Statement of Work for the ALS-U Booster to Accumulator Transfer Line Magnets

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ALS-U - BOOSTER TO ACCUMULATOR TRANSFER LINE MAGNETS - GENERAL

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REVISION HISTORY

Rev.	CM Number	Description of Change
A	AL-1504-9158	Initial Release

APPROVALS

List of approvers can be found referenced in the Windchill product lifecycle management system

ABBREVIATIONS AND ACRONYMS

ABRV	Abbreviation
ACL	Acceptance Criteria List
ALS	Advanced Light Source
ALS-U	Advanced Light Source Upgrade Project
AR	Accumulator Ring
BTA	Booster to Accumulator Transfer line
CAM	Control Account Manager
CAR	Corrective Action Report
CCB	Change Control Board
CMM	Coordinate Measurement Machine
CPO	Chief Procurement Officer
DEV	Deviation Request
DOE	Department of Energy
DEMO	Demonstration
ECN	Engineering Change Note
FAT	Factory Acceptance Test
FATP	Factory Acceptance Test Plan
FATR	Factory Acceptance Test Report
FDR	Final Design Review
HAC	Hypothetical Accident Condition
LBNL	Lawrence Berkeley National Laboratory
MBA	Multibend Achromat
NCR	Nonconformance Report
NRTL	Nationally Recognized Testing Laboratory (Electrical)
QA	Quality Assurance
QAP	Quality Assurance Program or Quality Assurance Plan
QC	Quality Control
TBEND	Transfer Line Bend Magnet
TBENDX	Transfer Line Bend Magnet “X” Geometry
WI	Work Instructions

1 PROJECT OVERVIEW

ALS-U is an upgrade project to the LBNL Advanced Light Source (ALS). The ALS is a 1.9 GeV storage ring operating at 500 mA of beam current. It is optimized to produce intense beams of soft x-rays, which offer spectroscopic contrast, nanometer-scale resolution, and broad temporal sensitivity. The ALS facility includes an accelerator complex and photon delivery system that is capable of providing the foundations for an upgrade that will achieve world-leading soft x-ray coherent flux. The existing ALS provides a ready-made foundation, including conventional facilities and also includes extensive beamlines (up to 40 simultaneously operating beamlines) and instrumentation, an experimental hall, computing resources, ancillary laboratories, offices, and related infrastructure that will be heavily utilized in an upgrade scenario.

The ALS will be upgraded with a multibend achromat (MBA) lattice design that will provide a soft x-ray source that is orders of magnitudes brighter — an up to 100-1000 times increase in brightness and will provide a significantly higher fraction of coherent light in the soft x-ray region than is currently available at ALS.

Any resulting Subcontract will be between the University and the party identified as the Subcontractor and will be issued under Prime Contract No. DE-AC02-05CH11231 between the University and the United States Government (hereinafter “U.S. Government”), represented by the Department of Energy (hereinafter “DOE”) for the management and operation of LBNL and the performance of research and related work.

1.1 Description of Items

The purpose of this statement of work is to define the design, development, and production work required to provide all of the magnets required for the Booster to Accumulator Transfer Line that is part of Advanced Light Source Upgrade Project at Lawrence Berkeley Laboratory. The BTA will provide the transition path from the existing ALS Booster to a new Accumulator Ring. The BTA is comprised of 17 total magnets of two family types, quadrupoles and dipoles. The individual magnets are unique in configuration, with two exceptions. Figure 1-1 illustrates the magnet layout of the BTA.

