.
- B. Qualification Data: For qualified Installer.
- C. Zoning Chart: Show each irrigation zone and its control valve.
- D. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For controllers and automatic control valves to include in operation and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Drip-Tube System Tubing: Equal to 10 percent of total length installed for each type and size indicated, but not less than 100 feet.

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1.9 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers that include a certified irrigation designer qualified by The Irrigation Association.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.11 PROJECT CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
 - 2. Do not proceed with interruption of water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- B. Galvanized-Steel Pipe: ASTM A53/A53M, Standard Weight, Type E, Grade B.
 - 1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Standard Weight, seamless-steel pipe with threaded ends.
 - 2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
 - 3. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
 - 4. Cast-Iron Flanges: ASME B16.1, Class 125.
- C. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

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- D. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Gaskets: AWWA C111, rubber.
- E. Soft Copper Tube: ASTM B88, Type L (ASTM B88M, Type B), water tube, annealed temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- F. Hard Copper Tube: ASTM B88, Type L (ASTM B88M, Type B), water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- G. PVC Pipe: ASTM D1785, PVC 1120 compound, Schedules 40 and 80.
 - 1. PVC Socket Fittings: ASTM D2466, Schedules 40 and 80.
 - 2. PVC Threaded Fittings: ASTM D2464, Schedule 80.
 - 3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

2.2 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick unless otherwise indicated; full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
- E. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.
- F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 MANUAL VALVES

- A. Brass Ball Valves:

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1. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Forged brass.
- f. Ends: Threaded or solder joint if indicated.
- g. Seats: PTFE or TFE.
- h. Stem: Brass.
- i. Ball: Chrome-plated brass.
- j. Port: Full or regular, but not reduced.

B. Bronze Ball Valves:

1. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Bronze.
- f. Ends: Threaded or solder joint if indicated.
- g. Seats: PTFE or TFE.
- h. Stem: Bronze.
- i. Ball: Chrome-plated brass.
- j. Port: Full or regular, but not reduced.

C. Iron Ball Valves:

1. Description:

- a. Standard: MSS SP-72.
- b. CWP Rating: 200 psig.
- c. Body Design: Split body.
- d. Body Material: ASTM A126, gray iron.
- e. Ends: Flanged.
- f. Seats: PTFE or TFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel.
- i. Port: Full.

D. Plastic Ball Valves:

1. Description:

- a. Standard: MSS SP-122.
- b. Pressure Rating: 150.
- c. Body Material: PVC.
- d. Type: Union.
- e. End Connections: Socket or threaded.
- f. Port: Full.

E. Bronze Gate Valves:

1. Description:

- a. Standard: MSS SP-80, Type 2.

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- b. Class: 125.
- c. CWP Rating: 200 psig.
- d. Body Material: ASTM B62 bronze with integral seat and screw-in bonnet.
- e. Ends: Threaded or solder joint.
- f. Stem: Bronze, nonrising.
- g. Disc: Solid wedge; bronze.
- h. Packing: Asbestos free.
- i. Handwheel: Malleable iron, bronze, or aluminum.

F. Iron Gate Valves, NRS:

1. Description:

- a. Standard: MSS SP-70, Type I.
- b. CWP Rating: 200 psig.
- c. Body Material: ASTM A126, gray iron with bolted bonnet.
- d. Ends: Flanged.
- e. Trim: All bronze.
- f. Disc: Solid wedge.
- g. Packing and Gasket: Asbestos free.

G. Iron Gate Valves, OS&Y:

1. Description:

- a. Standard: MSS SP-70, Type I.
- b. CWP Rating: 200 psig.
- c. Body Material: ASTM A126, gray iron with bolted bonnet.
- d. Ends: Flanged.
- e. Trim: All bronze.
- f. Disc: Solid wedge.
- g. Packing and Gasket: Asbestos free.

2.4 AUTOMATIC CONTROL VALVES

A. Plastic, Automatic Control Valves:

- 1. Rainbird Control Zone Kit or approved equal
- 2. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.
 - a. Pressure Regulated
 - b. Integral filtration: 200 mesh stainless steel screen
 - c. Size: per zone flow requirements.

2.5 AUTOMATIC DRAIN VALVES

- ### A.
- Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig.

2.6 TRANSITION FITTINGS

- ### A.
- General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

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- B. Plastic-to-Metal Transition Fittings:
 - 1. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket end.
- C. Plastic-to-Metal Transition Unions:
 - 1. Description: MSS SP-107, PVC four-part union. Include one brass threaded end, one solvent-cement-joint plastic end, rubber O-ring, and union nut.

2.7 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions:
 - 1. Description: Factory-fabricated union, NPS 2 (DN 50) and smaller.
 - a. Pressure Rating: 150 psig minimum at 180 deg F (82 deg C).
 - b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
- C. Dielectric-Flange Kits:
 - 1. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 (DN 65) and larger.
 - a. Pressure Rating: 150 psig minimum.
 - b. Gasket: Neoprene or phenolic.
 - c. Bolt Sleeves: Phenolic or polyethylene.
 - d. Washers: Phenolic with steel backing washers.
- D. Dielectric Couplings:
 - 1. Description: Galvanized-steel coupling.
 - a. Pressure Rating: 300 psig at 225 deg F (107 deg C).
 - b. End Connections: Female threaded.
 - c. Lining: Inert and noncorrosive, thermoplastic lining.
- E. Dielectric Nipples:
 - 1. Description: Electroplated steel nipple complying with ASTM F1545.
 - a. Pressure Rating: 300 psig at 225 deg F (107 deg C)
 - b. End Connections: Male threaded or grooved.
 - c. Lining: Inert and noncorrosive, propylene.

2.8 DRIP IRRIGATION SPECIALTIES

- A. Rainbird XFD On-Surface Drip Line or approved equal
 - 1. Tubing: Flexible PE or PVC with plugged end.
 - 2. Emitters: Devices to deliver water at approximately 20 psig.
 - a. Body Material: PE or vinyl, with flow control.
 - 3. Capacities and Characteristics:

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- a. Tubing Size: NPS 1/2
 - b. Emitter Spacing: Per manufacturer's recommendation for soil type.
 - c. Emitter Flow: Per manufacturer's recommendation for soil type.
- B. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.
- C. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.9 CONTROLLERS

- A. Rainbird ESP-LX Controller or approved equal
- B. Description:
- 1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 12 to 48 minutes. Include switch for manual or automatic operation of each station.
 - 2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
 - a. Body Material: Molded plastic.
 - b. Mounting: Surface type for wall.
 - 3. Control Transformer: 24-V secondary, with primary fuse.
 - 4. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.
 - a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
 - b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
 - c. Surge Protection: Metal-oxide-varistor type on each station and primary power.
 - 5. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
 - 6. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
 - a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
 - c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector, or crimped joint and epoxy resin moisture seal; suitable for direct burial.

2.10 BOXES FOR AUTOMATIC CONTROL VALVES

- A. Plastic Boxes:
- 1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

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- a. Size: As required for valves and service.
- b. Shape: Round, Square, Rectangular.
- c. Sidewall Material: PE, ABS, or FRP.
- d. Cover Material: PE, ABS, or FRP.

1) Lettering: IRRIGATION."

- B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4-inch (19 mm) minimum to 3 inches (75 mm) maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
- B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches (150 mm) below subgrade under pavement and slabs.
- C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches, to 12 inches 300 mm below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.
- D. Provide minimum cover over top of underground piping according to the following:
 - 1. Irrigation Main Piping: Minimum depth of 36 inches (900 mm) below finished grade, or not less than 18 inches below average local frost depth, whichever is deeper.
 - 2. Circuit Piping: 12 inches
 - 3. Drain Piping: 12 inches
 - 4. Sleeves: 24 inches

3.2 PREPARATION

- A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

3.3 PIPING INSTALLATION

- A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with NPS 2 (DN 50) or smaller pipe connection.

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- G. Install underground thermoplastic piping according to ASTM D2774 and ASTM F690.
- H. Install expansion loops in control-valve boxes for plastic piping.
- I. Lay piping on solid subbase, uniformly sloped without humps or depressions.
- J. Install ductile-iron piping according to AWWA C600.
- K. Install PVC piping in dry weather when temperature is above 40 deg F (5 deg C). Allow joints to cure at least 24 hours at temperatures above 40 deg F (5 deg C) before testing.
- L. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.
- M. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.
- N. Install piping in sleeves under parking lots, roadways, and sidewalks.
- O. Install sleeves made of Schedule 80 PVC pipe and socket fittings, and solvent-cemented joints.
- P. Install transition fittings for plastic-to-metal pipe connections according to the following:
 - 1. Underground Piping:
 - a. NPS 1-1/2 (DN 40) and Smaller: Plastic-to-metal transition fittings.
 - b. NPS 2 (DN 50) and Larger: AWWA transition couplings.
 - 2. Aboveground Piping:
 - a. NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.
 - b. NPS 2 (DN 50) and Larger: Use dielectric flange kits with one plastic flange.
- Q. Install dielectric fittings for dissimilar-metal pipe connections according to the following:
 - 1. Underground Piping:
 - a. NPS 2 (DN 50) and Smaller: Dielectric coupling or dielectric nipple.
 - b. NPS 2-1/2 (DN 65) and Larger: Prohibited except in control-valve box.
 - 2. Aboveground Piping:
 - a. NPS 2 (DN 50) and Smaller: Dielectric union.
 - b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric flange.
 - c. NPS 5 (DN 125) and Larger: Dielectric flange kit.
 - 3. Piping in Control-Valve Boxes:
 - a. NPS 2 (DN 50) and Smaller: Dielectric union.
 - b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric flange.
 - c. NPS 5 (DN 125) and Larger: Dielectric flange kit.

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3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.
- F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.
- G. Copper-Tubing Soldered Joints: Apply ASTM B813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.
- H. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Pressure Piping: Join schedule number, ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
 - 3. PVC Non-pressure Piping: Join according to ASTM D2855.

3.5 VALVE INSTALLATION

- A. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 DRIP IRRIGATION SPECIALTY INSTALLATION

- A. Install drip tubes with direct-attached emitters on ground.
- B. Install application pressure regulators and filter units in piping near device being protected, and in control-valve boxes.
- C. Install air relief valves and vacuum relief valves in piping, and in control-valve boxes.

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3.7 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

- A. Equipment Mounting: Install interior controllers on wall.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Install control cable in same trench as irrigation piping and at least 2 inches (51 mm) below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.8 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221113 "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.
- C. Connect wiring between controllers and automatic control valves.

3.9 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
 - 1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.10 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.

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1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Any irrigation product will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup check according to manufacturer's written instructions.
2. Verify that controllers are installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.12 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.

3.13 CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.14 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.

3.15 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

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- B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.
- C. Aboveground irrigation main piping, NPS 4 (DN 100) and smaller one of the following:
 - 1. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
 - 2. Type L (Type B) hard copper tube, wrought- or cast-copper fittings, and brazed soldered joints.
- D. Underground irrigation main piping, NPS 4 (DN 100) and smaller, shall be one of the following:
 - 1. Schedule 40, PVC pipe and socket fittings, and solvent-cemented joints.
 - 2. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
- E. Circuit piping NPS 2 (DN 50) and smaller, shall be one of the following:
 - 1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
- F. Drain piping shall be the following:
 - 1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

3.16 VALVE SCHEDULE

- A. Drain Valves:

Retain one of first three subparagraphs below.