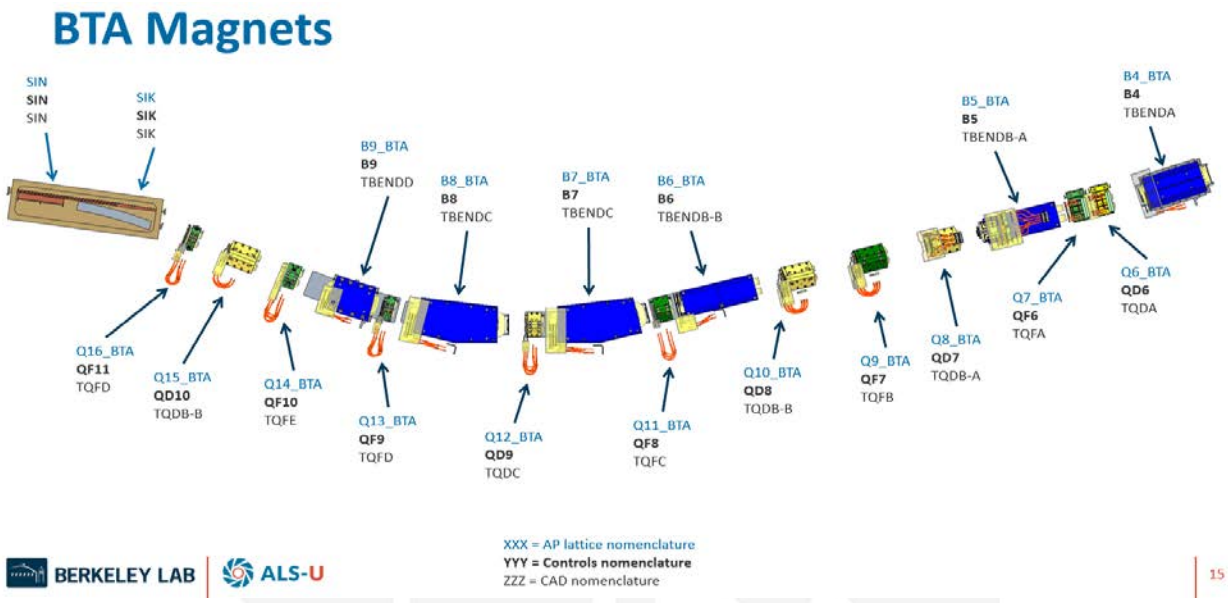

Figure 1-1 CAD illustration of the magnet layout for the BTA

1.2 Roles and Responsibilities

For the purposes of this document, the terms University and LBNL may be used interchangeably.

Two individuals will be identified in the awarded contract: a University Procurement Specialist and a University Technical Representative. The named University personnel are responsible for the contract administration from award initiation through the receipt and acceptance of the purchased item.

University Procurement Representative – See Subcontract for details.

University Technical Representative – See Subcontract for details.

The selected Subcontractor is required to identify a project manager to act as the single point of contact at the Subcontractor. The project manager interfaces directly with the University Technical Representative for technical, programmatic, and schedule items.

2 SCOPE OF WORK

The BTA is comprised of 17 total magnets of two family types, quadrupoles and dipoles. With two exceptions, the individual magnets are unique in configuration. The ALS-U Project intends to procure sufficient magnets to construct the Booster to Accumulator Transfer line. The scope of work for this effort is the design, manufacture, assembly, inspection, and mechanical and magnetic testing of the magnets required for the BTA.

Table 2-1 BTA magnet quantity and geometry summary

Production Package	Lattice Position	Magnet Name	Quantity	Description
Quadrupoles	Q6	TQDA	1	Transfer Line Defocusing Quadrupole Type A
	Q7	TQFA	1	Transfer Line Focusing Quadrupole Type A
	Q8	TQDB-A	1	Transfer Line Defocusing Quadrupole Type B-A
	Q9	TQFB	1	Transfer Line Focusing Quadrupole Type B
	Q10	TQDB-B	1	Transfer Line Defocusing Quadrupole Type B-B
	Q11	TQFC	1	Transfer Line Focusing Quadrupole Type C
	Q12	TQDC	1	Transfer Line Defocusing Quadrupole Type C
	Q13	TQFD	1	Transfer Line Focusing Quadrupole Type D
	Q14	TQFE	1	Transfer Line Focusing Quadrupole Type E
	Q15	TQDB-B	1	Transfer Line Defocusing Quadrupole Type B-B
	Q16	TQFD	1	Transfer Line Focusing Quadrupole Type D
Dipoles	B4	TBENDA	1	Transfer Line Bending Dipole Type A
	B5	TBENDB-A	1	Transfer Line Bending Dipole Type B-A
	B6	TBENDB-B	1	Transfer Line Bending Dipole Type B-B
	B7	TBENDC	1	Transfer Line Bending Dipole Type C
	B8	TBENDC	1	Transfer Line Bending Dipole Type C
	B9	TBENDD	1	Transfer Line Bending Dipole Type D

3 DELIVERABLES

This section details the required deliverables for each phase of the magnet design and build process. A final, contractual closeout set of deliverables is listed in Appendix A: Verification Table.

Table 3-1 Deliverables

Item #	Name	Quantity Req'd	Description
0001	TQDA	1	Complete, fully manufactured, assembled, and tested - Transfer Line Defocusing Quadrupole Magnet Type A
0002	TQFA	1	Complete, fully manufactured, assembled, and tested - Transfer Line Focusing Quadrupole Magnet Type A
0003	TQDB-A	1	Complete, fully manufactured, assembled, and tested - Transfer Line Defocusing Quadrupole Magnet Type B-A
0004	TQFB	1	Complete, fully manufactured, assembled, and tested - Transfer Line Focusing Quadrupole Magnet Type B
0005	TQDB-B	1	Complete, fully manufactured, assembled, and tested - Transfer Line Defocusing Quadrupole Magnet Type B-B
0006	TQFC	1	Complete, fully manufactured, assembled, and tested - Transfer Line Focusing Quadrupole Magnet Type C
0007	TQDC	1	Complete, fully manufactured, assembled, and tested - Transfer Line Defocusing Quadrupole Magnet Type C
0008	TQFD	1	Complete, fully manufactured, assembled, and tested - Transfer Line Focusing Quadrupole Magnet Type D
0009	TQFE	1	Complete, fully manufactured, assembled, and tested - Transfer Line Focusing Quadrupole Magnet Type E
0010	TQDB-B	1	Complete, fully manufactured, assembled, and tested - Transfer Line Defocusing Quadrupole Magnet Type B-B
0011	TQFD	1	Complete, fully manufactured, assembled, and tested - Transfer Line Focusing Quadrupole Magnet Type D
0012	TBENDA	1	Complete, fully manufactured, assembled, and tested - Transfer Line Bending Dipole Magnet Type A
0013	TBENDB-A	1	Complete, fully manufactured, assembled, and tested - Transfer Line Bending Dipole Magnet Type B-A
0014	TBENDB-B	1	Complete, fully manufactured, assembled, and tested - Transfer Line Bending Dipole Magnet Type B-B