- 1. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Automatic drain valve.

END OF SECTION 32 84 00

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. DRAWINGS AND GENERAL PROVISIONS OF THE CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION 01 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

1.2 SUMMARY

- A. SECTION INCLUDES:

- 1. PLANTS.
- 2. TREE STABILIZATION.
- 3. TREE-WATERING DEVICES.
- 4. LANDSCAPE EDGINGS.

1.3 ALLOWANCES

- A. ALLOWANCES FOR PLANTS ARE SPECIFIED

- 1. AUTHORIZED WORK INCLUDES WORK REQUIRED BY DRAWINGS AND THE SPECIFICATIONS AND ONLY WORK AUTHORIZED IN WRITING BY ARCHITECT.
- 2. NOTIFY ARCHITECT WEEKLY OF EXTENT OF WORK PERFORMED THAT IS ATTRIBUTABLE TO QUANTITY ALLOWANCES.
- 3. PERFORM WORK THAT EXCEEDS QUANTITY ALLOWANCES ONLY AS AUTHORIZED BY CHANGE ORDERS.

1.4 UNIT PRICES

- A. UNIT PRICES APPLY TO AUTHORIZED WORK COVERED BY QUANTITY ALLOWANCES.
- B. UNIT PRICES APPLY TO ADDITIONS TO AND DELETIONS FROM THE WORK AS AUTHORIZED BY CHANGE ORDERS.

1.5 DEFINITIONS

- A. BACKFILL: THE EARTH USED TO REPLACE OR THE ACT OF REPLACING EARTH IN AN EXCAVATION.
- B. BALLED AND BURLAPPED STOCK: PLANTS DUG WITH FIRM, NATURAL BALLS OF EARTH IN WHICH THEY WERE GROWN, WITH A BALL SIZE NOT LESS THAN DIAMETER AND DEPTH RECOMMENDED BY ANSI Z60.1 FOR TYPE AND SIZE OF PLANT REQUIRED; WRAPPED WITH BURLAP, TIED, RIGIDLY SUPPORTED, AND DRUM LACED WITH TWINE WITH THE ROOT FLARE VISIBLE AT THE SURFACE OF THE BALL AS RECOMMENDED BY ANSI Z60.1.
- C. BALLED AND POTTED STOCK: PLANTS DUG WITH FIRM, NATURAL BALLS OF EARTH IN WHICH THEY ARE GROWN AND PLACED, UNBROKEN, IN A CONTAINER. BALL SIZE IS NOT LESS THAN DIAMETER AND DEPTH RECOMMENDED BY ANSI Z60.1 FOR TYPE AND SIZE OF PLANT REQUIRED.

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- D. BARE-ROOT STOCK: PLANTS WITH A WELL-BRANCHED, FIBROUS-ROOT SYSTEM DEVELOPED BY TRANSPLANTING OR ROOT PRUNING, WITH SOIL OR GROWING MEDIUM REMOVED, AND WITH NOT LESS THAN THE MINIMUM ROOT SPREAD ACCORDING TO ANSI Z60.1 FOR TYPE AND SIZE OF PLANT REQUIRED.
 - E. CONTAINER-GROWN STOCK: HEALTHY, VIGOROUS, WELL-ROOTED PLANTS GROWN IN A CONTAINER, WITH A WELL-ESTABLISHED ROOT SYSTEM REACHING SIDES OF CONTAINER AND MAINTAINING A FIRM BALL WHEN REMOVED FROM CONTAINER. CONTAINER SHALL BE RIGID ENOUGH TO HOLD BALL SHAPE AND PROTECT ROOT MASS DURING SHIPPING AND BE SIZED ACCORDING TO ANSI Z60.1 FOR TYPE AND SIZE OF PLANT REQUIRED.
 - F. FABRIC BAG-GROWN STOCK: HEALTHY, VIGOROUS, WELL-ROOTED PLANTS ESTABLISHED AND GROWN IN-GROUND IN A POROUS FABRIC BAG WITH WELL-ESTABLISHED ROOT SYSTEM REACHING SIDES OF FABRIC BAG. FABRIC BAG SIZE IS NOT LESS THAN DIAMETER, DEPTH, AND VOLUME REQUIRED BY ANSI Z60.1 FOR TYPE AND SIZE OF PLANT.
 - G. FINISH GRADE: ELEVATION OF FINISHED SURFACE OF PLANTING SOIL.
 - H. PESTICIDE: A SUBSTANCE OR MIXTURE INTENDED FOR PREVENTING, DESTROYING, REPELLING, OR MITIGATING A PEST. PESTICIDES INCLUDE INSECTICIDES, MITICIDES, HERBICIDES, FUNGICIDES, RODENTICIDES, AND MOLLUSCICIDES. THEY ALSO INCLUDE SUBSTANCES OR MIXTURES INTENDED FOR USE AS A PLANT REGULATOR, DEFOLIANT, OR DESICCANT. SOME SOURCES CLASSIFY HERBICIDES SEPARATELY FROM PESTICIDES.
 - I. PESTS: LIVING ORGANISMS THAT OCCUR WHERE THEY ARE NOT DESIRED OR THAT CAUSE DAMAGE TO PLANTS, ANIMALS, OR PEOPLE. PESTS INCLUDE INSECTS, MITES, GRUBS, MOLLUSKS (SNAILS AND SLUGS), RODENTS (GOPHERS, MOLES, AND MICE), UNWANTED PLANTS (WEEDS), FUNGI, BACTERIA, AND VIRUSES.
 - J. PLANTING AREA: AREAS TO BE PLANTED.
 - K. PLANTING SOIL: EXISTING, ON-SITE SOIL; IMPORTED SOIL; OR MANUFACTURED SOIL THAT HAS BEEN MODIFIED WITH SOIL AMENDMENTS AND PERHAPS FERTILIZERS TO PRODUCE A SOIL MIXTURE BEST FOR PLANT GROWTH.
 - L. PLANT; PLANTS; PLANT MATERIAL: THESE TERMS REFER TO VEGETATION IN GENERAL, INCLUDING TREES, SHRUBS, VINES, GROUND COVERS, ORNAMENTAL GRASSES, BULBS, CORMS, TUBERS, OR HERBACEOUS VEGETATION.
 - M. ROOT FLARE: ALSO CALLED "TRUNK FLARE." THE AREA AT THE BASE OF THE PLANT'S STEM OR TRUNK WHERE THE STEM OR TRUNK BROADENS TO FORM ROOTS, THE AREA OF TRANSITION BETWEEN THE ROOT SYSTEM AND THE STEM OR TRUNK.
 - N. STEM GIRDLING ROOTS: ROOTS THAT ENCIRCLE THE STEMS (TRUNKS) OF TREES BELOW THE SOIL SURFACE.
 - O. SUBGRADE: THE SURFACE OR ELEVATION OF SUBSOIL REMAINING AFTER EXCAVATION IS COMPLETE, OR THE TOP SURFACE OF A FILL OR BACKFILL BEFORE PLANTING SOIL IS PLACED.
- 1.6 COORDINATION
- A. COORDINATION WITH TURF AREAS (LAWNS): PLANT TREES, SHRUBS, AND OTHER PLANTS AFTER FINISH GRADES ARE ESTABLISHED AND BEFORE PLANTING TURF AREAS UNLESS OTHERWISE INDICATED.

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1. WHEN PLANTING TREES, SHRUBS, AND OTHER PLANTS AFTER PLANTING TURF AREAS, PROTECT TURF AREAS, AND PROMPTLY REPAIR DAMAGE CAUSED BY PLANTING OPERATIONS.
- 1.7 PREINSTALLATION MEETINGS
- 1.8 ACTION SUBMITTALS
- A. PRODUCT DATA: FOR EACH TYPE OF PRODUCT.
1. PLANT MATERIALS: INCLUDE QUANTITIES, SIZES, QUALITY, AND SOURCES FOR PLANT MATERIALS.
 2. PLANT PHOTOGRAPHS: INCLUDE COLOR PHOTOGRAPHS IN DIGITAL FORMAT OF EACH REQUIRED SPECIES AND SIZE OF PLANT MATERIAL AS IT WILL BE FURNISHED TO PROJECT. TAKE PHOTOGRAPHS FROM AN ANGLE DEPICTING TRUE SIZE AND CONDITION OF THE TYPICAL PLANT TO BE FURNISHED. INCLUDE A SCALE ROD OR OTHER MEASURING DEVICE IN EACH PHOTOGRAPH. FOR SPECIES WHERE MORE THAN 20 PLANTS ARE REQUIRED, INCLUDE A MINIMUM OF THREE PHOTOGRAPHS SHOWING THE AVERAGE PLANT, THE BEST QUALITY PLANT, AND THE WORST QUALITY PLANT TO BE FURNISHED. IDENTIFY EACH PHOTOGRAPH WITH THE FULL SCIENTIFIC NAME OF THE PLANT, PLANT SIZE, AND NAME OF THE GROWING NURSERY.
- B. SAMPLES FOR VERIFICATION: FOR EACH OF THE FOLLOWING:
1. TREES AND SHRUBS: THREE SAMPLES OF EACH VARIETY AND SIZE DELIVERED TO SITE FOR REVIEW. MAINTAIN APPROVED SAMPLES ON-SITE AS A STANDARD FOR COMPARISON.
 2. COMPOST MULCH: 1-QUART (1-L) VOLUME OF EACH ORGANIC MULCH REQUIRED; IN SEALED PLASTIC BAGS LABELED WITH COMPOSITION OF MATERIALS BY PERCENTAGE OF WEIGHT AND SOURCE OF MULCH. EACH SAMPLE SHALL BE TYPICAL OF THE LOT OF MATERIAL TO BE FURNISHED; PROVIDE AN ACCURATE REPRESENTATION OF COLOR, TEXTURE, AND ORGANIC MAKEUP.
 3. MINERAL MULCH: 2 LB (1.0 KG) OF EACH MINERAL MULCH REQUIRED, IN SEALED PLASTIC BAGS LABELED WITH SOURCE OF MULCH. SAMPLE SHALL BE TYPICAL OF THE LOT OF MATERIAL TO BE DELIVERED AND INSTALLED ON-SITE; PROVIDE AN ACCURATE INDICATION OF COLOR, TEXTURE, AND MAKEUP OF THE MATERIAL.
 4. PROPRIETARY ROOT-BALL-STABILIZATION DEVICE: ONE UNIT.
 5. SLOW-RELEASE, TREE-WATERING DEVICE: ONE UNIT OF EACH SIZE REQUIRED.
 6. EDGING MATERIALS AND ACCESSORIES: MANUFACTURER'S STANDARD SIZE, TO VERIFY COLOR SELECTED.
 7. ROOT BARRIER: WIDTH OF PANEL BY 12 INCHES (300 MM).
- 1.9 INFORMATIONAL SUBMITTALS
- A. QUALIFICATION DATA: FOR LANDSCAPE INSTALLER. INCLUDE LIST OF SIMILAR PROJECTS COMPLETED BY INSTALLER DEMONSTRATING INSTALLER'S CAPABILITIES AND EXPERIENCE. INCLUDE PROJECT NAMES, ADDRESSES, AND YEAR COMPLETED, AND INCLUDE NAMES AND ADDRESSES OF OWNERS' CONTACT PERSONS.
- B. PRODUCT CERTIFICATES: FOR EACH TYPE OF MANUFACTURED PRODUCT, FROM MANUFACTURER, AND COMPLYING WITH THE FOLLOWING:
1. MANUFACTURER'S CERTIFIED ANALYSIS OF STANDARD PRODUCTS.