Item #	Name	Quantity Req'd	Description
0015	TBENDC	1	Complete, fully manufactured, assembled, and tested - Transfer Line Bending Magnet Dipole Type C
0016	TBENDC	1	Complete, fully manufactured, assembled, and tested - Transfer Line Bending Dipole Magnet Type C
0017	TBENDD	1	Complete, fully manufactured, assembled, and tested - Transfer Line Bending Dipole Magnet Type D
0018	Quadrupole Final Designs	1	Complete, final, as built documentation package for each Quadrupole assembly as specified above
0019	Dipole Final Designs	1	Complete, final, as built documentation package for each Dipole assembly as specified above
0020	Quadrupole Assembly and Alignment Instructions	1	Work instructions for the assembly, disassembly, and alignment of each Quadrupole magnet as specified in the Quadrupole assembly list above
0021	Dipole Assembly and Alignment Instructions	1	Work instructions for the assembly, disassembly, and alignment of each Dipole magnet as specified in the Dipole assembly list above
0022	Complete magnetic test reports	1	A complete report of the tests performed and associated output or test results for each Quadrupole magnet assembly specified above
0023	Complete magnetic test reports	1	A complete report of the tests performed and associated output or test results for each Dipole magnet assembly specified above
0024	Dipole coil tooling	1 Lot	A complete set of supply coil fabrication tooling and winding fabrication instructions for all dipoles
025	Spare Quadrupole Coils	1 Lot	One complete spare quadrupole magnet coil set

3.1 Final Magnet Design

The selected Subcontractor will be responsible for supplying the final magnet designs which incorporate the LBNL technical requirements specified in technical specifications AL-1462-7396, AL-1443-0548, AL-1471-4086, and AL-1441-1075.

All final magnet designs require a complete, formal review by LBNL personnel. This review may be conducted at either the Subcontractor's or the LBNL site or via web/video conference tools.

LBNL reserves the right to modify the deliverables as needed for the Final Design Review. The FDR is required to include of the following components:

1. A complete design documentation package providing evidence of compliance with technical requirements established by LBNL technical specifications AL-1462-7396, AL-1443-0548, AL-1471-4086, and AL-1441-1075. Design documentation shall include, at a minimum, the following items:
    a. Complete, finalized 3D CAD assembly model with associated requested meta data per the requirements specified in LBNL specification AL-1265-6612
    b. A set of draft drawings for the full manufacture and assembly of each magnet assembly
    c. A list of anticipated commercial off the shelf components
2. Documentation of heat and/or other engineering calculations as required to demonstrate design conformance to the technical requirements.
3. A design validation test plan which outlines the processes that will be used to demonstrate compliance with all of the requirements in LBNL technical specifications AL-1462-7396, AL-1443-0548, AL-1441-4086, and AL-1441-1075. A design validation test plan is required for each magnet.
4. Draft schedule.
5. Draft shipping plan.

All Final Design Review documents are to be submitted to LBNL via the established Windchill portal no fewer than 10 working days prior the review date. Written approval from LBNL is required following the final design and before beginning fabrication.

3.2 Magnet Production

Each magnet is required to have the following:

1. Complete mechanical magnet assemblies per the reviewed and approved final design.
2. Complete FATs and associated reports.
3. Final, completed work instructions, as necessary.
4. Magnet measurement test data in .asc, .csv, .txt, .dat, or .xml formats.
5. Quality assurance receipts and certifications.
6. Nonconformance or deviation documentation pertaining to each individual magnet assembly.
7. Final, approved shipping plan.
8. Written authorization from LBNL to proceed with shipping.

3.3 Final Documentation Packages

LBNL shall be provided with a full and complete documentation package. Reference LBNL document AL-1265-6612 for specific file requirements. The documentation package shall contain the items listed below.

1. A complete, as-built bill of materials identifying both fabricated and commercially available components for each magnet.
2. A complete, as-built CAD model in an editable format for each magnet, reference AL-1265-6612.
3. Complete, as-built drawings for each magnet in English, and in an editable format, reference AL-1265-6612.
4. Final assembly documentation for each magnet such as travelers and/or work instructions.
5. Other documentation as requested.

3.4 Verification Summary

At the time of delivery, the vendor shall follow the instructions in Appendix A; print and complete the table with the correct information. Attachments may be added if needed for further explanations.

4 MAGNET MEASUREMENT

4.1 Magnetic Test Methodology

Field integral measurements referenced in this document will be performed with a stretched wire system. The wire radius shall be set at a maximum value consistent with pole clearance to maximize signal to noise. The specified field values correspond to reference or normalization radii, which in general are smaller than the wire measurement radii. Field integral values are specified in T-m units at the corresponding magnet reference radius. Central field values are specified in T at the same reference radius.

The following term definitions for this section are provided for clarity.

Pole Radius: The magnet physical aperture radius. This radius provides a constraint on the maximum radius of a measurement probe.

Horizontal Pole Aperture: Applicable to TBENDB-A, and TBENDB-B vertical bending dipole magnets. The horizontal distance between magnet poles. The horizontal pole aperture is specified at the magnetic axis.

Vertical Pole Aperture: Applicable to TBENDA, TBENDC, and TBEND horizontal bending dipole magnets. The vertical distance between poles. For this case the vertical pole aperture is specified at the magnetic axis.

Minimum Integral Probe Length: The axial length of the coil necessary to measure the full field integral. The values specified are based upon the corresponding magnet's calculated effective length plus twelve aperture radii, or six apertures. This length is based upon the assumption that field will be effectively zero at three apertures beyond the magnets entrance and exit.

Maximum Central Field Value: Central field value of fundamental component for quadrupoles. Values are based upon 125% of nominal.

Maximum Central Dipole Field: Central dipole field for bend magnets. Values are based upon 105% of nominal.

Maximum Field Integral: Field integral of fundamental component for quadrupoles. Values are based upon 125% of nominal.

Maximum Dipole Integral: Field integral of dipole for bend magnets. Values are based upon 105% of nominal.

Required Field Integral Accuracy: Values are based upon 10% of the specified allowed variance in the fundamental field component integral.

Required Field Integral Precision: Values are based upon 10% of the smallest allowed variance of higher order multipole integrals.

Required Angular Field Alignment Accuracy: Values are based upon 10% of the ratio of the maximum allowed skew of the fundamental field component and the nominal fundamental field component. BTA Quadrupole Magnets

The stretched wire system shall measure the integrated gradient versus current and higher order multipoles with sufficient precision and accuracy. With a specified pole radius of 14.5 mm for all magnets, the wire radius can be set at 13.5 mm, giving a clearance of 1 mm. When values are calculated for the 10 mm normalization radius, the effective precision will be 7×10^{-5} for the fundamental and 2×10^{-5} for the first allowed harmonic. This precision should be more than an order of magnitude below the requirement for determining fundamental and higher order multipole field strengths. The wire should be configured so that its integral length is at least the expected magnetic length plus three aperture lengths (six pole radii) at each end.

Table 4-1 BTA quadrupole magnet features

AP Attribute/Magnet	Q6 BTA	Q7 BTA	Q8 BTA	Q9 BTA	Q10 BTA	Q11 BTA	Q12 BTA	Q13 BTA	Q14 BTA	Q15 BTA	Q16 BTA
CAD Attribute/Magnet	TQDA	TQFA	TQDB-A	TQFB	TQDB-B	TQFC	TQDC	TQFD	TQFE	TQDB-B	TQFD
Magnetic length [m]	0.2300	0.2300	0.4000	0.4000	0.4000	0.2120	0.1900	0.1250	0.1900	0.4000	0.1250
Pole radius [mm]	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Normalization radius [mm]	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Nominal gradient integral [T]	10.25	-10.25	14.72	-10.55	14.72	-7.28	5.63	-0.44	-5.83	10.34	-3.45
Minimum gradient integral [T]	5.12	-5.13	7.36	-5.27	7.36	-3.64	2.81	-0.22	-2.92	5.17	-1.72
Maximum gradient integral {T}	12.81	-12.82	16.19	-13.71	16.19	-10.20	7.88	-1.10	-8.75	12.93	-4.31
Nominal gradient field integral* [T-m]	0.1025	-0.1025	0.1472	-0.1055	0.1472	-0.0728	0.0563	-0.0044	-0.0583	0.1034	-0.0345
Minimum gradient field integral* [T-m]	0.0512	-0.0513	0.0736	-0.0527	0.0736	-0.0364	0.0281	-0.0022	-0.0292	0.0517	-0.0172
Maximum gradient field integral* [T-m]	0.1281	-0.1282	0.1619	-0.1371	0.1619	-0.1020	0.0788	-0.0110	-0.0875	0.1293	-0.0431

*Field integral at normalization radius.

4.2 BTA Dipole Magnets

Table 4-2 BTA dipole magnet features

AP Attribute /Magnet	**B4 BTA**	**B5 BTA & B6 BTA**	**B7 BTA & B8 BTA**	**B9 BTA**
CAD Attribute /Magnet	TBENDA	TBENDB-A TBENDB-B	TBENDC	TBENDD
Circuit Topology in Transfer Line	SOLO	STRING	STRING	SOLO
Effective Magnetic Length [m]	0.800	1.000	1.100	0.600
Magnet Geometry	STRAIGHT Horizontal Bend	SWEPT Vertical Bend	SWEPT Horizontal Bend	SWEPT Horizontal Bend
Magnetic Radius /Gap [mm]	20.00	41.00	21.00	21.00
Field Normalization Radius [mm]	9.00	15.00	9.00	9.00
Specified Nominal Dipole [T]	-1.237	-1.016	-1.482	-1.514
Nominal Dipole Integral [T-m]	-0.990	-1.016	-1.630	-0.908
Maximum Dipole Field [T] ("+5%")	-1.299	-1.066	-1.556	-1.5890

The B4 dipole specification is based upon straight line integrated fundamental and multipole values. The B5–B9 dipoles are swept geometry, that is, poles built along a radius to follow the specified beam trajectory.