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2. ANALYSIS OF OTHER MATERIALS BY A RECOGNIZED LABORATORY MADE ACCORDING TO METHODS ESTABLISHED BY THE ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, WHERE APPLICABLE.
 - C. PESTICIDES AND HERBICIDES: PRODUCT LABEL AND MANUFACTURER'S APPLICATION INSTRUCTIONS SPECIFIC TO PROJECT.
 - D. SAMPLE WARRANTY: FOR SPECIAL WARRANTY.
- 1.10 CLOSEOUT SUBMITTALS
- A. MAINTENANCE DATA: RECOMMENDED PROCEDURES TO BE ESTABLISHED BY OWNER FOR MAINTENANCE OF PLANTS DURING A CALENDAR YEAR. SUBMIT BEFORE EXPIRATION OF REQUIRED MAINTENANCE PERIODS.
- 1.11 QUALITY ASSURANCE
- A. INSTALLER QUALIFICATIONS: A QUALIFIED LANDSCAPE INSTALLER WHOSE WORK HAS RESULTED IN SUCCESSFUL ESTABLISHMENT OF PLANTS.
 1. PROFESSIONAL MEMBERSHIP: INSTALLER SHALL BE A MEMBER IN GOOD STANDING OF EITHER THE PROFESSIONAL LANDSCAPE NETWORK OR THE AMERICAN NURSERY AND LANDSCAPE ASSOCIATION.
 2. EXPERIENCE: THREE YEARS' EXPERIENCE IN LANDSCAPE INSTALLATION
 3. INSTALLER'S FIELD SUPERVISION: REQUIRE INSTALLER TO MAINTAIN AN EXPERIENCED FULL-TIME SUPERVISOR ON PROJECT SITE WHEN WORK IS IN PROGRESS.
 4. PERSONNEL CERTIFICATIONS: INSTALLER'S FIELD SUPERVISOR SHALL HAVE CERTIFICATION IN ONE OF THE FOLLOWING CATEGORIES FROM THE PROFESSIONAL LANDSCAPE NETWORK:
 - A. LANDSCAPE INDUSTRY CERTIFIED TECHNICIAN - EXTERIOR.
 - B. LANDSCAPE INDUSTRY CERTIFIED INTERIOR.
 - C. LANDSCAPE INDUSTRY CERTIFIED HORTICULTURAL TECHNICIAN.
 5. PESTICIDE APPLICATOR: STATE LICENSED, COMMERCIAL.
 - B. PROVIDE QUALITY, SIZE, GENUS, SPECIES, AND VARIETY OF PLANTS INDICATED, COMPLYING WITH APPLICABLE REQUIREMENTS IN ANSI Z60.1.
 1. SELECTION OF PLANTS PURCHASED UNDER ALLOWANCES IS MADE BY ARCHITECT, WHO TAGS PLANTS AT THEIR PLACE OF GROWTH BEFORE THEY ARE PREPARED FOR TRANSPLANTING.
 - C. MEASUREMENTS: MEASURE ACCORDING TO ANSI Z60.1. DO NOT PRUNE TO OBTAIN REQUIRED SIZES.
 1. TREES AND SHRUBS: MEASURE WITH BRANCHES AND TRUNKS OR CANES IN THEIR NORMAL POSITION. TAKE HEIGHT MEASUREMENTS FROM OR NEAR THE TOP OF THE ROOT FLARE FOR FIELD-GROWN STOCK AND CONTAINER-GROWN STOCK. MEASURE MAIN BODY OF TREE OR SHRUB FOR HEIGHT AND SPREAD; DO NOT MEASURE BRANCHES OR ROOTS TIP TO TIP. TAKE CALIPER MEASUREMENTS 6 INCHES (150 MM) ABOVE THE ROOT FLARE FOR TREES UP TO 4-INCH (100-MM) CALIPER SIZE, AND 12 INCHES (300 MM) ABOVE THE ROOT FLARE FOR LARGER SIZES.
 2. OTHER PLANTS: MEASURE WITH STEMS, PETIOLES, AND FOLIAGE IN THEIR NORMAL POSITION.

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- D. PLANT MATERIAL OBSERVATION: ARCHITECT MAY OBSERVE PLANT MATERIAL EITHER AT PLACE OF GROWTH OR AT SITE BEFORE PLANTING FOR COMPLIANCE WITH REQUIREMENTS FOR GENUS, SPECIES, VARIETY, CULTIVAR, SIZE, AND QUALITY. ARCHITECT MAY ALSO OBSERVE TREES AND SHRUBS FURTHER FOR SIZE AND CONDITION OF BALLS AND ROOT SYSTEMS, PESTS, DISEASE SYMPTOMS, INJURIES, AND LATENT DEFECTS AND MAY REJECT UNSATISFACTORY OR DEFECTIVE MATERIAL AT ANY TIME DURING PROGRESS OF WORK. REMOVE REJECTED TREES OR SHRUBS IMMEDIATELY FROM PROJECT SITE.

1. NOTIFY ARCHITECT OF SOURCES OF PLANTING MATERIALS SEVEN DAYS IN ADVANCE OF DELIVERY TO SITE.

1.12 DELIVERY, STORAGE, AND HANDLING

- A. PACKAGED MATERIALS: DELIVER PACKAGED MATERIALS IN ORIGINAL, UNOPENED CONTAINERS SHOWING WEIGHT, CERTIFIED ANALYSIS, NAME AND ADDRESS OF MANUFACTURER, AND INDICATION OF COMPLIANCE WITH STATE AND FEDERAL LAWS IF APPLICABLE.
- B. BULK MATERIALS:
1. DO NOT DUMP OR STORE BULK MATERIALS NEAR STRUCTURES, UTILITIES, WALKWAYS AND PAVEMENTS, OR ON EXISTING TURF AREAS OR PLANTS.
 2. PROVIDE EROSION-CONTROL MEASURES TO PREVENT EROSION OR DISPLACEMENT OF BULK MATERIALS; DISCHARGE OF SOIL-BEARING WATER RUNOFF; AND AIRBORNE DUST REACHING ADJACENT PROPERTIES, WATER CONVEYANCE SYSTEMS, OR WALKWAYS.
 3. ACCOMPANY EACH DELIVERY OF BULK MATERIALS WITH APPROPRIATE CERTIFICATES.
- C. DO NOT PRUNE TREES AND SHRUBS BEFORE DELIVERY. PROTECT BARK, BRANCHES, AND ROOT SYSTEMS FROM SUN SCALD, DRYING, WIND BURN, SWEATING, WHIPPING, AND OTHER HANDLING AND TYING DAMAGE. DO NOT BEND OR BIND-TIE TREES OR SHRUBS IN SUCH A MANNER AS TO DESTROY THEIR NATURAL SHAPE. PROVIDE PROTECTIVE COVERING OF PLANTS DURING SHIPPING AND DELIVERY. DO NOT DROP PLANTS DURING DELIVERY AND HANDLING.
- D. HANDLE PLANTING STOCK BY ROOT BALL.
- E. STORE BULBS, CORMS, AND TUBERS IN A DRY PLACE AT 60 TO 65 DEG F (16 TO 18 DEG C) UNTIL PLANTING.
- F. APPLY ANTIDESICCANT TO TREES AND SHRUBS USING POWER SPRAY TO PROVIDE AN ADEQUATE FILM OVER TRUNKS (BEFORE WRAPPING), BRANCHES, STEMS, TWIGS, AND FOLIAGE TO PROTECT DURING DIGGING, HANDLING, AND TRANSPORTATION.
1. IF DECIDUOUS TREES OR SHRUBS ARE MOVED IN FULL LEAF, SPRAY WITH ANTIDESICCANT AT NURSERY BEFORE MOVING AND AGAIN TWO WEEKS AFTER PLANTING.
- G. WRAP TREES AND SHRUBS WITH BURLAP FABRIC OVER TRUNKS, BRANCHES, STEMS, TWIGS, AND FOLIAGE TO PROTECT FROM WIND AND OTHER DAMAGE DURING DIGGING, HANDLING, AND TRANSPORTATION.
- H. DELIVER PLANTS AFTER PREPARATIONS FOR PLANTING HAVE BEEN COMPLETED, AND INSTALL IMMEDIATELY. IF PLANTING IS DELAYED MORE THAN SIX HOURS AFTER DELIVERY, SET PLANTS AND TREES IN THEIR APPROPRIATE ASPECT (SUN, FILTERED SUN, OR SHADE), PROTECT FROM WEATHER AND MECHANICAL DAMAGE, AND KEEP ROOTS MOIST.

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1. HEEL-IN BARE-ROOT STOCK. SOAK ROOTS THAT ARE IN LESS THAN MOIST CONDITION IN WATER FOR TWO HOURS. REJECT PLANTS WITH DRY ROOTS.
2. SET BALLED STOCK ON GROUND AND COVER BALL WITH SOIL, PEAT MOSS, SAWDUST, OR OTHER ACCEPTABLE MATERIAL.
3. DO NOT REMOVE CONTAINER-GROWN STOCK FROM CONTAINERS BEFORE TIME OF PLANTING.
4. WATER ROOT SYSTEMS OF PLANTS STORED ON-SITE DEEPLY AND THOROUGHLY WITH A FINE-MIST SPRAY. WATER AS OFTEN AS NECESSARY TO MAINTAIN ROOT SYSTEMS IN A MOIST, BUT NOT OVERLY WET CONDITION.

1.13 FIELD CONDITIONS

- A. FIELD MEASUREMENTS: VERIFY ACTUAL GRADE ELEVATIONS, SERVICE AND UTILITY LOCATIONS, IRRIGATION SYSTEM COMPONENTS, AND DIMENSIONS OF PLANTINGS AND CONSTRUCTION CONTIGUOUS WITH NEW PLANTINGS BY FIELD MEASUREMENTS BEFORE PROCEEDING WITH PLANTING WORK.
- B. PLANTING RESTRICTIONS: PLANT DURING ONE OF THE FOLLOWING PERIODS. COORDINATE PLANTING PERIODS WITH MAINTENANCE PERIODS TO PROVIDE REQUIRED MAINTENANCE FROM DATE OF SUBSTANTIAL COMPLETION.
 1. SPRING PLANTING: MARCH - JUNE
 2. FALL PLANTING: SEPTEMBER - DECEMBER
- C. WEATHER LIMITATIONS: PROCEED WITH PLANTING ONLY WHEN EXISTING AND FORECASTED WEATHER CONDITIONS PERMIT PLANTING TO BE PERFORMED WHEN BENEFICIAL AND OPTIMUM RESULTS MAY BE OBTAINED. APPLY PRODUCTS DURING FAVORABLE WEATHER CONDITIONS ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS AND WARRANTY REQUIREMENTS.