5 TESTING AND REPORTS

The selected Subcontract is required to supply a full Factory Acceptance Test Plan for review and approval by LBNL prior to performing the final FAT. At the discretion of LBNL, additional tests or reports may be required. A full summary of the test process and subsequent results is a required deliverable.

5.1 Mechanical Inspection

The minimum mechanical test requirements are:

1. Individual component dimensional measurements as specified by any “Shall” requirement in LBNL technical specifications AL-1443-0548, AL-1462-7396, AL-1471-4086, and AL-1441-1075.
2. Magnet assembly dimensional measurements as specified by any “Shall” requirement in LBNL technical specifications AL-1443-0548, AL-1462-7396, AL-1471-4086, and AL-1441-1075.
3. Repeatability testing comprised of a full disassemble as required for installation, reassemble and verification of critical dimensions. Repeatability testing is required for each magnet assembly.

5.2 Coil Inspection

The minimum magnet coil inspection and tests are required for each magnet assembly. Inspection and test requirements are:

1. Hi-Pot verification of the yoke and main circuit.
2. Measurement and validation of the thermal performance of the coils while energized at peak current.
3. Hydraulic testing, measuring the cooling water flow rate, inlet and outlet temperatures and pressures.

Table 5-1 Coil Requirements for main circuits

Description	Value	Unit
Minimum Insulation Hi-Pot Testing Voltage	2x Max operating voltage + 1000V	V
Minimum Insulation Resistance at Minimum Hi-Pot Voltage	2	GΩ
Impulse Testing Protocol	Required	-

5.3 Magnetic Measurement

5.3.1 Quadrupole Measurement Summary

Table 5-2 Requirements for all BTA Quadrupole magnets measurements

Specification Description	Value	Unit
Pole Radius	14.5	mm
Preferred Rotating Wire Radius	13.5	mm
Minimum Integral Stretched Wire Length	0.57	m
Maximum Central Field Value	0.405	T
Maximum Field Integral	0.162	T-m
Required Field Integral Accuracy	1.6×10^{-5}	T-m
Required Field Integral Precision	1.6×10^{-5}	T-m
Required Angular Field Alignment Accuracy	1.0×10^{-3}	rad

5.3.2 Dipole Measurement Summary

The B4 dipole is manufactured to be straight. This magnet will be measured with a stretched wire. The wire will be configured with a 19.0 mm radius, allowing for a 1.0 mm pole clearance in diameter, and with an effective length of at least 1.1 m. With a resolution of 1×10^{-4} at the measurement radius, the normalized resolution at the normalization radius will be 2×10^{-5}.

Table 5-3 Requirements for B4 magnet measurements

Specification Description	Value	Unit
Vertical Pole Aperture	20.0	mm
Preferred Rotating Wire Radius	9.0	mm
Minimum Stretched Wire Length for Integral Measurements	1.0	m
Maximum Central Dipole Field	1.299	T
Maximum Dipole Integral	1.039	T-m
Required Dipole Integral Accuracy	1.0×10^{-4}	T-m
Required Field Integral Precision	1.0×10^{-4}	Tm
Required Angular Field Alignment Accuracy	1.0×10^{-3}	rad

The B5–B9 dipoles are configured in a swept geometry (poles built along a radius to follow the specified beam trajectory). Given that the magnets are iron dominated, and that yoke assemblies can be precision machined and measured with CMM, it is sufficient to rely upon the mechanical fiducialization of the magnet poles and the yoke assembly to verify construction quality and the resultant predicted field quality. A scan of the central field and end field regions may be done relatively simply and will be sufficient for determining the salient magnetic features.

6 MANAGEMENT

This section provides details on the requirements for the management, reporting, documentation, and reviews over the entire lifetime of the contract.

6.1 Reporting/Communication Requirements

1. Upon award of the Subcontract, the University Technical Representative will contact the selected Subcontractor to set up a Project Kick-off meeting. This meeting will establish the requirements for communication and introduce the portal that will be used for data exchange.
2. Written and/or verbal progress updates are required on a bi-weekly basis or as agreed upon with LBNL. Progress updates may include drawings, manufacturing plans, test plans, QA plans, etc. in any state.
3. Written monthly schedule updates are required.
4. Visits by LBNL personnel or their representatives, including access to the factory where the units are being built, may be required.
5. Action item tracking is recommended and may be required based upon LBNL's discretion.
6. Other reports or data as requested in writing.

6.2 Documentation Requirements

Upon Subcontract award, a Windchill Project portal will be established by LBNL and access provided to the Subcontractor. Windchill will be used as the repository for all documentation, QA data, and certificates of conformance, test results, models, and drawings.

An electronic copy of all required documentation as noted in this document is required and shall be transmitted to LBNL via the designated Windchill portal. LBNL document AL-1265-6612: ALS-U BUILD TO SPECIFICATION CAD MODEL AND DRAWING REQUIREMENTS, identifies the acceptable file formats and requirements for the final drawings and CAD models.

Acceptable document formats include .docx, .xlsx, and other editable file formats or as noted in this document.

6.3 Reviews

The LBNL technical representative will work with the Subcontractor to establish an appropriate timeline and location for all reviews. Reviews may be conducted at either the Subcontractor's or the LBNL site or via web/video conference tools. External, non-LBNL reviewers may be included at LBNL's discretion. All review documents are to be submitted to LBNL no fewer than 10 working days prior the review date.

Written approval from LBNL is required following the final design and before beginning fabrication.

The following reviews are required for this project:

1. Final Design Review.
2. Pre-shipping Review.

6.4 Hold Points and what is required

Written approval from LBNL is required to proceed beyond any identified hold points. LBNL may approve long lead purchases or fabrications for the production of the magnet assemblies as deemed necessary and appropriate.

The following hold points are required for all of the BTA magnet assemblies:

1. Delivery and acceptance of the Final Design Review documentation and successful completion of the formal LBNL Design Review. Reference Section 3.1.
2. Release from LBNL to proceed to the manufacturing stage of the magnet parts, pieces, and systems. Until this hold point is satisfied, any fabrication or manufacturing done by the Subcontractor is performed at the Subcontractor's risk.
3. Review and acceptance by LBNL or LBNL's selected third party representative of the results of the Subcontractor magnet factory acceptance testing and associated reports.
4. Shipment configuration approval: LBNL shall review and approve the planned shipment containers and methodology prior to construction of containers or implementation of a shipping plan.
5. The completed assemblies shall not be shipped until written authorization to proceed with shipping is provided by LBNL.

6. Final payment to the Subcontractor shall only occur after receipt of all items listed in Appendix A, and completion of LBNL's receiving ACL. LBNL's receiving ACL shall be carried out by LBNL.

Additional hold points may be implemented at LBNL's discretion at any time after the Subcontractor enters into contract with LBNL.

7 ENGINEERING

7.1 General Engineering Requirements

Table 7-1 Standard engineering specifications

Document Number	Title
ASTM B188-09	Standard Specification for Seamless Copper Bus Pipe and Tube
ASTM B601-09	Heat Treating Temper Codes for Copper Metal and Copper Alloys
ASTM A677-16	Standard Specification for Non-oriented Electrical Steel Fully Processed Types
ASTM 6199-97	Standard Practice for Quality of Wood Members of Containers and Pallets

8 SHIPPING, HANDLING, AND STORAGE

The selected Subcontractor shall develop and utilize a shipping checklist to assist in ensuring all of the shipping requirements have been met.

8.1 Container

Containers or crates for the magnet assemblies may be used for both shipping and storage. Construction of the containers must be sufficient to adequately support and protect the full magnet assembly throughout shipping.

1. Crates are to be reusable with sides that attach using clips or other standard hardware that allow for ease of disassembly and/or reuse. LBNL must evaluate and approve shipping crate designs prior to fabrication of the crates or utilizing them for shipping.
2. All crate materials are to meet or exceed the quality standards for Wood Groups II, III, or IV per ASTMD 6199 – Standard Practice for Quality of Wood Members of Containers and Pallets.
3. LBNL may approve the shipment of more than one magnet in a shipping crate. Approval is required prior to shipment.
4. Magnet shipping containers shall be designed to allow for air-shipment.
5. Each magnet must be secured to the base pallet or skid.

6. Straps may be added to hold the crate sides in place while the walls are assembled, given that there are proper markings indicating that the support straps are not for crate lifting purposes.

8.2 Packaging

1. All water lines and magnet conductors must be free of any liquid prior to shipping. The use of clean forced dry air to evacuate each conductor line is preferred.
2. The use of desiccant is strictly forbidden.
3. The magnet assemblies shall be blocked/cribbed/supported to prevent movement or overstressing the component during transport. This includes:
    a. Placing foam between the magnet poles.
    b. Bracing the conductor with foam or cribbing to protect conductor from being bent during handling.
    c. Placing cribbing between the magnet and the sides of the crate to assist in minimizing movement during transportation.
4. If multiple magnets are shipped in the same container, cribbing or bracing shall be placed between the magnets.
5. A moisture barrier shall be utilized in the magnet shipping container to prevent condensation during air shipment.
6. Damage incurred to any of the magnets during shipment will be the responsibility of the Subcontractor to correct.

8.3 Shipping and/or Storage Specifications

Standard handling allows for incidental loads from normal transport methodologies such as forklift and lifting operations. Mishandling of the magnet assemblies can result in excessive loading which may be catastrophic to the shipping crate and/or magnet assemblies. The worst hypothetical accident condition is anticipated to be a 0.3 m drop onto an unyielding surface.

Should the magnet assemblies require storage, the storage location must be a temperature and moisture controlled, secured storage facility.

Ambient air temperature during storage is between 5◦ C and 40◦ C. Moisture barriers present in shipping crates alleviate strong humidity control requirements.

Magnet assemblies are to be transported on air ride trailers with the air ride feature engaged.

8.4 Monitoring Equipment

Each magnet assembly is required to be shipped with an active data logger to monitor temperature, humidity, vibration, and handling during the shipping process.