1.14 WARRANTY

- A. SPECIAL WARRANTY: INSTALLER AGREES TO REPAIR OR REPLACE PLANTINGS AND ACCESSORIES THAT FAIL IN MATERIALS, WORKMANSHIP, OR GROWTH WITHIN SPECIFIED WARRANTY PERIOD.
 1. FAILURES INCLUDE, BUT ARE NOT LIMITED TO, THE FOLLOWING:
 - A. DEATH AND UNSATISFACTORY GROWTH, EXCEPT FOR DEFECTS RESULTING FROM ABUSE, LACK OF ADEQUATE MAINTENANCE, OR NEGLECT BY OWNER.
 - B. STRUCTURAL FAILURES INCLUDING PLANTINGS FALLING OR BLOWING OVER.
 - C. FAULTY PERFORMANCE OF TREE STABILIZATION.
 - D. DETERIORATION OF METALS, METAL FINISHES, AND OTHER MATERIALS BEYOND NORMAL WEATHERING.
 2. WARRANTY PERIODS: FROM DATE OF SUBSTANTIAL COMPLETION.
 - A. TREES, SHRUBS, VINES, AND ORNAMENTAL GRASSES: 12 MONTHS.
 - B. GROUND COVERS, BIENNIALS, PERENNIALS, AND OTHER PLANTS: 12 MONTHS.
 - C. ANNUALS: THREE MONTHS.
 3. INCLUDE THE FOLLOWING REMEDIAL ACTIONS AS A MINIMUM:
 - A. IMMEDIATELY REMOVE DEAD PLANTS AND REPLACE UNLESS REQUIRED TO PLANT IN THE SUCCEEDING PLANTING SEASON.

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- B. REPLACE PLANTS THAT ARE MORE THAN 25 PERCENT DEAD OR IN AN UNHEALTHY CONDITION AT END OF WARRANTY PERIOD.
- C. A LIMIT OF ONE REPLACEMENT OF EACH PLANT IS REQUIRED EXCEPT FOR LOSSES OR REPLACEMENTS DUE TO FAILURE TO COMPLY WITH REQUIREMENTS.
- D. PROVIDE EXTENDED WARRANTY FOR PERIOD EQUAL TO ORIGINAL WARRANTY PERIOD, FOR REPLACED PLANT MATERIAL.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

- A. GENERAL: FURNISH NURSERY-GROWN PLANTS TRUE TO GENUS, SPECIES, VARIETY, CULTIVAR, STEM FORM, SHEARING, AND OTHER FEATURES INDICATED IN PLANT LIST, PLANT SCHEDULE, OR PLANT LEGEND INDICATED ON DRAWINGS AND COMPLYING WITH ANSI Z60.1; AND WITH HEALTHY ROOT SYSTEMS DEVELOPED BY TRANSPLANTING OR ROOT PRUNING. PROVIDE WELL-SHAPED, FULLY BRANCHED, HEALTHY, VIGOROUS STOCK, DENSELY FOLIATED WHEN IN LEAF AND FREE OF DISEASE, PESTS, EGGS, LARVAE, AND DEFECTS SUCH AS KNOTS, SUN SCALD, INJURIES, ABRASIONS, AND DISFIGUREMENT.
 - 1. TREES WITH DAMAGED, CROOKED, OR MULTIPLE LEADERS; TIGHT VERTICAL BRANCHES WHERE BARK IS SQUEEZED BETWEEN TWO BRANCHES OR BETWEEN BRANCH AND TRUNK ("INCLUDED BARK"); CROSSING TRUNKS; CUT-OFF LIMBS MORE THAN 3/4 INCH (19 MM) IN DIAMETER; OR WITH STEM GIRDLING ROOTS ARE UNACCEPTABLE.
 - 2. COLLECTED STOCK: DO NOT USE PLANTS HARVESTED FROM THE WILD, FROM NATIVE STANDS, FROM AN ESTABLISHED LANDSCAPE PLANTING, OR NOT GROWN IN A NURSERY UNLESS OTHERWISE INDICATED.
- B. PROVIDE PLANTS OF SIZES, GRADES, AND BALL OR CONTAINER SIZES COMPLYING WITH ANSI Z60.1 FOR TYPES AND FORM OF PLANTS REQUIRED. PLANTS OF A LARGER SIZE MAY BE USED IF ACCEPTABLE TO ARCHITECT, WITH A PROPORTIONATE INCREASE IN SIZE OF ROOTS OR BALLS.
- C. ROOT-BALL DEPTH: FURNISH TREES AND SHRUBS WITH ROOT BALLS MEASURED FROM TOP OF ROOT BALL, WHICH BEGINS AT ROOT FLARE ACCORDING TO ANSI Z60.1. ROOT FLARE SHALL BE VISIBLE BEFORE PLANTING.
- D. LABELING: LABEL AT LEAST ONE PLANT OF EACH VARIETY, SIZE, AND CALIPER WITH A SECURELY ATTACHED, WATERPROOF TAG BEARING LEGIBLE DESIGNATION OF COMMON NAME AND FULL SCIENTIFIC NAME, INCLUDING GENUS AND SPECIES. INCLUDE NOMENCLATURE FOR HYBRID, VARIETY, OR CULTIVAR, IF APPLICABLE FOR THE PLANT.
- E. IF FORMAL ARRANGEMENTS OR CONSECUTIVE ORDER OF PLANTS IS INDICATED ON DRAWINGS, SELECT STOCK FOR UNIFORM HEIGHT AND SPREAD, AND NUMBER THE LABELS TO ASSURE SYMMETRY IN PLANTING.
- F. ANNUALS PROVIDE HEALTHY, DISEASE-FREE PLANTS OF SPECIES AND VARIETY SHOWN OR LISTED, WITH WELL-ESTABLISHED ROOT SYSTEMS REACHING TO SIDES OF THE CONTAINER TO MAINTAIN A FIRM BALL, BUT NOT WITH EXCESSIVE ROOT GROWTH ENCIRCLING THE CONTAINER. PROVIDE ONLY PLANTS THAT ARE ACCLIMATED TO OUTDOOR CONDITIONS BEFORE DELIVERY.

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2.2 FERTILIZERS

- A. PLANTING TABLETS: TIGHTLY COMPRESSED CHIP-TYPE, LONG-LASTING, SLOW-RELEASE, COMMERCIAL-GRADE PLANTING FERTILIZER IN TABLET FORM. TABLETS SHALL BREAK DOWN WITH SOIL BACTERIA, CONVERTING NUTRIENTS INTO A FORM THAT CAN BE ABSORBED BY PLANT ROOTS.
1. SIZE: 10-GRAM TABLETS.
 2. NUTRIENT COMPOSITION: 20 PERCENT NITROGEN, 10 PERCENT PHOSPHOROUS, AND 5 PERCENT POTASSIUM, BY WEIGHT PLUS MICRONUTRIENTS.

2.3 MULCHES

- A. ORGANIC MULCH: FREE FROM DELETERIOUS MATERIALS AND SUITABLE AS A TOP DRESSING OF TREES AND SHRUBS, CONSISTING OF ONE OF THE FOLLOWING:

RETAIN APPROPRIATE MATERIALS IN "TYPE" SUBPARAGRAPH BELOW.

1. TYPE: SHREDDED HARDWOOD.

RETAIN "SIZE RANGE" SUBPARAGRAPH BELOW IF RETAINING ANY OF FIRST THREE OPTIONS IN "TYPE" SUBPARAGRAPH ABOVE; REVISE TO SUIT PROJECT.

2. SIZE RANGE: 3 INCHES (76 MM) MAXIMUM, 1/2 INCH (13 MM) MINIMUM.
3. COLOR: NATURAL.

- B. COMPOST MULCH: WELL-COMPOSTED, STABLE, AND WEED-FREE ORGANIC MATTER, PH OF 5.5 TO 8; MOISTURE CONTENT 35 TO 55 PERCENT BY WEIGHT; 100 PERCENT PASSING THROUGH A 1-INCH (25-MM) SIEVE; SOLUBLE-SALT CONTENT OF 2 TO 5 DS/M; NOT EXCEEDING 0.5 PERCENT INERT CONTAMINANTS AND FREE OF SUBSTANCES TOXIC TO PLANTINGS; AND AS FOLLOWS:

RETAIN "ORGANIC MATTER CONTENT" SUBPARAGRAPH BELOW IF REQUIRED. ORGANIC MATTER CONTENT FOR COMPOST AFFECTS APPLICATION RATE AND MAY BE AS LOW AS 30 OR AS HIGH AS 70 PERCENT. INSERT SUBPARAGRAPHS FOR OTHER CHARACTERISTICS SUCH AS SOLUBLE-SALT CONTENT, WATER-HOLDING CAPACITY, BULK DENSITY, AND NUTRIENT CONTENT IF REQUIRED.

1. ORGANIC MATTER CONTENT: 50 TO 60 PERCENT OF DRY WEIGHT.

COMPOST MAY BE PRODUCED FROM SEVERAL FEEDSTOCKS OR RAW MATERIALS. IN "FEEDSTOCK" SUBPARAGRAPH BELOW, REVISE TYPES OF FEEDSTOCKS IF LIMITING SOURCES. REVISE DESCRIPTIONS AND INSERT PRODUCT NAMES IF REQUIRED.

2. FEEDSTOCK: AGRICULTURAL, FOOD, OR INDUSTRIAL RESIDUALS; BIOSOLIDS; YARD TRIMMINGS; OR SOURCE-SEPARATED OR COMPOSTABLE MIXED SOLID WASTE.

- C. MINERAL MULCH: HARD, DURABLE STONE, WASHED FREE OF LOAM, SAND, CLAY, AND OTHER FOREIGN SUBSTANCES, OF THE FOLLOWING TYPE, SIZE RANGE, AND COLOR:

1. TYPE: GRANITE CHIPS.

RETAIN OR REVISE SIZES IN "SIZE RANGE" SUBPARAGRAPH BELOW OR INSERT OTHER RANGES TO SUIT PROJECT.

2. SIZE RANGE: 3/4 INCH (19 MM) MAXIMUM, 1/4 INCH (6.4 MM) MINIMUM
3. TAN-BEIGE COLOR RANGE ACCEPTABLE TO ARCHITECT.

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2.4 PESTICIDES

- A. GENERAL: PESTICIDE REGISTERED AND APPROVED BY THE EPA, ACCEPTABLE TO AUTHORITIES HAVING JURISDICTION, AND OF TYPE RECOMMENDED BY MANUFACTURER FOR EACH SPECIFIC PROBLEM AND AS REQUIRED FOR PROJECT CONDITIONS AND APPLICATION. DO NOT USE RESTRICTED PESTICIDES UNLESS AUTHORIZED IN WRITING BY AUTHORITIES HAVING JURISDICTION.
- B. PRE-EMERGENT HERBICIDE (SELECTIVE AND NONSELECTIVE): EFFECTIVE FOR CONTROLLING THE GERMINATION OR GROWTH OF WEEDS WITHIN PLANTED AREAS AT THE SOIL LEVEL DIRECTLY BELOW THE MULCH LAYER.
- C. POST-EMERGENT HERBICIDE (SELECTIVE AND NONSELECTIVE): EFFECTIVE FOR CONTROLLING WEED GROWTH THAT HAS ALREADY GERMINATED.

2.5 TREE-STABILIZATION MATERIALS

A. TRUNK-STABILIZATION MATERIALS:

- 1. UPRIGHT AND GUY STAKES: ROUGH-SAWN, SOUND, NEW HARDWOOD, FREE OF KNOTS, HOLES, CROSS GRAIN, AND OTHER DEFECTS, 2-BY-2-INCH NOMINAL (38-BY-38-MM ACTUAL) BY LENGTH INDICATED, POINTED AT ONE END.
- 2. WOOD DEADMEN: TIMBERS MEASURING 8 INCHES (200 MM) IN DIAMETER AND 48 INCHES (1200 MM) LONG, TREATED WITH SPECIFIED WOOD PRESSURE-PRESERVATIVE TREATMENT.

RETAIN "FLEXIBLE TIES" OR "GUYS AND TIE WIRES" SUBPARAGRAPH BELOW.

- 3. FLEXIBLE TIES: WIDE RUBBER OR ELASTIC BANDS OR STRAPS OF LENGTH REQUIRED TO REACH STAKES OR TURNBUCKLES.
- 4. GUYS AND TIE WIRES: ASTM A641/A641M, CLASS 1, GALVANIZED-STEEL WIRE, TWO-STRAND, TWISTED, 0.106 INCH (2.7 MM) IN DIAMETER.
- 5. TREE-TIE WEBBING: UV-RESISTANT POLYPROPYLENE OR NYLON WEBBING WITH BRASS GROMMETS.

RETAIN "GUY CABLES" SUBPARAGRAPH BELOW FOR TALL AND LARGE-CALIPER TREES.

- 6. GUY CABLES: FIVE-STRAND, 3/16-INCH- (4.8-MM-) DIAMETER, GALVANIZED-STEEL CABLE, WITH ZINC-COATED TURNBUCKLES A MINIMUM OF 3 INCHES (75 MM) LONG, WITH TWO 3/8-INCH (10-MM) GALVANIZED EYEBOLTS.
- 7. FLAGS: STANDARD SURVEYOR'S PLASTIC FLAGGING TAPE, WHITE, 6 INCHES (150 MM) LONG.
- 8. PROPRIETARY STAKING-AND-GUYING DEVICES: PROPRIETARY STAKE OR ANCHOR AND ADJUSTABLE TIE SYSTEMS TO SECURE EACH NEW PLANTING BY PLANT STEM; SIZED AS INDICATED AND ACCORDING TO MANUFACTURER'S WRITTEN RECOMMENDATIONS.

B. ROOT-BALL STABILIZATION MATERIALS:

- 1. UPRIGHT STAKES AND HORIZONTAL HOLD-DOWN: ROUGH-SAWN, SOUND, NEW HARDWOOD OR SOFTWOOD, FREE OF KNOTS, HOLES, CROSS GRAIN, AND OTHER DEFECTS, 2-BY-2-INCH NOMINAL (38-BY-38-MM ACTUAL) BY LENGTH INDICATED; STAKES POINTED AT ONE END.
- 2. WOOD SCREWS: ASME B18.6.1.
- 3. PROPRIETARY ROOT-BALL STABILIZATION DEVICES: PROPRIETARY AT- OR BELOW-GRADE STABILIZATION SYSTEMS TO SECURE EACH NEW PLANTING BY ROOT BALL AND THAT DO NOT ENCIRCLE THE TRUNK; SIZED ACCORDING TO MANUFACTURER'S WRITTEN RECOMMENDATIONS UNLESS OTHERWISE INDICATED.

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2.6 LANDSCAPE EDGINGS

- A. STEEL EDGING: STANDARD COMMERCIAL-STEEL EDGING, FABRICATED IN SECTIONS OF STANDARD LENGTHS, WITH LOOPS STAMPED FROM OR WELDED TO FACE OF SECTIONS TO RECEIVE STAKES.
 - 1. EDGING SIZE: 3/16 INCH (4.8 MM) THICK BY 4 INCHES (100 MM) DEEP.
 - 2. STAKES: TAPERED STEEL, A MINIMUM OF 12 INCHES (300 MM) LONG.
 - 3. ACCESSORIES: STANDARD TAPERED ENDS, CORNERS, AND SPLICERS.
 - 4. FINISH: MANUFACTURER'S STANDARD PAINT.
 - A. PAINT COLOR: BLACK.

2.7 TREE-WATERING DEVICES

- A. SLOW-RELEASE WATERING DEVICE: STANDARD PRODUCT MANUFACTURED FOR DRIP IRRIGATION OF PLANTS AND EMPTYING ITS WATER CONTENTS OVER AN EXTENDED TIME PERIOD; MANUFACTURED FROM UV-LIGHT-STABILIZED NYLON-REINFORCED POLYETHYLENE SHEET, PVC, OR HDPE PLASTIC.
 - 1. COLOR: AS SELECTED BY ARCHITECT FROM MANUFACTURER'S FULL RANGE.

2.8 MISCELLANEOUS PRODUCTS

- A. WOOD PRESSURE-PRESERVATIVE TREATMENT: AWPA U1, USE CATEGORY UC4A; ACCEPTABLE TO AUTHORITIES HAVING JURISDICTION, AND CONTAINING NO ARSENIC OR CHROMIUM.
- B. ROOT BARRIER: BLACK, MOLDED, MODULAR PANELS 18 INCHES (457 MM) HIGH (DEEP), 85 MILS (2.2 MM) THICK, AND WITH VERTICAL ROOT DEFLECTING RIBS PROTRUDING 3/4 INCH (19 MM) OUT FROM PANEL SURFACE; MANUFACTURED WITH MINIMUM 50 PERCENT RECYCLED POLYETHYLENE PLASTIC WITH UV INHIBITORS.
- C. ANTIDESICCANT: WATER-INSOLUBLE EMULSION, PERMEABLE MOISTURE RETARDER, FILM FORMING, FOR TREES AND SHRUBS. DELIVER IN ORIGINAL, SEALED, AND FULLY LABELED CONTAINERS AND MIX ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS.
- D. BURLAP: NON-SYNTHETIC, BIODEGRADABLE.
- E. PLANTER DRAINAGE GRAVEL: WASHED, SOUND CRUSHED STONE OR GRAVEL COMPLYING WITH ASTM D448 FOR SIZE NO. 8.
- F. PLANTER FILTER FABRIC: WOVEN GEOTEXTILE MANUFACTURED FOR SEPARATION APPLICATIONS AND MADE OF POLYPROPYLENE, POLYOLEFIN, OR POLYESTER FIBERS OR COMBINATION OF THEM.
- G. MYCORRHIZAL FUNGI: DRY, GRANULAR INOCULANT CONTAINING AT LEAST 5300 SPORES PER LB (0.45 KG) OF VESICULAR-ARBUSCULAR MYCORRHIZAL FUNGI AND 95 MILLION SPORES PER LB (0.45 KG) OF ECTOMYCORRHIZAL FUNGI, 33 PERCENT HYDROGEL, AND A MAXIMUM OF 5.5 PERCENT INERT MATERIAL.

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PART 3 - EXECUTION

3.1 EXAMINATION

- A. EXAMINE AREAS TO RECEIVE PLANTS, WITH INSTALLER PRESENT, FOR COMPLIANCE WITH REQUIREMENTS AND CONDITIONS AFFECTING INSTALLATION AND PERFORMANCE OF THE WORK.
 - 1. VERIFY THAT NO FOREIGN OR DELETERIOUS MATERIAL OR LIQUID SUCH AS PAINT, PAINT WASHOUT, CONCRETE SLURRY, CONCRETE LAYERS OR CHUNKS, CEMENT, PLASTER, OILS, GASOLINE, DIESEL FUEL, PAINT THINNER, TURPENTINE, TAR, ROOFING COMPOUND, OR ACID HAS BEEN DEPOSITED IN SOIL WITHIN A PLANTING AREA.
 - 2. VERIFY THAT PLANTS AND VEHICLES LOADED WITH PLANTS CAN TRAVEL TO PLANTING LOCATIONS WITH ADEQUATE OVERHEAD CLEARANCE.
 - 3. SUSPEND PLANTING OPERATIONS DURING PERIODS OF EXCESSIVE SOIL MOISTURE UNTIL THE MOISTURE CONTENT REACHES ACCEPTABLE LEVELS TO ATTAIN THE REQUIRED RESULTS.
 - 4. UNIFORMLY MOISTEN EXCESSIVELY DRY SOIL THAT IS NOT WORKABLE OR WHICH IS DUSTY.
- B. IF CONTAMINATION BY FOREIGN OR DELETERIOUS MATERIAL OR LIQUID IS PRESENT IN SOIL WITHIN A PLANTING AREA, REMOVE THE SOIL AND CONTAMINATION AS DIRECTED BY ARCHITECT AND REPLACE WITH NEW PLANTING SOIL.
- C. PROCEED WITH INSTALLATION ONLY AFTER UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED.

3.2 PREPARATION

- A. PROTECT STRUCTURES, UTILITIES, SIDEWALKS, PAVEMENTS, AND OTHER FACILITIES AND TURF AREAS AND EXISTING PLANTS FROM DAMAGE CAUSED BY PLANTING OPERATIONS.
- B. INSTALL EROSION-CONTROL MEASURES TO PREVENT EROSION OR DISPLACEMENT OF SOILS AND DISCHARGE OF SOIL-BEARING WATER RUNOFF OR AIRBORNE DUST TO ADJACENT PROPERTIES AND WALKWAYS.
- C. LAY OUT INDIVIDUAL TREE AND SHRUB LOCATIONS AND AREAS FOR MULTIPLE PLANTINGS. STAKE LOCATIONS, OUTLINE AREAS, ADJUST LOCATIONS WHEN REQUESTED, AND OBTAIN ARCHITECT'S ACCEPTANCE OF LAYOUT BEFORE EXCAVATING OR PLANTING. MAKE MINOR ADJUSTMENTS AS REQUIRED.
- D. LAY OUT PLANTS AT LOCATIONS DIRECTED BY ARCHITECT. STAKE LOCATIONS OF INDIVIDUAL TREES AND SHRUBS AND OUTLINE AREAS FOR MULTIPLE PLANTINGS.

3.3 PLANTING AREA ESTABLISHMENT

- A. PLACING PLANTING SOIL: BLEND PLANTING SOIL IN PLACE.
- B. BEFORE PLANTING, OBTAIN ARCHITECT'S ACCEPTANCE OF FINISH GRADING; RESTORE PLANTING AREAS IF ERODED OR OTHERWISE DISTURBED AFTER FINISH GRADING.
- C. APPLICATION OF MYCORRHIZAL FUNGI: AT TIME DIRECTED BY ARCHITECT, BROADCAST DRY PRODUCT UNIFORMLY OVER PREPARED SOIL AT APPLICATION RATE ACCORDING TO MANUFACTURER'S WRITTEN RECOMMENDATIONS.