One data logger shall be installed in each crate. The data logger must be mounted directly onto the magnet/one of the magnets in the crate to obtain a representative vibration signature. The Subcontractor may recommend a data logger. Approval of this monitoring device is at LBNL's discretion.

9 QUALITY ASSURANCE

9.1 Quality Reporting Requirements

9.1.1 Subcontractor Quality Program

The Subcontractor shall complete and return the ALS-U Supplier Quality Evaluation Survey (AL-1208-0209) during RFP.

The Subcontractor shall maintain and apply an effective QA program for the design, manufacture, and testing of all systems and equipment provided.

Post-award surveys may be required and shall be supported by the Subcontractor.

9.1.2 Deviation Requests

Any deviations from the dictating LBNL documents must be requested by the Subcontractor and approved by LBNL prior to implementation. LBNL will provide a standard deviation request form. However, a Subcontractor's existing or internal document may be utilized with LBNL approval.

Deviation requests apply to requests to modify processes or documented drawings. Deviation requests DO NOT apply to hardware that is built which fails to conform to the specification.

9.1.3 Nonconformance Reports

A nonconformance report provides a summary for products or procedures which do not conform to the defined requirements. Nonconformances may be determined and reported by either the Subcontractor or LBNL staff. LBNL will provide a standard nonconformance report form however, a Subcontractor's existing or internal document may be utilized with LBNL approval. Nonconformance reports are to be submitted to LBNL within 3 business days of the identification of a nonconformance.

Nonconformance reports apply to hardware that is built and does not conform to the specification(s). LBNL will provide a written disposition establishing a path forward for each nonconformance. No operations may be performed on the nonconforming item without LBNL's written disposition or approval to proceed.

9.2 Build Instructions

Detailed instructions for manufacturing staff describing the tools, materials, fabrication, assembly, and any in-process verification steps, as applicable, required for creation of a complete magnet assembly. The instructions shall cover the following:

- The manufacturing fabrication plans for all yoke and pole subassemblies.
- The manufacturing fabrication plans for the electromagnet's coil assemblies.
- The final assembly plan detailing how the coils are to be integrated into the final magnet assemblies.

9.3 Work Instructions

The Subcontractor shall develop detailed instructions to technical staff for how to perform certain operations on completed magnet assemblies. These instructions shall include, at minimum, drafts of the specific procedures listed below.

Work instructions may be developed in coordination between LBNL and the Subcontractor.

9.3.1 Magnet Splitting Instructions

The Subcontractor shall develop work instructions in the Subcontractor's documentation format identifying all tooling, fasteners, components, subassemblies, and assemblies involved in the operation of splitting the major (i.e. upper and lower in this case) halves of the magnet assembly, describing all manipulations or operations needed to complete this work safely and correctly.

9.3.2 Upper Half Flipping Instructions

The Subcontractor shall develop work instructions in the Subcontractor's documentation format identifying all tooling, fasteners, components, subassemblies, and assemblies involved in the operation of flipping the top half of the magnet assembly upside-down after it has been split from the lower half, describing all manipulations or operations needed to complete this work safely and correctly.

9.3.3 Coil Extraction Procedures

The Subcontractor shall develop work instructions in the Subcontractor's documentation format identifying all tooling, torque values/protocols, consumables, fasteners, components, subassemblies, and assemblies involved in the operation of reassembling the previously split major (i.e. upper and lower in this case) halves of the magnet assembly, describing all manipulations or operations needed to complete this work safely and correctly.

9.4 Factory Inspection and Test Plan

The Subcontractor shall provide a Factory Acceptance and Test (FAT) Plan which shall be submitted to LBNL for written approval by ALS-U Quality Assurance prior to its required use.

The Factory Acceptance Test outlines the processes that will be used to demonstrate compliance with all of the requirements in LBNL technical specifications AL-1443-0548, AL-1462-7396, AL-1471-4086, and AL-1441-1075. This FAT Plan shall consist of a plan in the Subcontractor's documentation format listing components, subassemblies, and assemblies; identifying and describing all Subcontractor QA/QC inspections and tests planned for the verification of quality of the fully integrated magnet assembly; and the corresponding documentation/planning, data collection, data management, data processing, and data interchange with LBNL.

The Subcontractor is encouraged to reference LBNL's Magnet Receiving Acceptance Criteria List (ACL) to develop their FAT plan to guarantee common acceptance criteria and ensure a common QC.

A production FAT plan is required for each magnet configuration type.

9.5 ACL upon Receipt at LBNL

A receiving ACL, produced by LBNL shall be carried out by LBNL within 60 business days of receipt of the BTA magnets. Full execution of the receiving ACL shall be done by LBNL before final payment is remitted to the Subcontractor.

LBNL may provide a reference receiving ACL upon Subcontractor request.

10 APPLICABLE DOCUMENTS

This section identifies applicable documents that are considered to be a part of this document. All information contained in an applicable document shall be valid to the full extent, unless specifically noted within this document. Applicable documents shall be obtained from the LBNL Document Control Center (DCC).