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3.4 EXCAVATION FOR TREES AND SHRUBS

A. PLANTING PITS AND TRENCHES: EXCAVATE CIRCULAR PLANTING PITS.

1. EXCAVATE PLANTING PITS WITH SIDES SLOPING INWARD AT A 45-DEGREE ANGLE. EXCAVATIONS WITH VERTICAL SIDES ARE UNACCEPTABLE. TRIM PERIMETER OF BOTTOM LEAVING CENTER AREA OF BOTTOM RAISED SLIGHTLY TO SUPPORT ROOT BALL AND ASSIST IN DRAINAGE AWAY FROM CENTER. DO NOT FURTHER DISTURB BASE. ENSURE THAT ROOT BALL WILL SIT ON UNDISTURBED BASE SOIL TO PREVENT SETTLING. SCARIFY SIDES OF PLANTING PIT SMEARED OR SMOOTHED DURING EXCAVATION.
2. EXCAVATE APPROXIMATELY THREE TIMES AS WIDE AS BALL DIAMETER FOR BALLED AND BURLAPPED STOCK.
3. EXCAVATE AT LEAST 12 INCHES (300 MM) WIDER THAN ROOT SPREAD AND DEEP ENOUGH TO ACCOMMODATE VERTICAL ROOTS FOR BARE-ROOT STOCK.
4. DO NOT EXCAVATE DEEPER THAN DEPTH OF THE ROOT BALL, MEASURED FROM THE ROOT FLARE TO THE BOTTOM OF THE ROOT BALL.
5. IF AREA UNDER THE PLANT WAS INITIALLY DUG TOO DEEP, ADD SOIL TO RAISE IT TO THE CORRECT LEVEL AND THOROUGHLY TAMP THE ADDED SOIL TO PREVENT SETTLING.
6. MAINTAIN ANGLES OF REPOSE OF ADJACENT MATERIALS TO ENSURE STABILITY. DO NOT EXCAVATE SUBGRADES OF ADJACENT PAVING, STRUCTURES, HARDSCAPES, OR OTHER NEW OR EXISTING IMPROVEMENTS.
7. MAINTAIN SUPERVISION OF EXCAVATIONS DURING WORKING HOURS.
8. KEEP EXCAVATIONS COVERED OR OTHERWISE PROTECTED WHEN UNATTENDED BY INSTALLER'S PERSONNEL.
9. IF DRAIN TILE IS INDICATED ON DRAWINGS OR REQUIRED UNDER PLANTING AREAS, EXCAVATE TO TOP OF POROUS BACKFILL OVER TILE.

B. BACKFILL SOIL: SUBSOIL AND TOPSOIL REMOVED FROM EXCAVATIONS MAY BE USED AS BACKFILL SOIL UNLESS OTHERWISE INDICATED.

C. OBSTRUCTIONS: NOTIFY ARCHITECT IF UNEXPECTED ROCK OR OBSTRUCTIONS DETRIMENTAL TO TREES OR SHRUBS ARE ENCOUNTERED IN EXCAVATIONS.

1. HARDPAN LAYER: DRILL 6-INCH- (150-MM-) DIAMETER HOLES, 24 INCHES (600 MM) APART, INTO FREE-DRAINING STRATA OR TO A DEPTH OF 10 FEET (3 M), WHICHEVER IS LESS, AND BACKFILL WITH FREE-DRAINING MATERIAL.

D. DRAINAGE: NOTIFY ARCHITECT IF SUBSOIL CONDITIONS EVIDENCE UNEXPECTED WATER SEEPAGE OR RETENTION IN TREE OR SHRUB PLANTING PITS.

E. FILL EXCAVATIONS WITH WATER AND ALLOW TO PERCOLATE AWAY BEFORE POSITIONING TREES AND SHRUBS.

3.5 TREE, SHRUB, AND VINE PLANTING

A. INSPECTION: AT TIME OF PLANTING, VERIFY THAT ROOT FLARE IS VISIBLE AT TOP OF ROOT BALL ACCORDING TO ANSI Z60.1. IF ROOT FLARE IS NOT VISIBLE, REMOVE SOIL IN A LEVEL MANNER FROM THE ROOT BALL TO WHERE THE TOP-MOST ROOT EMERGES FROM THE TRUNK. AFTER SOIL REMOVAL TO EXPOSE THE ROOT FLARE, VERIFY THAT ROOT BALL STILL MEETS SIZE REQUIREMENTS.

B. ROOTS: REMOVE STEM GIRDLING ROOTS AND KINKED ROOTS. REMOVE INJURED ROOTS BY CUTTING CLEANLY; DO NOT BREAK.

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- C. BALLED AND BURLAPPED STOCK: SET EACH PLANT PLUMB AND IN CENTER OF PLANTING PIT OR TRENCH WITH ROOT FLARE 1 INCH (25 MM) ABOVE ADJACENT FINISH GRADES.
1. BACKFILL: PLANTING SOIL
 2. AFTER PLACING SOME BACKFILL AROUND ROOT BALL TO STABILIZE PLANT, CAREFULLY CUT AND REMOVE BURLAP, ROPE, AND WIRE BASKETS FROM TOPS OF ROOT BALLS AND FROM SIDES, BUT DO NOT REMOVE FROM UNDER ROOT BALLS. REMOVE PALLETS, IF ANY, BEFORE SETTING. DO NOT USE PLANTING STOCK IF ROOT BALL IS CRACKED OR BROKEN BEFORE OR DURING PLANTING OPERATION.
 3. BACKFILL AROUND ROOT BALL IN LAYERS, TAMPING TO SETTLE SOIL AND ELIMINATE VOIDS AND AIR POCKETS. WHEN PLANTING PIT IS APPROXIMATELY ONE-HALF FILLED, WATER THOROUGHLY BEFORE PLACING REMAINDER OF BACKFILL. REPEAT WATERING UNTIL NO MORE WATER IS ABSORBED.
 4. PLACE PLANTING TABLETS EQUALLY DISTRIBUTED AROUND EACH PLANTING PIT WHEN PIT IS APPROXIMATELY ONE-HALF FILLED. PLACE TABLETS BESIDE THE ROOT BALL ABOUT 1 INCH (25 MM) FROM ROOT TIPS; DO NOT PLACE TABLETS IN BOTTOM OF THE HOLE.
 - A. QUANTITY: THREE FOR EACH CALIPER INCH OF PLANT.
 5. CONTINUE BACKFILLING PROCESS. WATER AGAIN AFTER PLACING AND TAMPING FINAL LAYER OF SOIL.
- D. BALLED AND POTTED AND CONTAINER-GROWN STOCK: SET EACH PLANT PLUMB AND IN CENTER OF PLANTING PIT OR TRENCH WITH ROOT FLARE 1 INCH (25 MM) ABOVE ADJACENT FINISH GRADES.
1. BACKFILL: PLANTING SOIL
 2. CAREFULLY REMOVE ROOT BALL FROM CONTAINER WITHOUT DAMAGING ROOT BALL OR PLANT.
 3. BACKFILL AROUND ROOT BALL IN LAYERS, TAMPING TO SETTLE SOIL AND ELIMINATE VOIDS AND AIR POCKETS. WHEN PLANTING PIT IS APPROXIMATELY ONE-HALF FILLED, WATER THOROUGHLY BEFORE PLACING REMAINDER OF BACKFILL. REPEAT WATERING UNTIL NO MORE WATER IS ABSORBED.
 4. PLACE PLANTING TABLETS EQUALLY DISTRIBUTED AROUND EACH PLANTING PIT WHEN PIT IS APPROXIMATELY ONE-HALF FILLED. PLACE TABLETS BESIDE THE ROOT BALL ABOUT 1 INCH (25 MM) FROM ROOT TIPS; DO NOT PLACE TABLETS IN BOTTOM OF THE HOLE.
 - A. QUANTITY: THREE FOR EACH CALIPER INCH OF PLANT.
 5. CONTINUE BACKFILLING PROCESS. WATER AGAIN AFTER PLACING AND TAMPING FINAL LAYER OF SOIL.
- E. SLOPES: WHEN PLANTING ON SLOPES, SET THE PLANT SO THE ROOT FLARE ON THE UPHILL SIDE IS FLUSH WITH THE SURROUNDING SOIL ON THE SLOPE; THE EDGE OF THE ROOT BALL ON THE DOWNHILL SIDE WILL BE ABOVE THE SURROUNDING SOIL. APPLY ENOUGH SOIL TO COVER THE DOWNHILL SIDE OF THE ROOT BALL.

3.6 MECHANIZED TREE-SPADE PLANTING

- A. TREES MAY BE PLANTED WITH AN APPROVED MECHANIZED TREE SPADE AT THE DESIGNATED LOCATIONS. DO NOT USE TREE SPADE TO MOVE TREES LARGER THAN THE MAXIMUM SIZE ALLOWED FOR A SIMILAR FIELD-GROWN, BALLED-AND-BURLAPPED ROOT-BALL DIAMETER ACCORDING TO ANSI Z60.1, OR LARGER THAN MANUFACTURER'S MAXIMUM SIZE RECOMMENDATION FOR THE TREE SPADE BEING USED, WHICHEVER IS SMALLER.

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- B. USE THE SAME TREE SPADE TO EXCAVATE THE PLANTING HOLE AS WILL BE USED TO EXTRACT AND TRANSPORT THE TREE.
- C. WHEN EXTRACTING THE TREE, CENTER THE TRUNK WITHIN THE TREE SPADE AND MOVE TREE WITH A SOLID BALL OF EARTH.
- D. CUT EXPOSED ROOTS CLEANLY DURING TRANSPLANTING OPERATIONS.
- E. PLANT TREES FOLLOWING PROCEDURES IN "TREE, SHRUB, AND VINE PLANTING" ARTICLE.
- F. WHERE POSSIBLE, ORIENT THE TREE IN THE SAME DIRECTION AS IN ITS ORIGINAL LOCATION.

3.7 TREE, SHRUB, AND VINE PRUNING

- A. REMOVE ONLY DEAD, DYING, OR BROKEN BRANCHES. DO NOT PRUNE FOR SHAPE.
- B. PRUNE, THIN, AND SHAPE TREES, SHRUBS, AND VINES AS DIRECTED BY ARCHITECT.
- C. PRUNE, THIN, AND SHAPE TREES, SHRUBS, AND VINES ACCORDING TO STANDARD PROFESSIONAL HORTICULTURAL AND ARBORICULTURAL PRACTICES. UNLESS OTHERWISE INDICATED BY ARCHITECT, DO NOT CUT TREE LEADERS; REMOVE ONLY INJURED, DYING, OR DEAD BRANCHES FROM TREES AND SHRUBS; AND PRUNE TO RETAIN NATURAL CHARACTER.
- D. DO NOT APPLY PRUNING PAINT TO WOUNDS.

3.8 TREE STABILIZATION

- A. TRUNK STABILIZATION BY UPRIGHT STAKING AND TYING: INSTALL TRUNK STABILIZATION AS FOLLOWS UNLESS OTHERWISE INDICATED:
 - 1. UPRIGHT STAKING AND TYING: STAKE TREES OF 2- THROUGH 5-INCH (50- THROUGH 125-MM) CALIPER. STAKE TREES OF LESS THAN 2-INCH (50-MM) CALIPER ONLY AS REQUIRED TO PREVENT WIND TIP OUT. USE A MINIMUM OF TWO STAKES OF LENGTH REQUIRED TO PENETRATE AT LEAST 18 INCHES (450 MM) BELOW BOTTOM OF BACKFILLED EXCAVATION AND TO EXTEND ONE-THIRD OF TRUNK HEIGHT ABOVE GRADE. SET VERTICAL STAKES AND SPACE TO AVOID PENETRATING ROOT BALLS OR ROOT MASSES.

IN "UPRIGHT STAKING AND TYING" SUBPARAGRAPH BELOW, ONE STAKE MAY BE ACCEPTABLE FOR HIGH-BRANCHED TREES IN SEMIPROTECTED LOCATIONS.

- 2. UPRIGHT STAKING AND TYING: STAKE TREES WITH TWO STAKES FOR TREES UP TO 12 FEET (3.6 M) HIGH AND 2-1/2 INCHES (63 MM) OR LESS IN CALIPER; THREE STAKES FOR TREES LESS THAN 14 FEET (4.2 M) HIGH AND UP TO 4 INCHES (100 MM) IN CALIPER. SPACE STAKES EQUALLY AROUND TREES.

RETAIN ONE OF TWO SUBPARAGRAPHS BELOW.

- 3. SUPPORT TREES WITH BANDS OF FLEXIBLE TIES AT CONTACT POINTS WITH TREE TRUNK. ALLOW ENOUGH SLACK TO AVOID RIGID RESTRAINT OF TREE.
- 4. SUPPORT TREES WITH TWO STRANDS OF TIE WIRE, CONNECTED TO THE BRASS GROMMETS OF TREE-TIE WEBBING AT CONTACT POINTS WITH TREE TRUNK. ALLOW ENOUGH SLACK TO AVOID RIGID RESTRAINT OF TREE.

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- B. TRUNK STABILIZATION BY STAKING AND GUYING: INSTALL TRUNK STABILIZATION AS FOLLOWS UNLESS OTHERWISE INDICATED ON DRAWINGS. STAKE AND GUY TREES MORE THAN 14 FEET (4.2 M) IN HEIGHT AND MORE THAN 3 INCHES (75 MM) IN CALIPER UNLESS OTHERWISE INDICATED.
1. SITE-FABRICATED, STAKING-AND-GUYING METHOD: INSTALL NO FEWER THAN THREE GUYS SPACED EQUALLY AROUND TREE.
 - A. SECURELY ATTACH GUYS TO STAKES 30 INCHES (760 MM) LONG, DRIVEN TO GRADE. ADJUST SPACING TO AVOID PENETRATING ROOT BALLS OR ROOT MASSES. PROVIDE TURNBUCKLE FOR EACH GUY WIRE AND TIGHTEN SECURELY.
 - B. FOR TREES MORE THAN 6 INCHES (150 MM) IN CALIPER, ANCHOR GUYS TO WOOD DEADMEN BURIED AT LEAST 36 INCHES (900 MM) BELOW GRADE. PROVIDE TURNBUCKLE FOR EACH GUY WIRE AND TIGHTEN SECURELY.
 - C. SUPPORT TREES WITH BANDS OF FLEXIBLE TIES AT CONTACT POINTS WITH TREE TRUNK AND REACHING TO TURNBUCKLE. ALLOW ENOUGH SLACK TO AVOID RIGID RESTRAINT OF TREE.
 - D. SUPPORT TREES WITH GUY CABLE, CONNECTED TO THE BRASS GROMMETS OF TREE-TIE WEBBING AT CONTACT POINTS WITH TREE TRUNK AND REACHING TO TURNBUCKLE. ALLOW ENOUGH SLACK TO AVOID RIGID RESTRAINT OF TREE.

RETAIN ONE OF FIRST TWO SUBPARAGRAPHS BELOW.

- E. ATTACH FLAGS TO EACH GUY WIRE, 30 INCHES (760 MM) ABOVE FINISH GRADE.
 - F. PAINT TURNBUCKLES WITH LUMINESCENT WHITE PAINT.
 2. PROPRIETARY STAKING AND GUYING DEVICE: INSTALL STAKING AND GUYING SYSTEM SIZED AND POSITIONED AS RECOMMENDED BY MANUFACTURER UNLESS OTHERWISE INDICATED AND ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS.
- C. ROOT-BALL STABILIZATION: INSTALL AT- OR BELOW-GRADE STABILIZATION SYSTEM TO SECURE EACH NEW PLANTING BY THE ROOT BALL UNLESS OTHERWISE INDICATED.
1. PROPRIETARY ROOT-BALL STABILIZATION DEVICE: INSTALL ROOT-BALL STABILIZATION SYSTEM SIZED AND POSITIONED AS RECOMMENDED BY MANUFACTURER UNLESS OTHERWISE INDICATED AND ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS.

3.9 ROOT-BARRIER INSTALLATION

- A. INSTALL ROOT BARRIER WHERE TREES ARE PLANTED WITHIN 48 INCHES (1200 MM) OF PAVING OR OTHER HARDSCAPE ELEMENTS, SUCH AS WALLS, CURBS, AND WALKWAYS, UNLESS OTHERWISE INDICATED ON DRAWINGS.
- B. ALIGN ROOT BARRIER WITH BOTTOM EDGE ANGLED AT 20 DEGREES AWAY FROM THE PAVING OR OTHER HARDSCAPE ELEMENT, AND RUN IT LINEARLY ALONG AND ADJACENT TO THE PAVING OR OTHER HARDSCAPE ELEMENTS TO BE PROTECTED FROM INVASIVE ROOTS.
- C. INSTALL ROOT BARRIER CONTINUOUSLY FOR A DISTANCE OF 60 INCHES (1500 MM) IN EACH DIRECTION FROM THE TREE TRUNK, FOR A TOTAL DISTANCE OF 10 FEET (3 M) PER TREE. IF TREES ARE SPACED CLOSER, USE A SINGLE CONTINUOUS PIECE OF ROOT BARRIER.
 1. POSITION TOP OF ROOT BARRIER FLUSH WITH FINISH GRADE OR ACCORDING TO MANUFACTURER'S WRITTEN RECOMMENDATIONS.
 2. OVERLAP ROOT BARRIER A MINIMUM OF 12 INCHES (300 MM) AT JOINTS.
 3. DO NOT DISTORT OR BEND ROOT BARRIER DURING CONSTRUCTION ACTIVITIES.
 4. DO NOT INSTALL ROOT BARRIER SURROUNDING THE ROOT BALL OF TREE.

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3.10 PLACING SOIL IN PLANTERS

- A. PLACE A LAYER OF DRAINAGE GRAVEL AT LEAST 4 INCHES (100 MM) THICK IN BOTTOM OF PLANTER. COVER BOTTOM WITH FILTER FABRIC AND WRAP FILTER FABRIC 4 INCHES (100 MM) UP ON ALL SIDES. DUCT TAPE ALONG THE ENTIRE TOP EDGE OF THE FILTER FABRIC, TO SECURE THE FILTER FABRIC AGAINST THE SIDES DURING THE SOIL-FILLING PROCESS.
- B. FILL PLANTER WITH PLANTING SOIL. PLACE SOIL IN LIGHTLY COMPACTED LAYERS TO AN ELEVATION OF 1-1/2 INCHES (38 MM) BELOW TOP OF PLANTER, ALLOWING NATURAL SETTLEMENT.

3.11 GROUND COVER AND PLANT PLANTING

- A. SET OUT AND SPACE GROUND COVER AND PLANTS OTHER THAN TREES, SHRUBS, AND VINES AS INDICATED ON DRAWINGS IN EVEN ROWS WITH TRIANGULAR SPACING.
- B. DIG HOLES LARGE ENOUGH TO ALLOW SPREADING OF ROOTS.
- C. FOR ROOTED CUTTING PLANTS SUPPLIED IN FLATS, PLANT EACH IN A MANNER THAT MINIMALLY DISTURBS THE ROOT SYSTEM BUT TO A DEPTH NOT LESS THAN TWO NODES.
- D. WORK SOIL AROUND ROOTS TO ELIMINATE AIR POCKETS AND LEAVE A SLIGHT SAUCER INDENTATION AROUND PLANTS TO HOLD WATER.
- E. WATER THOROUGHLY AFTER PLANTING, TAKING CARE NOT TO COVER PLANT CROWNS WITH WET SOIL.
- F. PROTECT PLANTS FROM HOT SUN AND WIND; REMOVE PROTECTION IF PLANTS SHOW EVIDENCE OF RECOVERY FROM TRANSPLANTING SHOCK.

3.12 PLANTING AREA MULCHING

- A. MULCH BACKFILLED SURFACES OF PLANTING AREAS AND OTHER AREAS INDICATED.

RETAIN REQUIRED MULCH APPLICATIONS IN THREE SUBPARAGRAPHS BELOW.

- 1. TREES IN TURF AREAS: APPLY ORGANIC MULCH RING OF 3-INCH (75-MM) AVERAGE THICKNESS, WITH 24-INCH (600-MM) RADIUS AROUND TRUNKS OR STEMS. DO NOT PLACE MULCH WITHIN 3 INCHES (75 MM) OF TRUNKS OR STEMS.
- 2. ORGANIC MULCH IN PLANTING AREAS: APPLY 3-INCH (75-MM) AVERAGE THICKNESS OF ORGANIC MULCH EXTENDING 12 INCHES (300 MM) BEYOND EDGE OF INDIVIDUAL PLANTING PIT OR TRENCH AND OVER WHOLE SURFACE OF PLANTING AREA, AND FINISH LEVEL WITH ADJACENT FINISH GRADES. DO NOT PLACE MULCH WITHIN 3 INCHES (75 MM) OF TRUNKS OR STEMS.

3.13 EDGING INSTALLATION

- A. STEEL EDGING: INSTALL STEEL EDGING WHERE INDICATED ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS. ANCHOR WITH STEEL STAKES SPACED APPROXIMATELY 30 INCHES (760 MM) APART, DRIVEN BELOW TOP ELEVATION OF EDGING.

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- B. SHOVEL-CUT EDGING: SEPARATE MULCHED AREAS FROM TURF AREAS (CURBS AND PAVING) WITH A 45-DEGREE, 4- TO 6-INCH- (100- TO 150-MM-) DEEP, SHOVEL-CUT EDGE.

RETAIN "MOW-STRIP INSTALLATION" IF MOW STRIPS ARE REQUIRED; REVISE TO SUIT PROJECT.

- C. MOW-STRIP INSTALLATION:

- 1. EXCAVATE FOR MOW STRIP.
- 2. COMPACT SUBGRADE UNIFORMLY BENEATH MOW STRIP.
- 3. APPLY NONSELECTIVE, PRE-EMERGENT HERBICIDE THAT INHIBITS GROWTH OF GRASS AND WEEDS.
- 4. RAKE MULCH TO A UNIFORM SURFACE LEVEL WITH ADJACENT FINISH GRADES.

3.14 INSTALLING SLOW-RELEASE WATERING DEVICE

- A. PROVIDE ONE DEVICE FOR EACH TREE.
- B. PLACE DEVICE ON TOP OF THE MULCH AT BASE OF TREE STEM AND FILL WITH WATER ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS.

3.15 PLANT MAINTENANCE

- A. MAINTAIN PLANTINGS BY PRUNING, CULTIVATING, WATERING, WEEDING, FERTILIZING, MULCHING, RESTORING PLANTING SAUCERS, ADJUSTING AND REPAIRING TREE-STABILIZATION DEVICES, RESETTING TO PROPER GRADES OR VERTICAL POSITION, AND PERFORMING OTHER OPERATIONS AS REQUIRED TO ESTABLISH HEALTHY, VIABLE PLANTINGS.
- B. FILL IN, AS NECESSARY, SOIL SUBSIDENCE THAT MAY OCCUR BECAUSE OF SETTLING OR OTHER PROCESSES. REPLACE MULCH MATERIALS DAMAGED OR LOST IN AREAS OF SUBSIDENCE.
- C. APPLY TREATMENTS AS REQUIRED TO KEEP PLANT MATERIALS, PLANTED AREAS, AND SOILS FREE OF PESTS AND PATHOGENS OR DISEASE. USE INTEGRATED PEST MANAGEMENT PRACTICES WHEN POSSIBLE TO MINIMIZE USE OF PESTICIDES AND REDUCE HAZARDS. TREATMENTS INCLUDE PHYSICAL CONTROLS SUCH AS HOSING OFF FOLIAGE, MECHANICAL CONTROLS SUCH AS TRAPS, AND BIOLOGICAL CONTROL AGENTS.

3.16 PESTICIDE APPLICATION

- A. APPLY PESTICIDES AND OTHER CHEMICAL PRODUCTS AND BIOLOGICAL CONTROL AGENTS ACCORDING TO AUTHORITIES HAVING JURISDICTION AND MANUFACTURER'S WRITTEN RECOMMENDATIONS. COORDINATE APPLICATIONS WITH OWNER'S OPERATIONS AND OTHERS IN PROXIMITY TO THE WORK. NOTIFY OWNER BEFORE EACH APPLICATION IS PERFORMED.
- B. PRE-EMERGENT HERBICIDES (SELECTIVE AND NONSELECTIVE): APPLY TO TREE, SHRUB, AND GROUND-COVER AREAS ACCORDING TO MANUFACTURER'S WRITTEN RECOMMENDATIONS. DO NOT APPLY TO SEEDED AREAS.
- C. POST-EMERGENT HERBICIDES (SELECTIVE AND NONSELECTIVE): APPLY ONLY AS NECESSARY TO TREAT ALREADY-GERMINATED WEEDS AND ACCORDING TO MANUFACTURER'S WRITTEN RECOMMENDATIONS.

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3.17 REPAIR AND REPLACEMENT

- A. GENERAL: REPAIR OR REPLACE EXISTING OR NEW TREES AND OTHER PLANTS THAT ARE DAMAGED BY CONSTRUCTION OPERATIONS, IN A MANNER APPROVED BY ARCHITECT.
 - 1. SUBMIT DETAILS OF PROPOSED PRUNING AND REPAIRS.
 - 2. PERFORM REPAIRS OF DAMAGED TRUNKS, BRANCHES, AND ROOTS WITHIN 24 HOURS, IF APPROVED.
 - 3. REPLACE TREES AND OTHER PLANTS THAT CANNOT BE REPAIRED AND RESTORED TO FULL-GROWTH STATUS, AS DETERMINED BY ARCHITECT.
- B. REMOVE AND REPLACE TREES THAT ARE MORE THAN 25 PERCENT DEAD OR IN AN UNHEALTHY CONDITION OR ARE DAMAGED DURING CONSTRUCTION OPERATIONS THAT ARCHITECT DETERMINES ARE INCAPABLE OF RESTORING TO NORMAL GROWTH PATTERN.
 - 1. PROVIDE NEW TREES OF SAME SIZE AS THOSE BEING REPLACED FOR EACH TREE OF 4 INCHES (100 MM) OR SMALLER IN CALIPER SIZE.

REVISE FIRST SUBPARAGRAPH BELOW TO SUIT PROJECT. REPLACING LARGER THAN 6-INCH (150-MM) CALIPER-SIZE TREES WITH TREES OF EQUAL SIZE IS DIFFICULT AND NOT ALWAYS SUCCESSFUL; SOME JURISDICTIONS HAVE ESTABLISHED FORMULAS FOR LARGE-TREE REPLACEMENTS.

- 2. PROVIDE ONE NEW TREE(S) OF 4-INCH (100-MM) CALIPER SIZE FOR EACH TREE BEING REPLACED THAT MEASURES MORE THAN 4 INCHES (100 MM) IN CALIPER SIZE.
- 3. SPECIES OF REPLACEMENT TREES: SPECIES SELECTED BY ARCHITECT.

3.18 CLEANING AND PROTECTION

- A. DURING PLANTING, KEEP ADJACENT PAVING AND CONSTRUCTION CLEAN AND WORK AREA IN AN ORDERLY CONDITION. CLEAN WHEELS OF VEHICLES BEFORE LEAVING SITE TO AVOID TRACKING SOIL ONTO ROADS, WALKS, OR OTHER PAVED AREAS.
- B. REMOVE SURPLUS SOIL AND WASTE MATERIAL INCLUDING EXCESS SUBSOIL, UNSUITABLE SOIL, TRASH, AND DEBRIS AND LEGALLY DISPOSE OF THEM OFF OWNER'S PROPERTY.
- C. PROTECT PLANTS FROM DAMAGE DUE TO LANDSCAPE OPERATIONS AND OPERATIONS OF OTHER CONTRACTORS AND TRADES. MAINTAIN PROTECTION DURING INSTALLATION AND MAINTENANCE PERIODS. TREAT, REPAIR, OR REPLACE DAMAGED PLANTINGS.
- D. AFTER INSTALLATION AND BEFORE SUBSTANTIAL COMPLETION REMOVE NURSERY TAGS, NURSERY STAKES, TIE TAPE, LABELS, WIRE, BURLAP, AND OTHER DEBRIS FROM PLANT MATERIAL, PLANTING AREAS, AND PROJECT SITE.
- E. AT TIME OF SUBSTANTIAL COMPLETION, VERIFY THAT TREE-WATERING DEVICES ARE IN GOOD WORKING ORDER AND LEAVE THEM IN PLACE. REPLACE IMPROPERLY FUNCTIONING DEVICES.

3.19 MAINTENANCE SERVICE

- A. MAINTENANCE SERVICE FOR TREES AND SHRUBS: PROVIDE MAINTENANCE BY SKILLED EMPLOYEES OF LANDSCAPE INSTALLER. MAINTAIN AS REQUIRED IN "PLANT MAINTENANCE" ARTICLE. BEGIN MAINTENANCE IMMEDIATELY AFTER PLANTS ARE INSTALLED AND CONTINUE UNTIL PLANTINGS ARE ACCEPTABLY HEALTHY AND WELL ESTABLISHED, BUT FOR NOT LESS THAN MAINTENANCE PERIOD BELOW:

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1. MAINTENANCE PERIOD: THREE MONTHS FROM DATE OF SUBSTANTIAL COMPLETION.
- B. MAINTENANCE SERVICE FOR GROUND COVER AND OTHER PLANTS: PROVIDE MAINTENANCE BY SKILLED EMPLOYEES OF LANDSCAPE INSTALLER. MAINTAIN AS REQUIRED IN "PLANT MAINTENANCE" ARTICLE. BEGIN MAINTENANCE IMMEDIATELY AFTER PLANTS ARE INSTALLED AND CONTINUE UNTIL PLANTINGS ARE ACCEPTABLY HEALTHY AND WELL ESTABLISHED, BUT FOR NOT LESS THAN MAINTENANCE PERIOD BELOW:
 1. MAINTENANCE PERIOD: THREE MONTHS FROM DATE OF SUBSTANTIAL COMPLETION.

END OF SECTION 329300

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APPENDIX B - CALCULATING QUANTITIES OF CHLORINE FOR DISINFECTING WATERMAINS

The amount or weight of chlorine required to disinfect a particular segment of water line is directly related to the volume of water contained in that particular segment of water main.

A. Volume of Water in Pipe

$$\begin{aligned}\text{Volume of Water (Gallons)} &= \text{Area of Pipe (Ft}^2\text{)} \times \text{Length (ft)} \times 7.48 \\ &= 7C R^2 L \times 7.48 \\ \text{Where: fi} &= 3.1416 \\ R &= \text{Inside Radius of Pipe in Feet} \\ L &= \text{Length of Pipe to be Disinfected, in Feet} \\ 7.48 &= \text{Gallons per Cubic Foot}\end{aligned}$$

B. Formula to Determine Lbs. of Chlorine Required

$$\begin{aligned}\text{Lbs. of Chlorine} &= \text{ppm} \times \text{MG} \times 8.34 \\ \text{where: Lbs. of Chlorine} &= 100\% \text{ Effective Chlorine} \\ \text{ppm} &= \text{Chlorine Dosage in Parts per Million MG} \\ &= \text{Million Gallons of Water} \\ 8.34 &= 8.34 \text{ Lbs. of Water per Gallon}\end{aligned}$$

C. Sample Calculations

Example: 4,500 lineal feet of 8" water main to be disinfected at a chlorine concentration of 25 ppm.

$$\begin{aligned}\text{Volume of Water} \quad R &= \pi R^2 L \times 7.48 \\ L &= 4" = 4/12 \text{ Ft} = 0.333 \text{ Ft} \\ &= 4,500 \text{ Ft}\end{aligned}$$

$$\begin{aligned}\text{Volume of Water} &= 3.1416 \times (.333)^2 \times 4,500 \times 7.48 \\ &= 11,726 \text{ Gallons} \\ &= 0.011726 \text{ MG}\end{aligned}$$

$$\begin{aligned}\text{Lbs- of Chlorine} \quad \text{ppm} &= \text{ppm, x MG} \times 8.34 \\ &= 25\end{aligned}$$

$$\begin{aligned}\text{Lbs. of Chlorine} &= 25 \times 0.011726 \times 8.34 \\ &= 2.44 \text{ Lbs. of 100\% Effective Chlorine}\end{aligned}$$

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APPENDIX B

Chlorine Disinfection

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D Using Chlorine Compounds or Solutions Less Than 100% Effective Chlorine

Most dry chlorine compounds or chlorine solutions on the market do not contain 100% effective chlorine. Normally the containers of the compound or solution will state the amount of effective chlorine as a percentage.

Example: Determine how much Chlorox (Sodium Hypochlorite) solution is required to provide 2.44 lbs. of 100% effective chlorine- Chlorox container is labeled at 5.25% effective chlorine.

$$\begin{aligned} \text{Effective Chlorine Per Gallon Chlorox} &= .0525 \times 8.34 \text{ Lbs./Gal} = 0.44 \text{ Lbs.} \\ \text{Gallons of Chlorox Required} &= \frac{2.44}{0.44} = 5.55 \text{ Gallons} \end{aligned}$$

E. Chlorine Dosage Table

Table 1 following presents the chlorine required to produce a 25 ppm concentration in 100 feet of pipe. Also shown are the gallons required for a solution containing 1 percent effective chlorine.

TABLE 1
Chlorine Required to Produce 25 mg/L Concentration
in 100 ft. of Pipe -- by Diameter

Pipe Diameter	100% Effective Chlorine	1 Percent Chlorine Solutions
Inches	Lbs.	Gallons
4	0.013	0.16
6	0.030	0.36
8	0.085	1.02
10	0.120	1.02
12	0.22	1.44
16	0.27	2.60
18	0.34	3.30
20	0.49	4.07
24	0.76	5.87
30	1.10	9.17
36	1.96	13.19
48		23.50

F. Dosage Table for Hypochlorite Tablets

The number of 5-g tablets required for each pipe section to provide a chlorine dosage of 25 mg/L is equal to $0.0012 \times d^2 \times L$, where d is the inside pipe diameter in inches and L is the length of the pipe section in feet. Table 2 shows the number of tablets required for commonly used sizes of pipe.

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TABLE 2
Number of a5-g Hypochlorite Tablets
Required for Dose of 25 mg/L^a

Pipe Diameter	Length of Pipe Section, ft.				
	13 or Less	18	20	30	40
4	1	1	1	1	1
6	1	1	1	2	2
8	1	2	2	3	4
10	2	3	3	4	5
12	3	4	4	6	7
16	4	6	7	10	13
18	5	7	8	12	16
20	7	9	10	15	20
24	9	13	14	21	28

^a Based on 3.25 g available chlorine per tablet. Any portion of tablet rounded to next higher number.

END OF SECTION APPENDIX B