Document Number	Title
AL-1462-7396	BTA-MAGNETS DIPOLE COMMON MECHANICAL REQUIREMENTS
AL-1471-4086	INDIVIDUAL MECHANICAL REQUIREMENTS FOR BTA DIPOLE MAGNETS
AL-1231-7540	BTA - TBENDA
AL-1262-9077	BTA MAGNET DIPOLE - TBENDA
AL-1252-2525	TBEND-A MAGNET ASSY
AL-1441-1019	LEFT YOKE CORE ASSY
AL-1441-0954	RIGHT YOKE CORE ASSY
AL-1441-0958	RIGHT YOKE AND FLUX RETURN ASSY
AL-1441-0954	RIGHT YOKE CORE ASSY
AL-1259-3222	TBENDB-B MAGNET ASSY
AL-1443-3431	LEFT YOKE CORE ASSY
AL-1443-3434	RIGHT YOKE CORE ASSY
AL-1443-3437	RIGHT YOKE AND FLUX RETURN ASSY
AL-1250-3624	TBENDC MAGNET ASSEMBLY
AL-1259-1980	TBENDC YOKE ASSEMBLY, TOP
AL-1259-1982	TBENDC YOKE ASSEMBLY, BOTTOM
Al-1441-1075	BTA-MAGNETS QUADRUPOLE COMMON MECHANICAL REQUIREMENTS
AL-1443-0548	INDIVIDUAL MECHANICAL REQUIREMENTS FOR BTA QUADRUPOLE MAGNETS
AL-1240-9666	BTA - TBENDD
AL-1252-2198	BTA MAGNET DIPOLE-TBENDD
AL-1248-7527	Q7_BTA TQFA
AL-1248-7526	Q6_BTA TQDA
AL-1430-5205	TQDB-A MAGNET ASSY
AL-1424-4278	TQDB-B MAGNET ASSY
AL-1423-8026	TQFC MAGNET ASSY
AL-1248-7953	TQDC MAGNET ASSY
AL-1424-4276	TQFE MAGNET ASSY
AL-1424-4816	TQFD MAGNET ASSY
AL-1424-1532	TQFB MAGNET ASSY
AL-1212-2823	COMMERCIAL OFF THE SHELF ITEM CREATION
AL-1265-6612	ALS-U BUILD TO SPECIFICATION CAD MODEL AND DRAWING REQUIREMENTS
AL-1119-4345	ALS-U NAMING CONVENTION STANDARD
AL-1298-1949	ALS-U POLICY ON COLOR SELECTION FOR COMPONENTS
AL-1259-2147	ALS-U SEISMIC DESIGN CRITERIA

11 REFERENCES

Documents listed in this section are considered reference documents that can be used to better describe, clarify intent, or provide information about where the information was obtained.

Document Number	Title
Al-1346-1757	ALS-U MAGNET NOMENCLATURE FOR LATEST REVISIONS
AL-1443-2987	BTA MAGNET MEASUREMENT PLAN AND REQUIREMENTS
AL-1119-2572	BTA MAGNETS SUMMARY
AL-1498-3155	CAD REF MODEL ONLY - THREADED GUIDE ROD, M16X3X30, MOS2 COATING
AL-1441-0961	CAD REF MODEL ONLY - TOP FLUX RETURN ASSY
AL-1441-0959	CAD REF MODEL ONLY - BOTTOM FLUX RETURN ASSY
AL-1498-3155	CAD REF MODEL ONLY - THREADED GUIDE ROD, M16X3X30, MOS2 COATING
AL-1443-3435	CAD REF MODEL ONLY - TOP FLUX RETURN ASSY
AL-1443-3436	CAD REF MODEL ONLY - BOTTOM FLUX RETURN ASSY

APPENDIX A: VERIFICATION TABLE

(To be completed by delivery date)

This appendix summarizes the final set of Subcontractor deliverables which are due to LBNL in addition to the other deliverables listed in section 3 above. It is LBNL's expectation that as a final action, the Subcontractor will print out this page, and complete the "Complete? (Y/N)" column as part of the completed delivery package. For any "N" (no) response, an explanation in the comments section below shall be provided as to why that deliverable is not complete. It is then up to LBNL to accept the deliverable as is through a waiver, or work with the Subcontractor for completion of the task before acceptance of the final delivery.

Item	Section	Item	Complete? (Y/N)
1	3.1	Complete and finalized magnet design documentation package for each magnet type	
2	3.2	Complete manufacturing and acceptance documentation	
3	3.3	Complete, final, as-built drawings, bills of materials, travelers, build and work instructions	
4	5.1	Complete, full mechanical inspection reports for 'shall' requirements specified in the technical specifications	
5	5.2	Complete, full coil inspection and test reports validating the coil requirements	
6	5.3.1	Complete quadrupole magnet measurement documents demonstrating compliance with the magnet performance requirements	
7	5.3.2	Complete B4 magnet measurement documents demonstrating compliance with the magnet performance requirements	
8	8.3	Shipping checklist confirming that shipping conditions - and, if needed, storage conditions - have been met	
N/A	N/A	All Government Furnished Property (GFP) and/or materials purchased by LBNL for this project have been returned to and received by LBNL	

Comments:

Attachments: