



**US Army Corps of Engineers
Omaha District
API 653 Out-of-Service
Inspection Report**



**Andrews Air Force Base, Morningside, Maryland
Facility 5025
Tank 25**

**US Army Corps of Engineers Center of Expertise for Petroleum, Oils and Lubricants
USACE POL-MCX**

16 January 2018

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ACRONYMS AND ABBREVIATIONS

AFFF	Aqueous Firefighting Foam
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society of Non-Destructive Testing
ATG	Automatic Tank Gauge
BBL	Barrel
CFR	Code of Federal Regulations
CMU	Concrete Masonry Unit
CP	Cathodic Protection
DFT	Dry Film Thickness
FAC	Facility
HLA	High Level Alarm
HHLA	High-High Level Alarm
IFR	Internal Floating Roof
LCV	Level Control Valve
LLA	Low Level Alarm
LLLA	Low-Low Level Alarm
MFL	Magnetic Flux Leakage
MT	Magnetic Particle Testing
NA	Not Applicable
NACE	National Association of Corrosion Engineers
NDT	Non-Destructive Testing
NFPA	National Fire Protection Association
NPT	National Pipe Taper Thread
PSI	Pounds per Square Inch
PT	Penetrant Testing
PTFE	Polytetrafluoroethylene (e.g., Teflon)
P/V	Pressure/Vacuum
RP	Recommended Practice
TRV	Thermal Relief Valve
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specifications

GENERAL SUMMARY

Austin Brockenbrough & Associates, LLP (Brockenbrough) was retained by Omaha District USACE under Contract No. W9128F-12-D-0006 Delivery Order 0036 to perform SPCC Mandated AST Inspections at various facilities throughout the CONUS. For Facility 5025, (locally known as Tank 25) at Andrews Airforce Base in Morningside, Maryland, an API 653 Out-of-service (internal and external) inspection was performed. This inspection was completed on October 25, 2017 in accordance with API Standard 653, "Tank Inspection, Repair, Alteration, and Reconstruction," and the referenced contract. The out-of-service inspection was performed by Brockenbrough and our sub-consultant, InterSpec, LLC (InterSpec).

Facility 5025, locally known as Tank 25, is a 43-foot and 6-inch diameter by 42-foot and 3-inch tall, single wall, vertical, field erected tank used to store jet fuel (F-24). The tank erector's nameplate indicates the tank was built to API 650 9th Edition in 1998 and has a nominal storage capacity of 11,183 barrels. However, the nominal capacity listed on the nameplate calculates to be to the top of the shell (42 feet and 3 inches counting the rim angle). The capacity to the over flow is only 10,200 barrels. The tank's aluminum internal floating pan was manufactured by Petrex. Tank bottom secondary containment and leak detection is provided by a liner under the tank bottom, which is connected by underground piping to four 16-inch monitoring wells in the dike basin. Dike area secondary containment is provided by concrete covered earthen berms. The design drawings indicate a liner under the concrete covering the dikes and dike basin. A concrete dike wall separates the dike area from that of the adjacent tank. Details of tank construction and appurtenances are also included in the Tank Information Table in Section 'B'. Our sub-consultant's report is included in Appendix 'A'. Additional photographs are included in Appendix 'B'. Design drawings, are included in Appendix C.

The tank was not returned to service following the inspection for the following reasons: Magnetic Flux Leakage (MFL) examination of the tank bottom located a band of severe underside corrosion in a ring pattern located approximately 3 feet in from the shell, resulting in several areas with remaining thickness less than allowed by API 653. While the cathodic protection system appears to be producing somewhat less electrical current than indicated in the June 2017 inspection report, it is unlikely the corrosion occurred in the few months since then; and the pattern of corrosion suggests it is above the level of the water (at the air-water interface) where the cathodic protection system would have little effect. Also considered Mandatory to be addressed prior to returning the tank to service, is the condition of the internal floating pan perimeter foam log seal, which was found to have failed and was dripping fuel all around the perimeter. A ten-foot long section of the foam log perimeter seal was found to be collapsed and starting to fall apart. The tank was found to be otherwise in good condition, but with some minor deterioration, and some appurtenances design deficiencies.

Recommendations for addressing the deficiencies are included in Section C of this report. The repairs should be performed in accordance with API 653 and military criteria. The repair plan and the completion of the repairs should be reviewed and inspected by an API 653 Inspector. The schedule for the next API 653 Out-of-service (internal and external) Inspection should be determined by the API 653 Inspector who assesses the repairs.

The next API Standard 653 In-Service (visual external) Inspection should be performed by October 2022. The next ultrasonic thickness inspection of the shell should be performed by October 2032.

THIS INSPECTION

API Out-of-Service (internal and external) Inspection Date:
Equipment Used:

25 October 2017

(See sub-consultant report.)

PREVIOUS INSPECTION DATES

API Out-of-Service (Internal) Inspection Date:
API In-Service (External) Inspection Date:

Dec 2007
June 2015

STATE REGULATIONS

State Regulation for API In-Service Tank Inspections
State Regulation for API Out-of-Service Tank Inspections

NA
NA

RECOMMENDED FUTURE INSPECTION DATES

API Out-of-service (Internal) Inspection Date:
API Ultrasonic Thickness Inspection of Shell Date:
API In-Service (External) Inspection Date:

Pending review of completed Mandatory repairs.
October 2032
October 2022



Mike O'Connor
Mechanical Designer
API 653 Inspector No. 6230

GENERAL TANK INFORMATION

ITEM		DESCRIPTION	
Owner		U.S. Air Force	
Location		Joint Base Andrews	
Facility Number		5025	
Tank Number		Tank 25	
State / Country		Maryland / U.S.A.	
City		Morningside	
Inspection Date		October 25, 2017	
Tank Manufacturer		Matrix Service	
Design Standard		API 650, 9th Edition	
Date of Construction		1998 (per nameplate)	
Tank Contents		Jet fuel (F-24)	
Tank Serial Number		EC-811	
Tank Diameter		43'-6"	
Shell Height		42'-3"	
Product Height		38'-8 1/2" (limited by overflow)	
Tank Capacity		10,200 bbl nominal (bottom to overflow). 8,400 useable (LLA to HLA)	
Foundation		6" high concrete ring wall.	
Construction/Material	Bottom	1/4-inch lap welded plate cone-down carbon steel of unknown grade.	
	Shell	Five butt-welded shell courses 1/4-inch plate /A36 Mod.	
	Floating Roof	Petrex aluminum honeycomb pan.	
	Fixed Roof	Supported cone roof. 1/4-inch carbon steel plate.	
Cathodic Protection		Impressed current.	
Interior Coating System		Interior 100% coated, likely epoxy.	
Exterior Coating System		Epoxy/polyurethane assumed.	
Level Gauging		Enraf ATG, Shand and Jurs Autogauge, 2" Vito water bottom probe well, 8-inch manual gauge well, 8-inch manual gauge ladder well.	
Overfill Protection		Independent high and high-high level alarms, float operated LCV.	
Piping	Receipt	8"	Welded stainless steel
	Issue	12"	Welded stainless steel
	Water Draw-off	3/4"	Stainless steel
Level Alarms		Independent high, high-high, and sub low level alarms; ATG Alarms.	
Cleaning, Inspection, Repair		In-service inspection 2015. Cleaned and out-of-service inspected in 2007.	
RPB/Leak Detection		Under bottom liner, 4 leak detection wells.	
Stairs/Ladders		Circumferential stairway with upper landing. Internal ladder	
Manholes		Two 36-inch lower shell manholes. One 36-inch roof manhole.	
Venting/Vapor Controls		Center roof vent, 4 roof perimeter vent/inspection hatches, 4 shell overflows.	
PST		Yes	
Secondary Containment		Concrete covered liner over earthen berms and dike basin.	
Fire Protection System		(2) fire hydrants within 300 feet.	

A. GENERAL PROJECT INFORMATION**1. API 653 Inspection**

This project will perform SPCC Mandated AST Inspections at various facilities throughout the United States. Additional consideration is given to federal, state, and local regulations as well as applicable military criteria and general industry standards. For Facility 5025 (Tank 25), an API Standard 653 Out-of-service (internal and external) Inspection was performed.

2. Site Information

On October 24 and 25, 2017 Brockenbrough and our subconsultant InterSpec performed API 653 Out-of-service (internal and external) Inspection of Facility 5025 (Tank 25) located at Andrews Air Force Base, which is located in Morningside, Prince George's County, Maryland.

In 2009, Andrews Air Force Base and Naval Air Facility Washington were merged to form Joint Base Andrews. The Base is named for Lieutenant General Frank Maxwell Andrews (1884–1943), former Commanding General of United States Armed Forces in the European Theater of Operations during World War II. The Base is widely known for serving as the home base of two Boeing VC-25 aircraft which have the call sign “Air Force One” while the President of the United States is on board. As of the 2010 census, the resident population was 2,973. The host unit at Andrews is the 11th Wing, assigned to the Air Force District of Washington. The Wing is responsible for maintaining emergency reaction rotary-wing airlift and other National Capital Region contingency response capabilities critical to national security, and for organizing, training, equipping and deploying combat-ready forces for Air and Space Expeditionary Forces (AEFs). The Wing also provides installation security, services and airfield management to support the President, Vice President, other U.S. senior leaders and more than 50 tenant organizations and federal agencies. The list of the types of aircraft that fly out of Andrews Air Force Base is extensive, as are the list of the branches of the military that fly out of Andrews Air Force Base.

3. Previous Repairs

Base personnel indicated no repairs have been performed on the tank since its construction. However, the coating repairs evidenced by the variations in the color/shade of the internal coating, suggest the autogauge (tape gauge), Enraf ATG stilling well, and Vito water probe were retrofitted.

4. Future Projects

Base personnel indicated the only known future project affecting the tank is repair of the tank bottom to foundation seal scheduled to be performed on 2 November 2017.

B. TANK INSPECTION COMMENTS**1. Tank Construction**

Tank Facility 5025 is a 43-foot and 6-inch diameter by 42-foot and 3-inch tall, Jet Fuel (F-24) aboveground vertical storage tank. The tank erector's nameplate indicates the tank was constructed in 1998 and its nominal capacity is 11,183 bbl. However, the capacity to the overflow is only 10,200 bbl, while the capacity between the sub low and high level alarms (useable capacity) is only approximately 8,400 bbl. The capacity listed on the nameplate includes the air above the overflow to the top of the shell. The tank has a cone down bottom, with a center sump, a Petrex aluminum honeycomb internal floating pan, and a cone roof.

2. Tank Foundation

The tank rests on a 6-inch high ringwall foundation. The foundation was visually evaluated during the inspection for broken concrete, spalling, cracks, and vegetation against the bottom of the tank. There are approximately 25 unsealed radial cracks in the top of the ringwall foundation. A shell settlement survey was performed during the inspection in accordance with Appendix B of API Standard 653. The shell settlement evaluation indicates the settlement of the bottom of the shell and perimeter of the tank bottom is within the applicable limits for the method of evaluation described in API, and is within tolerance for new construction. The measured out of plane deflection does not indicate significant settlement. Therefore, no action is required. The measurements and analysis are recorded in our sub-consultant's report.

3. Leak Detection

The design drawings included in Appendix D indicate each of the four 2-inch tank bottom leak detection tell-tale pipes extend inward under the tank bottom and terminate on that end halfway to the sump and terminate on the other end with a valve located in one of the four 16-inch monitoring wells located in the dike basin. The monitoring wells are sealed with 16-inch threaded plugs and are difficult to access. Opening one of the wells and leak detection valves in the well allowed a significant amount of water to drain out from under the tank bottom.

4. Tank Bottom

The lap welded cone down bottom slopes down to a center sump. The tank bottom was examined by magnetic flux leakage technology. Magnetic Flux Leakage (MFL) examination of the tank bottom located a band of severe underside corrosion in a ring pattern located approximately 3 feet in from the shell. The ultrasonic thickness measurements of the tank bottom at the locations of the underside corrosion indicate the tank bottom is not suitable for return to service without significant repair or replacement. The internal coating appeared to be in good condition. However, the floating roof striker plates are glued to the tank bottom rather than welded as required by API 650. In addition, the striker plates are stainless steel, which could cause galvanic corrosion of the interior of the tank bottom in the presence of water.

5. Cathodic Protection System

An impressed current cathodic protection system is installed on the underside of the tank bottom. While the cathodic protection system appears to be putting out somewhat less electrical current than indicated in the June 2017 inspection report, it is unlikely the corrosion occurred in the few months since then; and the pattern of corrosion suggests it is above the level of the water (at the air-water

interface) where the cathodic protection system would have less effect. The output readings in the control box read 4 volts and 0.2 amps.

6. Tank Shell

The vertical and cylindrical shell consists of five butt-welded courses. The exterior of the shell was visually inspected and evaluated for plumbness, roundness, peaking, and banding. Although some minor peaking of the vertical shell seams was noted, the shape of the shell appears to be within the allowable tolerances of API Standard 653. The shell coating was evaluated for deterioration and found to be in good condition. However, much of the lower part of the shell is covered with mold and algae. The ultrasonic thickness measurements of the shell and calculations included in Appendix A indicate the shell has more than 30 years of remaining life. API 653 recommends ultrasonic thickness measurements of the shell be taken at least every 15 years.

7. Tank Appurtenances

a. Tank Roof

The tank's steel, lap welded cone roof shows sign of isolated minor water ponding in a few places. There are 22 rafters. The rafters are spaced 74 1/2 inches apart at the perimeter of the roof. As early as 1996, API 650 required the rafter spacing at the perimeter of the tank roof to be no greater than 75 inches apart. Earlier API requirements may have been more stringent. Later editions of API 650, paragraph 5.10.4.4 increased the maximum allowable spacing to 84 inches.

b. Internal Floating Pan

The tank's aluminum honeycomb internal floating pan was manufactured by Petrex. The floating pan perimeter seal is a double foam log. The foam log primary seal is generally cracked and saturated with fuel. A 10-foot section of the foam log primary seal, located on the south southwest, was noted to have collapsed and is falling apart. The floating pan perimeter is not suitable for continued use.

c. Venting

The tank has a 24-inch diameter roof center vent, 4 perimeter vent inspection hatches, and 4 shell overflow/vents. Two of the perimeter vent inspection hatches have broken latches. Two of the overflows are over the stairs. API 650 discourages placing overflows over stairways or nozzles.

d. Gauging

The tank's Enraf ATG is installed in an 8-inch flanged aluminum stilling well mounted through a 10-inch roof nozzle. A Vito water probe is installed through the neck of the center vent and through a 2-inch stilling well. The water probe is too long, with the result that the bottom end of the water probe is lying against the sump piping and may not be effective. Manual gauging may be performed through the 8-inch ladder stilling well under the roof manhole cover, which is equipped with a gauge hatch. Manual gauging may also be performed through the 8-inch stilling well which is mounted through a 10-inch flanged roof nozzle, which is equipped with a floating plug retriever. The Shand and Jurs autogauge (tape gauge) is connected to the floating pan, with the result that the interior mechanism of the gauge head is damaged. The autogauge is not functioning. The manual and ATG stilling wells are welded to the guides, which are bolted rigidly to their mounting plates, which in turn are welded to the tank bottom. API 650 does not allow columns to be fastened to

both the tank roof and the tank bottom. The bolt holes are not slotted, however slotted bolt holes and their length are included in USACE Standard Design AW 78-24-27 for adjusting the datum plate elevation only. While perhaps not obvious, the intent of the detail included in the USACE Standard Design AW 78-24-27 in effect at the time was that the guides touch but not be welded to the stilling wells, so that the datum plates, which were to be welded to the bolted guides, could be adjusted using the slotted bolt holes. There is no standard in API 650 for the design of slotted bolt holes to allow movement of the roof and bottom connected by a column. The 2010 release of the DoD Standard Design AW 78-24-27 clarified the detail.

e. Level Alarms

The tank has independent (shell mounted) high and high-high level alarms. Guidance for new construction provided in UFC 3-460-01 and DoD Standard Design AW 78-24-27 include both high and high-high level alarms as well as low and low-low level alarms above the low leg level of the floating pan. Although the level alarm panel indicates a low level alarm, there is no low level alarm above the low leg level of the floating pan. There is however a sub-low level alarm set at approximately one foot below the low leg level of the floating pan. The high level alarms are accessible from the circumferential stairway but are not testable due to interference with the stairway.

f. Stairs, Landings and Ladders

The tank's steel cone roof is accessible by a circumferential stairway mounted on the shell of the tank. While the normal rise of the stairway steps is approximately 9 1/2 inches the bottom step is approximately 15 1/2 inches above the dike basin. There is no upper shell manhole or lower landing in the circumferential stairway for accessing the floating pan at the high leg position. The circumferential stairway also does not include an intermediate landing for accessing the high level alarms and controls. There is only 12 inches of clearance between the high level alarm and the stairway handrail and only approximately 4 feet of vertical clearance. OSHA requires stair steps to have a minimum width of 22 inches and 7 feet of overhead clearance. API requires 28 inch wide tread.

g. Grounding and Bonding

There are four grounding cables bolted to lugs, which are welded to the shell. The cables penetrate the dike basin through the dike basin to ring wall seal. The cables to grounding rod connections are accessible in cavities in the concrete dike basin. The ground rods and cables penetrate the dike concrete basin through unsealed cavities in the concrete; however, the design drawings indicate a liner under the concrete.

h. Shell Manholes

The tank has two 36-inch shell manholes. The shell manhole covers are hinged.

8. Tank Coating

The interior and exterior of the shell are coated. The exterior shell coating appears to be in good condition, but with some mold and algae covering the lower areas. There is isolated but scattered coating failure on the exterior of the roof. There is also coating failure and corrosion on the roof appurtenances, bolting, roof guardrail, shell nozzle isolation valves, and level alarm chambers. The high and high-high level alarm conduit clips are also corroded. The interior coating appears to be in good condition.

9. Tank Piping System

Fuel is received into the tank through 8-inch stainless steel piping via underground piping from the adjacent pumphouse, which receives fuel via underground pipeline from the bulk tanks in the southeast tank farm. Fuel is issued from the tank through 12-inch stainless steel underground piping through the adjacent pumphouse to a hydrant system.

10. Fire Protection System

There are two fire hydrants within 300 feet of the tank.

11. Secondary Containment

Secondary containment is provided by concrete covered earthen berms. The design drawings indicate a liner under the concrete covering the dikes and dike basin. A dike wall separates the dike area from that of the adjacent tank. The dike drainage swale is approximately 10 feet from the tank. A large pool of rain water was observed on the side of the dike basin opposite the dike drain and appears undrainable. The issue piping is routed over the swale. NFPA 30 paragraph 22.11.2.1 requires the dike basin to be sloped away from the tank for a distance of 50 feet or to the dike wall, whichever is less. NFPA 30 paragraph 22.12.2.1 requires the dike basin to also be sloped away from the piping for a distance of 50 feet. Draining the rainwater that had collected in the dike area overnight down to the top of the secondary containment drainage sump and holding for more than an hour while observing a stable water level in the sump (hydrostatic testing) indicates the integrity of the drain valve, sump, and drain piping is acceptable.

The volume of the secondary containment is sufficient to hold the contents of the tank full to the bottom of the overflow as required by NFPA 30, plus approximately 20 inches of free board. Guidance for the design of new tanks included in UFC 3-460-01 includes only 12 inches of freeboard.

C. FINDINGS AND RECOMMENDATIONS

With the exception of a few Mandatory repairs, Tank Facility 5025 was found to be in generally good condition. However, the tank is not serviceable in its current condition due to the Mandatory Repairs that are required to be performed before the tank can be returned to service. In addition, there were several items observed, that are not in full compliance with federal, state, and local regulations or military criteria.

1. MANDATORY REPAIRS per API 653, NFPA, or CFRs

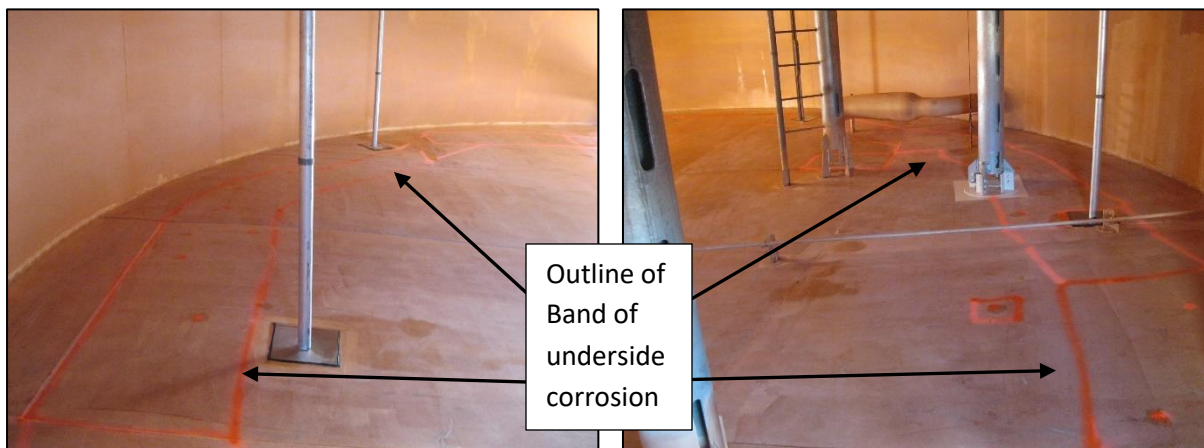
Mandatory repairs represent items that require immediate attention in order to prevent imminent risk to system operators, equipment, or the adjacent environment. The tank should remain out-of-service until completion of these repairs.

a. Replace the Tank Bottom

OBSERVATION: MFL examination of the tank bottom identified a band of corrosion approximately 3 feet in from the shell and extending all around the tank bottom with thinning to less than 0.050 inches of remaining thickness, and many areas within the band with remaining thickness less than 0.100 inches. It should be noted that the technology is not capable of scanning areas within 2 inches of the lap welds or obstructions. There are four 16-inch monitoring wells located in the dike basin. The monitoring wells are sealed with 16-inch threaded PVC plugs and are difficult to access. Vacuuming the water out of one of the wells and opening the 2-inch leak detection valve in that well allowed a significant amount of water to drain out from under the tank bottom. While the cathodic protection system appears to be putting out somewhat less electrical current than indicated in the June 2017 inspection report, it is unlikely the corrosion occurred in the few months since then. The pattern of corrosion suggests it is above the level of the water (at the air-water interface) and above the settled sand pad, and therefore above the area where the cathodic protection system could have been effective.

REFERENCE: API 653 paragraph 4.4.5.3 and Table 4.4 require the tank bottom to be repaired or replaced when the remaining thickness of a tank bottom with leak detection and secondary containment is less than 0.050 inches.

RECOMMENDATION: Replace the tank bottom by the shell slotting method, and under the new tank bottom, provide a liner, sand pad, cathodic protection, and leak detection. Arrange to have an API 653 Inspector review the repairs and make recommendations for scheduling the next internal inspection.

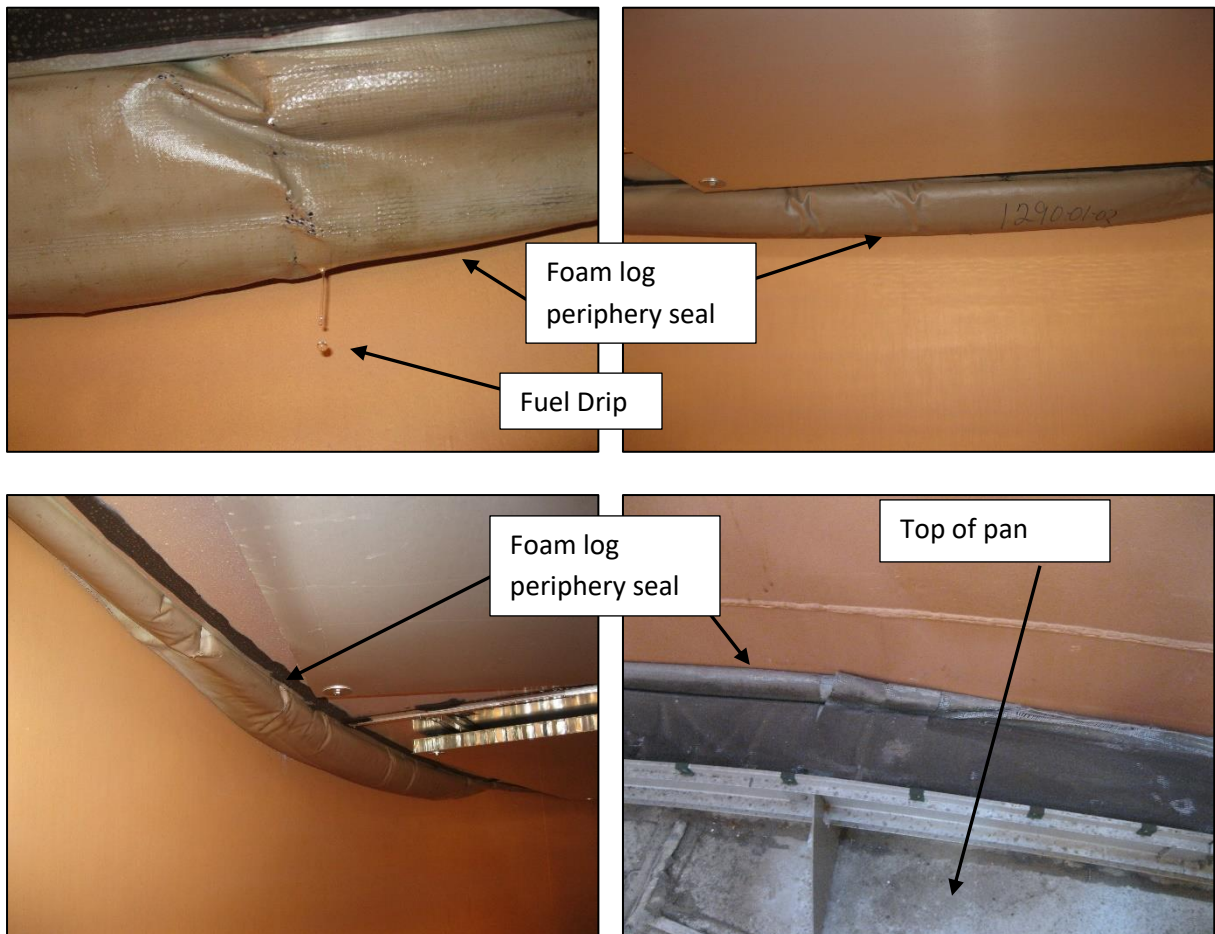


b. Replace the Floating Pan Perimeter and Penetration Seals

OBSERVATION: The internal floating pan perimeter foam log seal was found to have failed and was dripping fuel all around the perimeter. A ten-foot long section of the foam log perimeter seal is collapsed and is starting to fall apart. The penetration seals are also deteriorated.

REFERENCE: Guidance for new construction provided in DoD Standard Design AW 78-24-27 includes flexible wiper squeegee primary and secondary periphery seals made of closed cell cast urethane.

RECOMMENDATION: Replace the internal floating pan periphery foam log seals with closed cell cast urethane flexible wiper squeegee primary and secondary seals. Replace the floating pan penetration seals with material similar to the periphery seals.



2. SIGNIFICANT FINDINGS per API 653, NFPA 30 or CFRs

The following information identifies the significant findings found during the tank inspection, and includes repair recommendations.

a. Replace Level Control Valve

OBSERVATION: The level control valve is made of aluminum.

REFERENCE: NFPA 30 paragraph 27.4.3 and UFC 3-460-01 paragraph 3-6.7.1 prohibit valves made of aluminum and other low melting point materials.

RECOMMENDATION: Replace the aluminum level control valve with a steel valve.

**b. Replace the Cathodic Protection System**

OBSERVATION: The tank was built in 1998 with the impressed current cathodic protection system under the tank bottom. The cathodic protection (CP) system rectifier multiuse meters indicate 4 volts, and only 0.2 amps. Review of cathodic protection inspection reports indicate the readings for this tank and the sister tank have been historically much higher. The system may be near the end of its useful life.

REFERENCE: Guidance for the design of new storage tanks provided in DoD Standard Design AW 78-24-27 and UFC 3-460-01 include cathodic protection under tank bottoms.

RECOMMENDATION: When the tank bottom is replaced, replace the cathodic protection system.

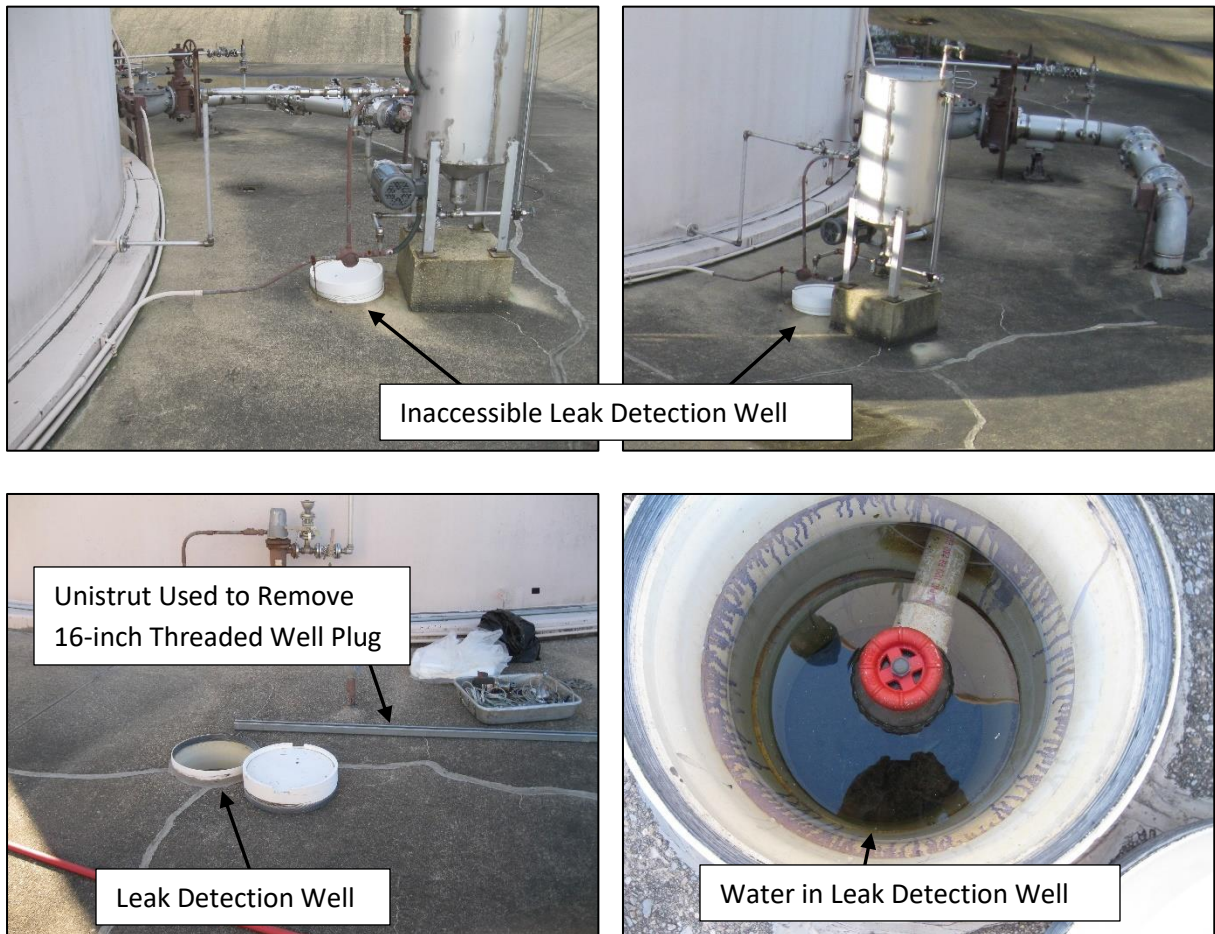


c. Provide Leak Detection

OBSERVATION: The design drawings included in Appendix D indicate that each of the four 2-inch tank bottom leak detection tell-tale pipes extend under the tank bottom only halfway to the bottom sump and terminate on the outside with a valve located in one of the four 16-inch monitoring wells located in the dike basin. The drawings do not indicate means to drain the center portion of the underside of the tank bottom. The monitoring wells are sealed with 16-inch threaded plugs, which are difficult to open. The wells are non-standard design and were not recognized as monitoring wells by POL personnel prior to the inspection. However, one of the leak detection wells was opened using a 6-foot long piece of 1 1/2-inch unistrut to apply torque. Some of the wells are located where there are obstructions that would complicate opening. The non-standard leak detection pipes and wells resulted in the buildup of water under the tank bottom, which may have contributed to the underside corrosion and necessity of replacing the tank bottom.

REFERENCE: Guidance for replacing tank bottoms provided in API 653 paragraph 9-10.2.6 and UFC 3-460-01 paragraph 12-3.3 includes providing a new bottom above the existing bottom, and providing leak detection piping that penetrates the shell below the new bottom for easy access. Guidance for new construction provided in DoD Standard Design AW 78-24-27 includes leak detection/drain piping extending to under the tank bottom sump.

RECOMMENDATION: When the tank bottom is replaced by the shell slotting method, provide leak detection piping per the latest military criteria.



d. Modify Stilling Well Guides

OBSERVATION: The ATG well, manual gauging well and internal ladder are attached to the tank roof as well as bolted to their bottom end guides, which are welded to the tank bottom. The bolts attaching the ATG well to the bottom end guides protrude through to the inside of the well and could cause the ATG to hang up.

REFERENCE: API 650 paragraph 5.10.4.7.d) requires columns to be free to move vertically relative to the tank bottom. Guidance for the design of new storage tanks provided in DoD Standard Design AW 78-24-27 allows stilling wells and ladders to be free to move vertically.

RECOMMENDATION: When the tank bottom is replaced provide new well guides in accordance with current military criteria. Ensure the U-bolts at the top of the ladder side rails are double nutted to the ladder access opening and do not restrict the vertical movement of the ladder.



e. Remove Stainless Steel IFR Striker Plates

OBSERVATION: The internal floating pan support leg striker plates are stainless steel and glued to the tank bottom. Galvanic corrosion of the interior of the tank may occur, if water is present and the stainless steel striker plates make contact with the tank bottom, or the pan support legs make contact with the stainless steel striker plates.

REFERENCE: API 650 paragraph H.4.6.6 (paragraph H.4.7.4 in the 1993 and previous editions) requires that if striker plates are used, they be welded to the tank bottom. Guidance included in UFC 3-460-01 paragraph 2-12.3.3 discourages the bonding of dissimilar metals in new storage tanks. Guidance for new construction included in UFGS Guide Specification 33 56 163.13 includes PTFE feet on the bottoms of IFR support legs.

RECOMMENDATION: When the tank bottom is replaced, provide PTFE feet on the bottoms of the IFR support legs. Ensure that stainless steel IFR support leg striker plates are not installed.

**f. Modify the Diffuser**

OBSERVATION: The receipt diffuser discharges horizontally approximately one foot above the tank bottom.

REFERENCE: Guidance for new construction provided in UFC 3-460-01 paragraph 2-19.01 and DoD Standard Design includes a diffuser design that limits free falling of the fuel and creation of static by angling the diffuser down to within 4 inches of the tank bottom.

RECOMMENDATION: Modify the diffuser to limit free falling of the fuel and creation of static by angling the diffuser down to within 4 inches of the tank bottom.



g. Provide Valve on Water Draw-off Nozzle

OBSERVATION: There is no isolation valve or electrical isolation flange kit on the water draw-off nozzle. The product saver tank piping is stainless steel. The product saver tank is not grounded.

REFERENCE: NFPA 30 – 22.13.1 requires isolation valves to be located as close to the shell as practical. Guidance provided in DoD Standard Design AW 78-24-27 includes isolation valves on tank nozzles. Guidance for new construction provided in DoD Standard Design AW 78-24-27 and UFC 3-460-01 paragraph 2-12.3 include grounding for new product saver tanks. Paragraph 9-8 i) includes isolation flanges for connecting dissimilar metals.

RECOMMENDATION: Provide an electrical isolation flange kit and an isolation valve on the water draw-off nozzle. Provide a grounding system for the product saver tank. Do not bond the product saver tank to the grounding of the tank in order to maintain some degree of electrical isolation.

**h. Provide OSHA Compliant Internal Ladder Access Hatch**

OBSERVATION: The 36-inch internal ladder access manhole provides approximately only 28 inches of clearance on the climbing side of the ladder. The cover is not bolted and does not have a rain lip.

REFERENCE: OSHA regulation 29 CFR 1910.27 (c) requires 30 inches of clearance (24 inches with a deflector plate) on the climbing side of a ladder including at access hatches. Guidance for new construction provided in DoD design Standard AW 78-24-27 includes an OSHA compliant internal ladder access hatch with a rain lip.

RECOMMENDATION: Provide an OSHA compliant internal ladder access hatch with a rain lip.

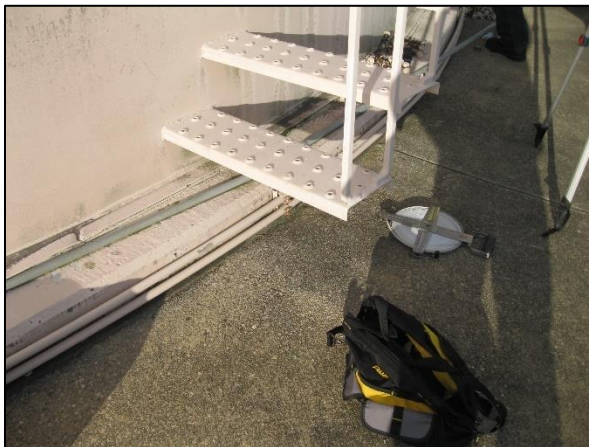


i. Modify Stairway

OBSERVATION: Clearance between the stairway handrail and the high level alarm piping is only 12 inches. The high-high level alarm is untestable due to interference with the stairway. The rise of the stairway steps is generally 9 1/2 inches; however, the bottom step is approximately 15 1/2 inches above the dike basin. There is no upper shell manhole or intermediate landing for accessing an upper shell manhole.

REFERENCE: OSHA regulation 29 CFR 1610.25 (c) (4) (December 2017) requires clearance at a stairway of at least 22 inches. The minimum width of stairs required in API 650 Table 5.18 has increased over the years, from 24 inches in 1993 to 28 inches in the latest edition. Guidance for new construction provided in DoD Standard Design AW 78-24-27 includes upper shell manholes for accessing the internal floating pan at high leg position, landings on circumferential stairways to access high level alarms, controls, and the upper shell manhole. OSHA regulation 29 CFR 1910.25 (b) (3) (December 2017) requires the step rise to be uniform throughout any flight of stairs.

RECOMMENDATION: Provide an upper shell manhole. Modify the circumferential stairway to provide lower and intermediate landings to access level alarms, controls, and the new upper shell manhole while providing 28 inches of horizontal clearance and a continuous rise from ground level or a bottom landing.



j. Provide Level Alarm Test Tubing

OBSERVATION: There is no alarm test tubing for testing the high level alarms and controls using the product saver tank return pump. Manual testing requires personnel raise a bucket of fuel high above the stairway and pour fuel into a funnel on top of the alarm piping, which often results in spilled fuel covering the tank, the dike basin, and personnel.

REFERENCE: Guidance for new construction included in AW-78-24-27 includes tubing from the product saver tank return pump for testing the high level alarms and controls.

RECOMMENDATION: Provide alarm and control test tubing from the product saver tank return pump for testing the high level alarms and controls.

**k. Replace Nuts and Bolts**

OBSERVATION: The bolting on the Enraf chamber flanges, pan installation hatch, and roof center vent as well as the clamps on the high level alarm conduit are corroded.

REFERENCE: Guidance for the design of new storage tanks provided in UFC 3-460-01 paragraph 8-3.10 requires the exterior to be coated.

RECOMMENDATION: Provide new with corrosion resistant bolting on the Enraf chamber flanges, pan installation hatch, and roof center vent. Replace the high level alarm conduit clamps.



I. Repair Coatings

OBSERVATION: There is scattered coating failure on the exterior of the roof, and coating failure and corrosion on the floating plug retriever nozzle flange, pan installation hatch cover, roof guardrail, autogauge guide pipe, interior of the roof manhole cover and flange, and the interior of the roof perimeter vent/inspection hatch hoods. There is also coating failure and corrosion on the receipt and issue DBB valves, and on the level alarm sensor chambers.

REFERENCE: Guidance for new construction provided in UFC 3-460-01 paragraph 8-3.10 includes coating the exterior. Paragraph 8-3.9 includes coating the interior.

RECOMMENDATION: Replace the coatings on the exterior of the roof including on the floating plug retriever nozzle flange, pan installation hatch cover, the roof guardrail, autogauge guide pipe, interior of the roof manhole cover and flange, and interior of the roof perimeter vent/inspection hatch hoods. Replace the coatings on the receipt and issue DBB valves, and on the level alarm sensor chambers.

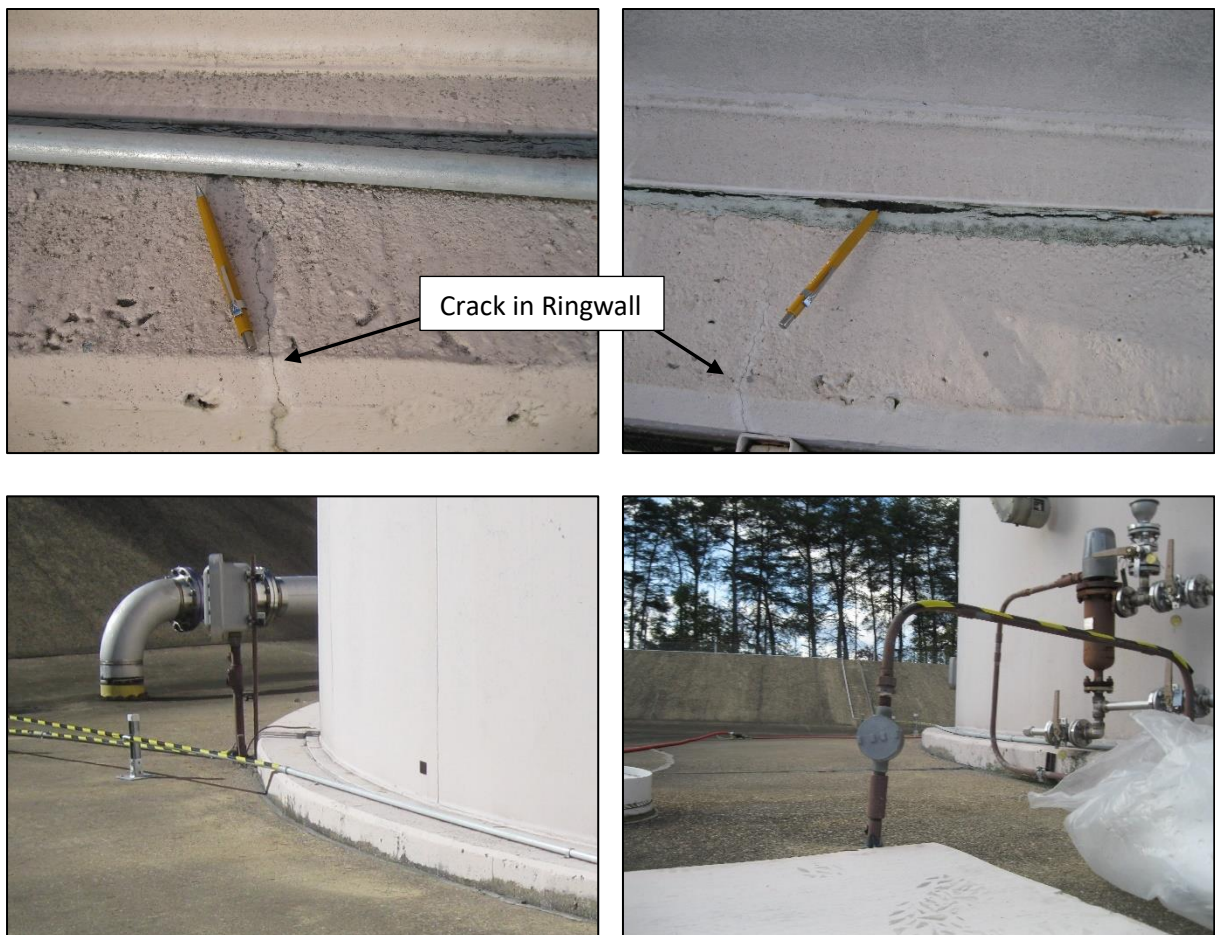


m. Rehabilitate the Foundation

OBSERVATION: The tank bottom to foundation seal has generally failed. There are approximately 25 radial cracks in the concrete ringwall foundation. The ringwall foundation is sloped toward the tank bottom which forces rain water under the tank bottom.

REFERENCE: NFPA 30 paragraph 22.11.2.4 and CFR 112.7(c)(1) require secondary containment to be liquid tight. Guidance for new construction provided in DoD Standard Design AW 78-24-27 and UFGS Specification 33 56.13.13 include installation of the tank bottom to foundation seal to be performed by a coating contractor and sloping the exposed foundation away from the tank bottom. API 650 Figures B.1 and B.2 require the top of the ring wall to be level or sloped away from the tank bottom. Guidance for new construction provided in DoD Design Standard AW 78-24-27 also includes sloping the top of the ring wall away from the tank bottom. The example inspection checklist included in API 653 Appendix C includes item – C.1.1.1.d), which cites examining the ringwall foundation to note if runoff rainwater from the shell drains away from the tank.

RECOMMENDATION: Slope the exposed top of the concrete ringwall foundation away from the tank bottom. Seal the cracks in the concrete foundation. Coat the underside perimeter of the tank bottom and replace the tank bottom to foundation perimeter seal. Seal coat the foundation.



n. Provide Latches

OBSERVATION: The four (4) roof perimeter vent/inspection hatches have one latch each. Two of the hatches have broken latches.

Reference: Guidance for new construction provided in DoD Standard Design AW-24-27 includes roof perimeter vent inspection hatches with latches.

RECOMMENDATION: Provide new latches on two of the roof perimeter vent Inspection hatches.

**o. Reinstall Water Probe**

OBSERVATION: The Vito water probe is installed through the neck of the center vent and through a 2-inch stilling well. The water probe is too long, with the result that the bottom end of the water probe is lying against the sump piping and may not be effective.

Reference: Guidance for new construction provided in UFC 3-460-01 Table 8-1 item p and DoD Standard Design AW-24-27 include a water probe over and in the bottom sump. Manufacturer's installations instructions for the Vito Water Probe include the following caution: "There should be at least 50 mm (2") free space between the sensitive part of the water probe and the tank shell (or any other large metal part in the tank, i.e. stilling well)."

RECOMMENDATION: Reinstall the Vito Water Probe per the manufacturer's instructions.



3. RECOMMENDED REPAIRS as Part of Regular Maintenance

Recommended repairs represent items that should be addressed in a timely manner in order to prevent future potential risks to system operators, equipment integrity, or the adjacent environment.

a. Continue to Remove Algae

OBSERVATION: Due to the undrainable area of the secondary containment, a considerable quantity of algae collects in the dike area.

Reference: Guidance for maintenance of fuel storage facilities provided in UFC 3-460-03 paragraph 8-10.3.1 includes inspection of dike areas for cleanliness and removal of debris and vegetation. NFPA 30 paragraph 22.11.2.8 prohibits storing combustible material in the dike area.

RECOMMENDATION: Continue to remove the algae from the dike area.



b. Pressure Wash the Roof and Lower Shell

OBSERVATION: Bird droppings were observed on the roof and guardrails. Scattered coating failure was also noted on the roof. There is isolated stain from water ponding on the perimeter of the roof. The lower portion of the shell is coated with mold and algae.

REFERENCE: API 570 paragraph 4.3.2.3.h) reads, "bird turds can also cause accelerated corrosion and unsightly stains."

RECOMMENDATION: In the periodic maintenance checklist, include pressure washing of the lower portion of the shell and the tank roof to remove bird droppings and loose debris.



c. Seal Concrete Dike Area Cracks

OBSERVATION: There are approximately 800 linear feet of cracks in the concrete covering the dike basin and 400 linear feet of cracks in the concrete covering the dike berms. The design drawings indicate a liner under the concrete ballast. Although the integrity of the line could not be visually verified, the liner seemed to be intact, based on the operators observations of retained rain water.

REFERENCE: Guidance for operation and maintenance of fuel facilities provided in UFC 3-460-03 paragraph 8-10.2 includes inspection of dike areas, removal of vegetation, and sealing of cracks.

RECOMMENDATION: As there is a liner under the concrete, sealing the cracks is not required. However, to inhibit growth of vegetation and further deterioration, and to simplify evaluation of the dike for environmental regulators, seal all of the cracks in the concrete covering the dike liner. Some of the cracks that should be repaired are shown in a sketch in our subconsultants report.

**d. Tighten Enraf Access Door Latches**

OBSERVATION: The Enraf access door latches are loose and may allow rain water to enter through the edges of the door cover.

REFERENCE: NA.

RECOMMENDATION: Tighten the Enraf Access Door Latches.



4. REPAIRS to Fully Comply with API 653, or UFC 3-460-01 and/or AW 78-24-27 Guidance

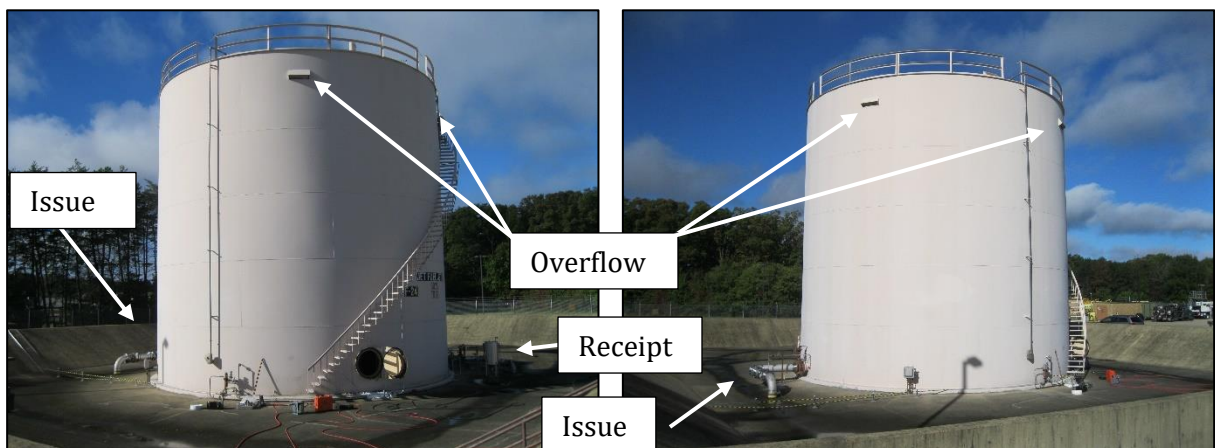
These items represent repairs and/or upgrades that could be performed to bring the tank into full compliance with current standards, but that do not represent potential risks to system operators, equipment integrity, or the adjacent environment. Our recommendations to perform, or not to perform these repairs and/or upgrades, take into consideration the cost of the repair, the operational benefit of the repairs, the age of the tank/system, operator safety, environmental risks, and equipment integrity.

a. Eliminate Unnecessary Overflows

OBSERVATION: The tank has four shell overflows each with approximately one square foot of net open area. One is located over the top of the stairs. One is located over the bottom of the stairs. Fuel is received into the tank through 8-inch piping capable of a flow of 1800 gpm at 12 feet per second.

REFERENCE: API 650 paragraph H.5.3.3 does not recommend locating overflows over stairways or tank nozzle isolation valves. Guidance for new construction included in DoD Standard Design shows only one overflow with 2 square feet of net open area on both 10,000 and 20,000 bbl tanks with 8-inch receipt nozzles. The overflow shown in the Standard Design is on the side of the tank opposite the product nozzles and not over the stairway.

RECOMMENDATION: Eliminate the two shell overflows located over the circumferential stairway, and repair the shell at those locations. Verify the capacity of the remaining overflows are adequate and if necessary provide overflows to meet the latest military criteria and capacity.



b. Provide Scaffold Cable Supports

OBSERVATION: There are no scaffold cable supports on the fixed roof.

REFERENCE: Guidance for the design of new storage tanks provided in UFC 3-460-01, Table 8-1, Item ff, and DoD Standard Design AW 78-24-27 include scaffold cable supports on the fixed roof.

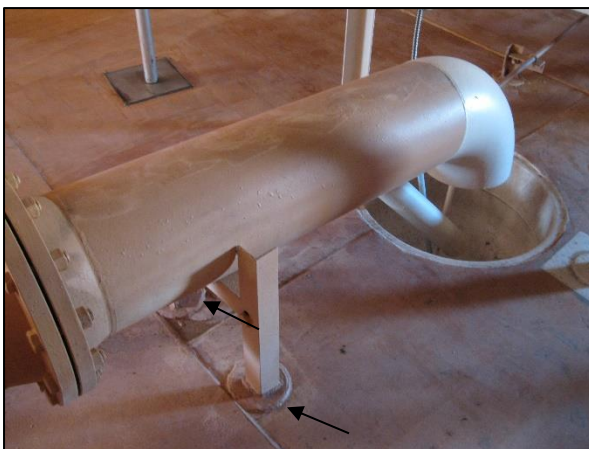
RECOMMENDATION: The next time interior tank coating work is performed, provide two scaffold cable supports on the fixed roof.

**c. Provide API Compliant Internal Pipe Support Mounting Plates**

OBSERVATION: Three internal pipe support weld-on base plates are closer than 2 inches to a tank bottom weld seam. In addition, the anti-rotation cable base plate is closer than 2 inches to a tank bottom weld seam.

REFERENCE: In later editions of API 653, paragraph 9.10.3.1 and Figure 9.13 require welds attaching plates to the tank bottom to be at least 2 inches from bottom lap welds. API 653 paragraph 9.10.3.1 allows existing noncompliant weld spacing to be accepted at the time of modification, if the welds are MT or PT examined. The above requirements were incorporated into API 653 some years after the plates were installed, and API 653 does not require MT or PT of existing welds on tank bottoms that do not meet weld spacing requirements but have been in service.

RECOMMENDATION: When the tank bottom is replaced ensure the pipe support mounting plates and the anti-rotation cable anchor mounting plate meet API 653 for size and weld spacing.

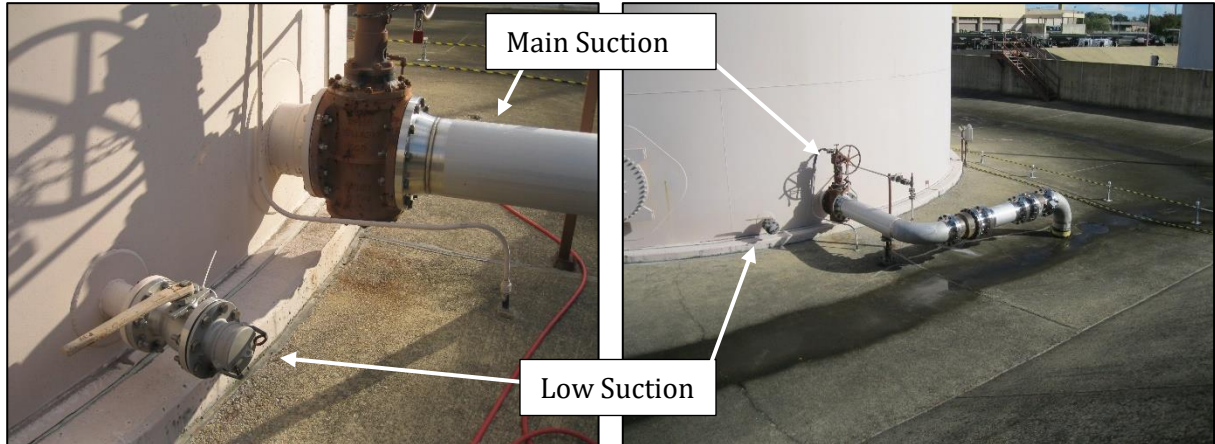


d. Pipe Low Suction to Main Suction

OBSERVATION: The low suction nozzle is not piped to allow using the issue pumps to drain the tank in preparation for tank cleaning and entry. As a result, approximately one thousand gallons of jet fuel that would normally be transferred from the tank into the adjacent tank is wasted every time the tank is cleaned. Considering the value of the fuel and the cost of disposal of the fuel, water, and sludge mixture, the potential loss to the government in 32 years is approximately \$20,000.

REFERENCE: Guidance for the design of new storage tanks provided in UFC 3-460-01 Table 8-1, Item v and DoD Standard Design AW 78-24-26 include hard piping the low suction to the main suction.

RECOMMENDATION: Provide piping and valves to connect the low suction piping to the issue piping.

**e. Provide Removable Mid-rail Chain**

OBSERVATION: There is no mid-rail or removable mid-rail chain above the roof perimeter vent/inspection hatches.

REFERENCE: 29 CFR Part 1910.23 (c) requires every open-sided floor or platform 4 feet or more above adjacent floor or ground level to be guarded by a standard railing. Guidance for design of the new tanks provided in DoD Standard Design AW 78-24-27, includes a guardrail around the top of vertical ASTs, Detail 1/D.09 indicates a removable intermediate guardrail chain above the perimeter vent/inspection hatches.

RECOMMENDATION: Provide steel angle top rails with removable mid-rail chains above the perimeter vent/inspection hatches.

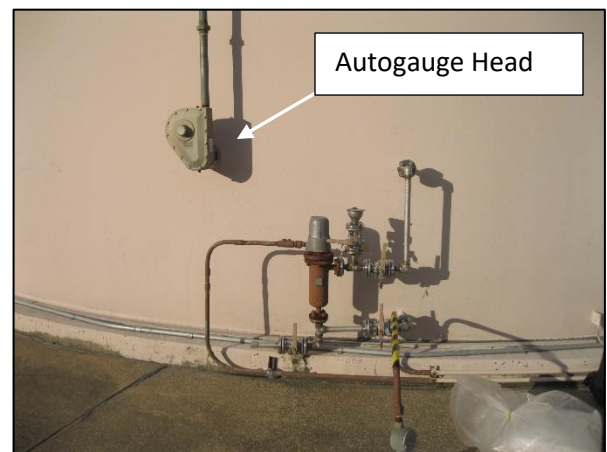
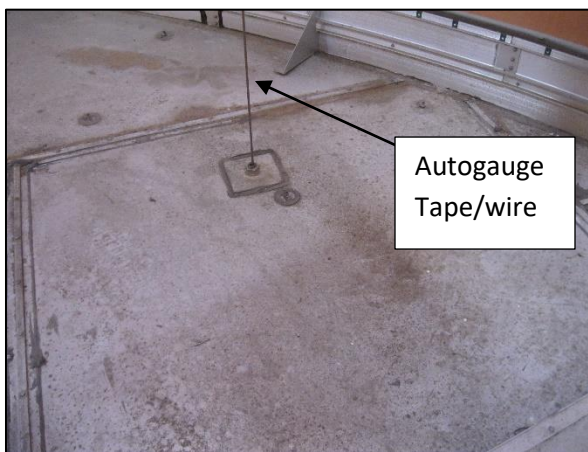


f. Replace Autogauge

OBSERVATION: The Shand and Jurs autogauge tape is connected directly to the floating pan. As a result, the gauge is inoperable. The operator and some branches of the military do not consider an autogauge necessary equipment.

REFERENCE: Guidance for new construction provided in UFC 3-460-01, Table 8-1, Item o, includes a liquid level gauge. Guidance for new construction provided in DoD Standard Design AW 78-24-27 also includes a mechanical tape level gauge. Manufacturers of mechanical tape level gauges (Varec and Shand and Jurs) recommend attaching the tape to a float in a floating pan penetration well or to a weight resting on top of the pan, but not directly to the pan to avoid damage to the tape or gauge head in the event the pan does not descend smoothly with the fuel.

RECOMMENDATION: Consider providing a new autogauge with the tape attached to a weight resting on top of the floating pan, or also providing a well and float in the pan and attaching the autogauge tape to the float.

**g. Provide Exothermic Grounding Connections**

OBSERVATION: The tank's grounding cables are bolted to shell mounted lugs.

REFERENCE: Guidance for new construction provided in DoD Standard Design AW 78-24-27 Detail 2/ED.02 includes exothermic welding the grounding cables to stainless steel grounding lugs.

RECOMMENDATION: Consider providing exothermically welded grounding connections.



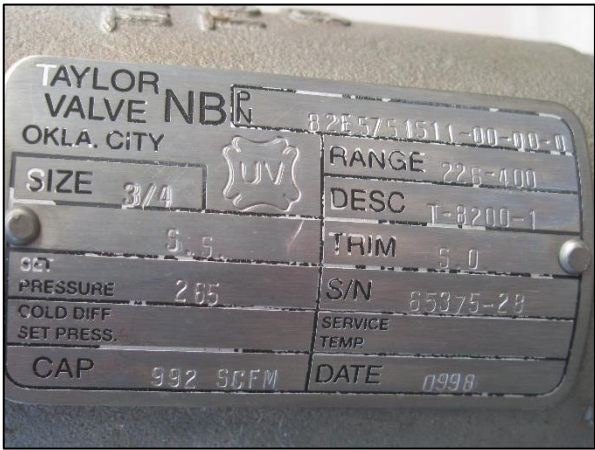
h. Modify Thermal Relief Piping

OBSERVATION: The issue and receipt piping thermal relief valve data plates indicate set pressures of 265 psig, and an applicable range of 226 to 400 psi. If the pumps are not oversized, the actual pump deadhead would normally be expected to be in the 60 to 150 psi range. Excessively high TRV settings reduce the life of gaskets, cause expansion strains in piping, and may lead to other problems such as underground leaks. Conventional Pressure Testing and Qualified Leak Testing requirements as described in the last IMP are based on pressure not less than the greater of pump deadhead pressure or 110% of the thermal relief valve settings. It should be noted that the 2013 IMP reported the west hydrant system pumps appear to provide a higher pressure than necessary, and that pressure surge of up to 290 psi was observed. The IMP also noted a history of leaks in the west hydrant system and recommended a full thermal relief study. The receipt and issue thermal relief piping includes sight flow indicators but does not include testing tees. Facility personnel indicated they want to keep the sight flow indicators.

REFERENCE: Guidance for the design of new storage tanks provided in UFC 3-460-01 paragraph 9-3.5 includes TRV piping around isolation valves; paragraph 9-3.5.1 discourages site flow indicators on thermal relief valve piping and recommends a set pressure of 10 % above pump deadhead. DoD Standard Design AW 78-24-27 includes testing tees for new thermal relief piping.

RECOMMENDATION: Provide testing tees for the thermal relief piping, and if Facility personnel agree, modify the thermal relief piping to eliminate the site flow indicators, otherwise forward their rationale to the Fuel Facilities Engineering Panel for consideration in revising the UFCs. If the excessively high pump pressure has not been resolved, the TRVs should not be replaced at this time. If the pump pressures for the west hydrant system have been resolved, the TRV settings should be adjusted or the TRVs replaced.



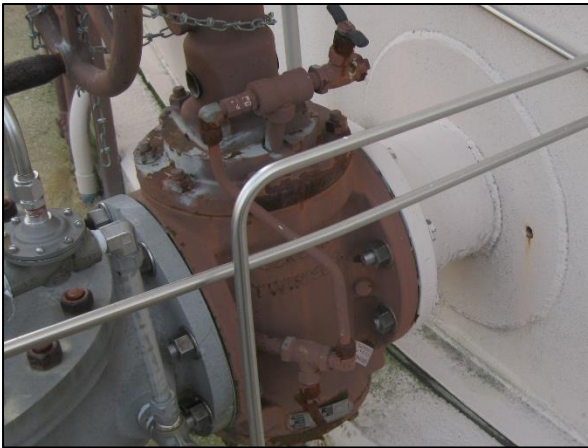


i. Re-plumb Integral Body Cavity Relief Valves

OBSERVATION: The body cavity integral thermal relief valves on the shell nozzle isolation valves are plumbed to relieve away from the tank. The integral thermal relief are differential (not balanced) type and open only when upstream pressure exceeds downstream pressure by a set amount, typically 25 psi. As the thermal relief for the piping is set at 265 psi, the integral relief valves may not open until the internal pressure in the valve exceeds the sum of the set pressures (290 psi).

REFERENCE: Guidance for new construction included in UFC 3-460-01 recommends using balanced thermal relief valves where cascading cannot be avoided.

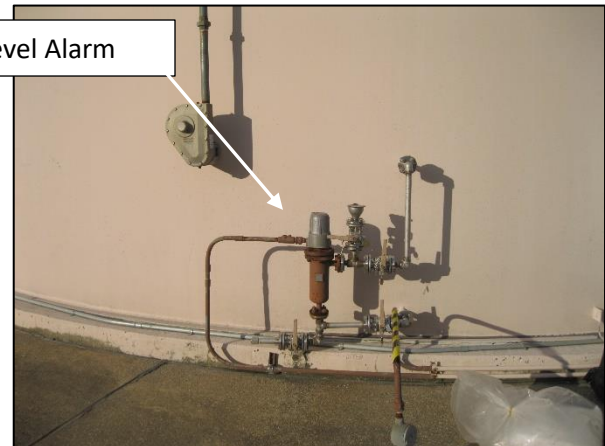
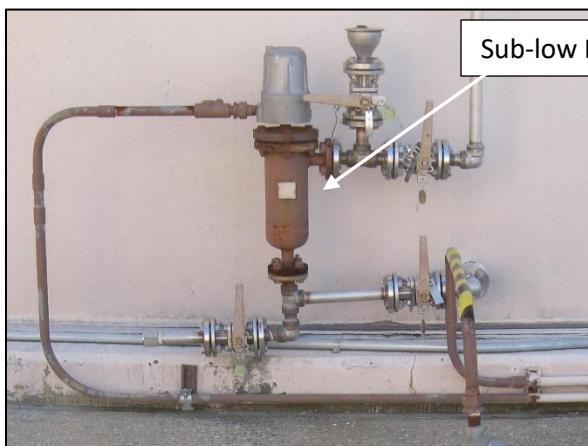
RECOMMENDATION: Eliminate cascading by replumbing the integral body cavity thermal relief valves on the tank shell nozzle isolation valves to relieve into the tank.

**j. Provide Independent Low and Low-low Level Alarms**

OBSERVATION: Although the level alarm panel indicates a low level alarm, there is no low level alarm above the low leg level of the floating pan. There is however a sub-low level alarm set at approximately one foot below the low leg level of the floating pan.

REFERENCE: Guidance for new construction provided in DoD Standard Design AW 78-24-27 include both high and high-high level alarms as well as low and low-low level alarms above the low leg level of the floating pan. Guidance for new construction provided in UFC 3-460-01, Table 8-1, Item I includes high, high-high, low and low-low level alarms, independent from the tank gauging system.

RECOMMENDATION: Provide low, and low-low level alarms independent of the tank gauging system.

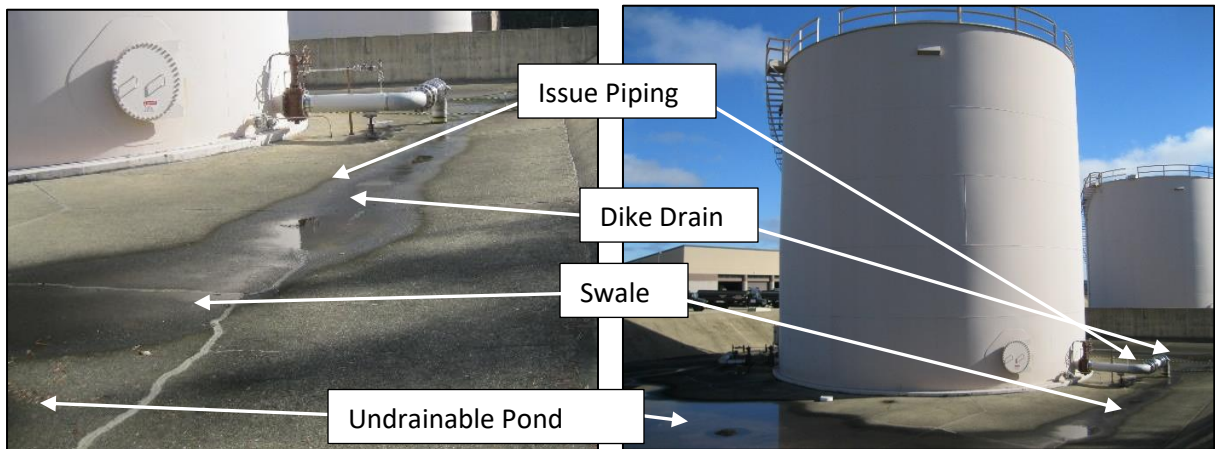


k. Rehabilitate Secondary Containment

OBSERVATION: The secondary containment basin is sloped to a swale approximately 10 feet from the tank. The issue piping is routed over the swale. A large undrainable pond of rain water collects in the dike area on the side opposite the dike drain. There are numerous cracks in the concrete covering the secondary containment. However, the design drawings indicate a liner under the concrete covering the secondary containment.

REFERENCE: NFPA 30 requires secondary containment to be sloped away from the tank for 50 feet or to the dike wall, whichever is less, and away from product piping for a distance of 50 feet.

RECOMMENDATION: Modify the secondary containment and drain to slope way from the tank all the way to the dike wall, away from the product piping, and to drain the entire dike area.



APPENDIX A: SUB-CONSULTANT REPORTS

API 653 OUT-OF-SERVICE INSPECTION REPORT



Environmental Inspection Services

464 S Independence Blvd, C-104, Virginia Beach, VA 23452

www.interspecllc.net

Office: 757-622-6299

Fax: 757-622-9103

Toll Free: 800-546-7853

API-653 Engineering Inspection Report Tank # 25 (Facility 5025)



Prepared for
US Air Force - Andrews AFB; Andrews AFB, MD

October 25, 2017

API Standard 653 recommends this document
containing valuable historical information be
retained for the life of the tank.

Signature(s):

Wayne K. Bailey, Inspector, API-653 # 1331, API-570 # 351, API-510 # 2654

General Conditions

The information referenced in this engineering report is based solely upon the area or areas agreed upon and contracted for inspection on the date of the inspection and under those present, known, same, and current conditions. This report was prepared using retrievable data from those areas that were properly cleaned and prepared and made available and accessible during the inspection. Areas not contracted for inspection and/or made available and accessible are not included in this report.

The methods, standards and regulations used by InterSpec, LLC during the inspection and in preparing this engineering report comply with the most current and widely accepted standards and regulations in the industry, in which these standards and regulations make no representation, warranty or guarantee. The professional opinions and recommendations stated in this report, including predictability of life, maximum length of time for re-inspection, suitability for product storage, and safe fill height are conclusive approximations and are intended to serve mainly as guidelines for obtaining the utmost in spill prevention and environmental protection. The listed recommendations may not necessarily be mandatory actions, but corrective actions that InterSpec, LLC suggests would better preserve the owners'/operators' facility components and may contribute to a safer and more convenient operation. Failure to comply with these could result in, but may not be limited to, reduction of service life, tank mishap, legal consequences and/or fines for owners/operators. It is best advised that the recommended repairs, corrective actions and procedures be fully and accurately complied with in order to meet the required and applicable federal, state and local regulations, and to have the necessary repairs and upgrades performed prior to making any change in service, product and/or current conditions. Some recommendations and requirements are necessary to bring the component(s) into compliance with federal, state, and local regulations. InterSpec, LLC recommends re-inspection after any corrective action, repair or change in usage when the change is to a more severe service. Any change in facility conditions that are applicable to this inspection report, such as, but not limited to, a change in service or usage could result in outdating this report. The predictability of any component in this report is a result of following the procedures in the applicable industry standard. InterSpec, LLC accepts absolutely no responsibility or liability for any mishap or failure, including any subsequent clean-up costs or legal ramifications, resulting from owners'/operators' failure to perform the required repairs, inspections and re-inspections, as they apply.

Executive Summary

An API Standard 653 Out-of-Service inspection of Tank # 25 was completed on October 25, 2017 to evaluate the tank's integrity, collect data, and establish a database for future inspections and evaluations. A service life evaluation performed on the tank shows it as having greater than 30 years of remaining shell life under current conditions. Inspection Results are listed in section 4.1. Maintenance Recommendations are listed in section 4.2. Compliance Requirements are listed in section 4.3. All engineering calculations are provided in Appendix A.

The tank does not meet the compliance requirements mandated by federal, state, and/or local regulatory bodies and requires that corrective action(s) be taken. In addition, the tank does not meet the requirements for structural integrity in accordance with the API-653 standard. Refer to Inspection section 4.1.4. The owner/operator may follow the schedule(s) in section 4.4. Refer to Compliance Requirements section 4.3 for details.

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1.0 Introduction

1.1 Purpose:

- 1.1.1 This report presents an analysis of data collected during an inspection conducted on October 25, 2017 for Tank # 25, servicing Jet A, located at the US Air Force - Andrews AFB facility in Andrews AFB, MD. The inspection was performed by a certified API-653 inspector. This report summarizes the results of the inspection meeting the requirements of API Standard 653 and API-650, 9th Edition. The primary containment including the supports, foundation, vents, gauges, and appurtenances were evaluated. The inspection was conducted by *InterSpec, LLC*.

2.0 References

2.1 Code of Federal Regulations (CFR):

United States Department of Labor, Occupational Safety & Health Administration

- 2.1.1 CFR, Title 29, Subtitle B, Volume 5, Chapter XVII, Part 1910, Subpart H, Section 119, Process safety management of highly hazardous chemicals
- 2.1.2 CFR, Title 29, Subtitle B, Volume 5, Chapter XVII, Part 1910, Subpart J, Section 147, The control of hazardous energy (lockout/tagout)
- 2.1.3 CFR, Title 29, Subtitle B, Volume 5, Chapter XVII, Part 1910, Subpart S, Section 331-335, Safety-Related Work Practices

United States Environmental Protection Agency

- 2.1.4 CFR, Title 40, Volume 21, Chapter I, Subchapter D, Part 112, Oil Pollution Prevention

2.2 American Petroleum Institute (API):

- 2.2.1 API Standard 650, Welded Steel Tanks for Oil Storage
- 2.2.2 API Standard 653, Tank Inspection, Repair, Alteration, and Reconstruction
- 2.2.3 API RP 652, Lining of Aboveground Petroleum Storage Tank Bottoms
- 2.2.4 API RP 651, Cathodic Protection of Aboveground Petroleum Storage Tanks
- 2.2.5 API RP 575, Inspection of Atmospheric and Low-Pressure Storage Tanks
- 2.2.6 API RP 577, Welding Inspection and Metallurgy
- 2.2.7 API RP 2000, Venting Atmospheric and Low Pressure Storage Tanks
- 2.2.8 API Standard 570, Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-Service Piping Systems

2.3 American Society of Mechanical Engineers Codes (ASME):

- 2.3.1 ASME Boiler and Pressure Vessel Code; Section V, Non-Destructive Examination
- 2.3.2 ASME Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

2.4 National Fire Protection Association (NFPA):

- 2.4.1 NFPA-30, 2012 Ed., Flammable and Combustible Liquids Code
- 2.4.2 NFPA-70, 2011 Ed., National Electrical Code
- 2.4.3 NFPA-780, 2008 Ed., Standard for the Installation of Lightning Protection Systems

2.5 American Society of Nondestructive Testing (ASNT):

- 2.5.1 ASNT-SNT-TC-1A

3.0 Description

3.1 Job Description:

Job Number: 17-0826
Contracted by: Austin Brockenbrough & Associates

3.2 Tank Description:

Owner/Operator: US Air Force - Andrews AFB
Location: Andrews AFB, MD
Tank Identification: 25
Diameter: 43.50 feet
Shell Height: 42.30 feet
Capacity: 11,183 Barrels (Capacity Based on Shell Volume)
Configuration: Vertical
Foundation: Concrete Ringwall
Secondary Containment: Concrete Covered Liner Over Floor and Earthen Dike Berms
Year Installed: 1998
Age: 19 years
Construction Code: API-650, 9th Edition
Manufacturer Name: MATRIX Services

3.3 Service Description:

Service: Jet A
Specific Gravity: 0.84
Operating Limits:
Minimum Metal Temperature: Ambient
Maximum Metal Temperature: 200 °F
Minimum Pressure: Atmospheric (no vacuum)
Maximum Pressure: Product
Seismic Zone: 1
Current Fill Height: 0.00 feet
Max Fill Height: 38.71 feet

3.4 Part Description:

Bottom
Material: Carbon Steel
Specification: Unknown
Design: Cone-Down
Shell
Material: Carbon Steel
Specification: A-36M
Design: Cylindrical
Floating Roof
Material: Aluminum
Specification: Unknown Specification
Design: PETREX

Fixed Roof

Material:	Carbon Steel
Specification:	Unknown
Design:	Supported Cone

3.5 Joint Type Description:

Bottom Plate-to-Plate:	Lap-Welded
Shell Plate-to-Plate:	Butt-Welded
Floating Roof Plate-to-Plate:	Threaded Fasteners
Fixed Roof Plate-to-Plate:	Lap-Welded
Bottom-to-Shell:	Fillet-Welded

3.6 Inspection Description:

Inspection Type:	API-653 Out-of-Service
Equipment Used:	Ultrasonic Thickness Meter Magnetic Flux Leakage
Inspection Date:	October 25, 2017
Inspector(s):	Wayne K. Bailey

3.7 Equipment Description:**Ultrasonic Thickness Meter**

Manufacturer:	General Electric
Model:	DMS 2
Calibration Methods Used:	Zeroing Procedure, Copper Coating Calibration Procedure, and Two Point Calibration Procedure
Manufacturer:	MFE Enterprise
Model:	MFE 2412 Mark II
Calibration Methods Used:	Manufacturer Calibration Procedure

4.0 Inspection

4.1 Results:

4.1.1 Secondary Containment: The secondary containment area consists of a concrete floor with sloped concrete walls. An informal evaluation of the secondary containment area was conducted. Field assessment indicates the secondary containment is of sufficient size to contain a total tank loss and thus satisfies the requirements of API Standard 653. The secondary containment drain is in satisfactory condition. The integrity of the secondary containment to contain product is questionable due to numerous cracks in the secondary containment floor and walls. The secondary containment floor has approximately 800 LF of exposed cracks. The secondary containment sloped walls have approximately 400 LF of exposed cracks. The design drawings indicate a liner under the concrete, the liner could not be visually evaluated. The secondary containment area does not appear to be properly graded to drain water away from the tank in accordance with NFPA 30. The secondary containment has a low-lying area collecting water on the West side of the tank.

4.1.2 Foundation: The tank rests on top of a concrete ringwall. The tank bottom is equipped with a secondary containment liner underneath and bottom leak detection. The sealant between the tank bottom and concrete ringwall has deteriorated. The concrete ringwall has approximately 100 LF of exposed cracks. The concrete ringwall is slightly sloped towards the tank allowing water buildup at the chime. The bottom leak detection monitoring wells were full of water. When the telltale drain was opened, water was observed from underneath the bottom.

4.1.3 Cathodic Protection: The tank is equipped with an impressed current cathodic protection system. The cathodic protection reports do not show any significant deficiencies with the system and conclude that the tank is afforded adequate protection. The cathodic protection system does not provide adequate protection because the bottom has severe underside corrosion.

4.1.4 Bottom: The cone-down tank bottom consists of carbon steel plates that are of lap-welded configuration and are fillet-welded to the shell. The bottom has a thin film epoxy coating system. The coating was inspected for disbonding, adhesion, deterioration, and discoloration and is in satisfactory condition, except for the findings referenced below. The useful life of the bottom coating system is estimated to be greater than 10 years. The bottom was scanned (approximately 95%) for underside corrosion using magnetic flux leakage (MFL) technology. The MFE 2412 Mark II unit was used for the MFL bottom scan. The MFL scan did reveal areas of severe underside corrosion. The bottom has no stockside (top side) pitting. The general thickness of each bottom plate was measured using ultrasonic technology. The general thickness measurements and associated thickness measurement locations (TML) are listed in the Bottom Plate Thickness Measurements table in Appendix C. The bottom is equipped with a circular sump located in the center of the tank. The bottom plate lap-welds, shell-to-bottom weld, attachment welds, piping supports, and support pads were visually examined and appear to be in satisfactory condition. The visual examination of the welds for defects was extremely limited because the welds are coated. The bottom service life evaluation shows the bottom service life has expired. The bottom service life evaluation is shown in Appendix A.

The bottom has a band of severe underside corrosion around the circumference. The lowest measured remaining metal thickness measured 0.043 inches of remaining metal. Several areas in this band measured below 0.1 inches of remaining metal. Four (4) other areas outside of the band of corrosion measured between 0.173 and 0.097 inches of remaining metal. The bottom useful service life has expired.

The ENRAF ATG and VITO water probe stilling wells are bolted at the bottom and flanged at the top on the fixed roof; thereby, the stilling wells do not allow adequate movement and may cause bottom failure in accordance with API Standard 653 Section 4.4.2.i. The receipt line diffuser is not in contact with the pipe support.

4.1.5 Shell: The shell is constructed of carbon steel material. The shell is a cylindrical design, butt-welded together, consisting of five (5) courses. The shell (interior and exterior) has a thin film epoxy coating system. The coating was inspected for disbonding, adhesion, deterioration, and discoloration. The shell was evaluated for remaining metal thickness using ultrasonic technology. The ultrasonic thickness measurements and thickness measurement locations (TML) are listed in the Shell Plate Thickness Measurements table in Appendix C. A shell service life evaluation performed on all shell courses shows the shell has a remaining life of greater than 30 years under current conditions.

The shell service life evaluation is shown in the Shell Service Life Evaluation table in Appendix A. Shell roundness and plumbness of the shell are within the allowable tolerances of API Standard 653. The shell roundness and plumbness evaluation is shown in Appendix A. The tank appears to be stable and does not appear to be in danger of overturning or buckling due to high winds or seismic conditions.

4.1.6 Floating Roof: The tank is equipped with a PETREX internal floating roof. The floating roof is of aluminum honeycomb construction. The annular space between the floating roof and the shell was satisfactory. The floating roof has foam log seals that are deteriorated and are fuel soaked. The floating roof seals are beyond their useful life.

4.1.7 Fixed Roof: The fixed roof is a supported cone roof constructed of carbon steel material. The fixed roof has an epoxy coating system on the interior and exterior. The coating was inspected for disbonding, adhesion, deterioration, and discoloration. The fixed roof interior coating is in satisfactory condition. The useful life of the fixed roof interior coating system is estimated to be greater than 10 years. The fixed roof was evaluated for remaining metal thickness using ultrasonic technology. The ultrasonic thickness measurements and ultrasonic thickness locations (TML) are listed in the Fixed Roof Plate Thickness Measurements table in Appendix C.

4.1.8 Appurtenances: The tank is properly grounded via ground straps in accordance with NFPA 30. The accessible shell nozzles and reinforcements were evaluated for remaining metal thickness using ultrasonic technology. The ultrasonic thickness measurements on the nozzles revealed no significant loss of metal from corrosion or erosion. All nozzles have a minimum remaining life of greater than 30 years. All nozzles were adequately reinforced. All the shell nozzle reinforcement plates have telltale holes to allow visible indication of weeping due to any possible weld failure. The nozzles are shown on the Shell Layout drawings in Appendix B, as well as listed in the Nozzles Ultrasonic Thickness Readings table in Appendix C. The product level is measured by an electronic ENRAF automatic tank gauge (ATG) system, which is in satisfactory condition. The product level is measured locally by a SHAND&JURS mechanical tape level gauge.

The weld spacing between the reinforcement pad and shell-to-bottom weld of the 4-inch drain line is less than the minimum required spacing of 3 inches in accordance with API Standard 650 Section 5.7.1.1. (Quantity: 1). The weld spacing between the reinforcement pad for the 30-inch manhole and stairway treads is less than the minimum required spacing of 6 inches in accordance with API Standard 650 Section 5.8.1.2. (Quantity: 3 areas). The mechanical tape level gauge read 99 feet with the tank empty. The tank ground straps are bolted to the tank chime (bottom extension) and are not CAD welded. The drain line of the high-high level alarm assembly does

not have a blank flange. The open flange is within a ¼-inch of the circumferential stair tread, which prevents bolting a blank flange.

The fixed roof is accessible via a circumferential stairway. The internal floating roof is accessible via an internal ladder. The bottom of the circumferential staircase has a 15-1/2-inch clearance between the first step and the secondary containment slab, which does not meet the rise run requirements of 29 CFR 1910. The circumferential stairway has inadequate clearance between the handrail and the high level control assemblies. The existing clearance is 12 inches. OSHA 1910.24(d) requires a minimum width of 22 inches.

4.1.9 Painting/Insulation: The fixed roof exterior has approximately 100 SF of minor coating failure. The fixed roof components have minor coating failure.

4.2 Maintenance Recommendations:

4.2.1 **Secondary Containment:** Repair all exposed cracks in the secondary containment floor and sloped walls by grinding in a V-shape pattern with at least ¼-inch width at the surface and a depth of at least ¼-inch and sealing with flexible urethane (e.g. Sikaflex 1c) or a similar approved sealant.

4.2.2 **Foundation:** Repair all exposed cracks in the ringwall by grinding in a V-shape pattern with at least ¼-inch width at the surface and a depth of at least ¼-inch and sealing with flexible urethane (e.g. Sikaflex 1c) or a similar approved sealant.

Replace the foundation-to-secondary containment sealant.

4.2.3 **Cathodic Protection:** None.

4.2.4 **Bottom:** None.

4.2.5 **Shell:** None.

4.2.6 **Floating Roof:** Remove the existing foam log periphery seals and install double wiper seals in accordance with UFGS 33 56 13.13 Section 2.13.2.7.

4.2.7 **Fixed Roof:** See Painting/Insulation.

4.2.8 **Appurtenances:** Calibrate the SHAND&JURS mechanical tape level gauge.

Modify the tank grounding straps in accordance with AW 78-24-27 Drawing ED.02 Detail 2.

Modify the circumferential stair tread to allow installing a blank flange on the drain line of the high-high level alarm assembly.

Install concrete approach stairs between the secondary containment floor and the circumferential stairway to meet the rise run requirements of 29 CFR 1910.

Extend the existing circumferential stairway stair treads and handrail at the high level control assemblies to achieve a clearance of at least 22 inches in accordance with OSHA 1910.24(d).

4.2.9 **Painting/Insulation:** Repair the coating failures on the fixed roof exterior and appurtenances.

4.3 Compliance Requirements:

4.3.1 **Secondary Containment:** None.

4.3.2 **Foundation:** See Bottom Section.

4.3.3 **Cathodic Protection:** See Bottom section.

4.3.4 **Bottom:** Replace or install a slotted bottom with secondary containment, leak detection, and cathodic protection.

Modify the base of the ENRAF ATG and VITO water probe stilling wells to allow vertical movement of the wells independent of the tank bottom.

Modify the pipe support of the receipt line diffuser to adequately support the diffuser.

4.3.5 **Shell:** None.

4.3.6 **Floating Roof:** None.

4.3.7 **Fixed Roof:** None.

4.3.8 **Appurtenances:** Modify the reinforcement pad of the manhole in the bottom shell course near the bottom of the circumferential stairway and the reinforcement for the 4-inch low point drain to meet weld spacing requirements in accordance with API Standard 653 Section 9.7 and API 650 5.8.1.2. Note: Magnetic particle test all affected welds as an alternative to repair, in accordance with API Standard 653 Section 4.3.9.1. Retain the results of testing for review during subsequent inspections. It is suggested to repair the weld spacing in lieu of testing to prevent future repeat or question of any previous magnetic particle testing during future inspections. The cost of repair verses the cost of testing is comparable.

4.3.9 **Painting/Insulation:** None.

4.4 Serviceability:

4.4.1 API-653 Schedule:

Tank # 25 does not meet the compliance requirements mandated by federal, state, and/or local regulatory bodies and requires that corrective actions be taken; however, the tank does meet requirements for structural integrity in accordance with the API 653 standard. The owner may immediately follow the schedule(s) in section 4.4. Refer to Compliance Requirements section 4.3 for details.

4.4.1.1 Perform routine monthly visual inspections by owner/operator personnel that are knowledgeable of the storage facility operations, the tank, and the characteristics of the product stored; conduct in accordance with API Standard 653.

4.4.1.2 The next visual external inspection should be accomplished by a certified API-653 inspector prior to October 2022 in accordance with API-653.

4.4.1.3 The next external ultrasonic thickness measurement inspection should be accomplished by a certified API-653 inspector prior to October 2032 in accordance with API-653.

4.4.1.4 The next internal inspection interval should be determined by the post repair inspector. arrange to have an API 653 Inspector review the repairs and make an internal inspection recommendation.

Appendix A

Engineering Calculations

1. Bottom Service Life
2. Shell Service Life
3. Settlement Evaluation

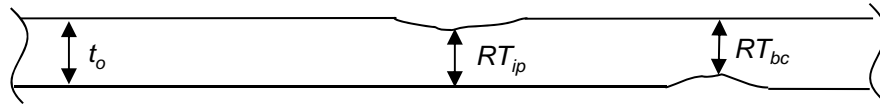
Bottom Service Life Evaluation

$$MRT = (\text{Minimum of } RT_{bc} \text{ and } RT_{ip}) - O_r(StP_r + Up_r)$$

$$O_r = \frac{(\text{Minimum of } RT_{bc} \text{ and } RT_{ip}) - MRT}{StP_r + Up_r}$$

Where:

- MRT = minimum remaining thickness at the end of the in-service period of operation, in inches.
- O_r = in-service interval of operation (years to next internal inspection), in years; not to exceed that allowed by 6.4.2.
- t_o = original plate thickness, in inches.
- RT_{bc} = minimum remaining thickness from bottom side corrosion after repairs, in inches.
- RT_{ip} = minimum remaining thickness from internal corrosion after repairs, in inches.
- StP_r = maximum rate of corrosion not repaired on the top side, in inches per year. $StP_r = 0$ for coated areas of the bottom. The expected service life of the coating must equal or exceed O_r to use $StP_r = 0$.
- UP_r = maximum rate of corrosion on the bottom, in inches per year. To calculate the corrosion rate, use the minimum remaining thicknesses after repairs. Assume a linear rate based on the age of the tanks. $UP_r = 0$ for areas that have effective cathodic protection.



MRT (inches)	Tank Bottom/Foundation Design
0.1	Tank bottom/foundation design with no means for detection and containment of bottom leak
0.05	Tank bottom/foundation design with means to provide detection and containment of bottom leak
0.05	Applied tank bottom reinforced lining, > 0.05 in. thick, in accordance with API RP 652

Note: For areas of a bottom that have been scanned by the magnetic flux leakage (or exclusion) process, and do not have effective cathodic protection, the thickness used for calculating UP_r must be the lesser of the MFL threshold or the minimum thickness of corrosion areas that are not repaired. The MFL threshold is defined as the minimum remaining thickness to be detected in the areas inspected. The MFL unit used for scanning the bottom does not have a threshold set point. This unit visually displays all anomalies. The confidence level of this unit diminishes greatly for underside pitting/corrosion that is less than 0.04 inches in depth, based on company experience.

Areas of bottom side corrosion that are repaired should be evaluated with the corrosion rate for the repaired area unless the cause of corrosion has been removed. The evaluation is done by using the corrosion rate of the repaired area for UP_r , and adding the patch plate (if used) thickness to the term "minimum of RT_{bc} or RT_{ip} ".

NOTE: The engineering data used to calculate the in-service interval of operation (O_r) assumes the tank remains in the same service and all corrosion rates remain constant.

Bottom Service Life Evaluation (Middle Plates)

Present Condition:

1) In-Service Interval of Operation (years to next internal inspection)

Cathodic Protection:	Yes
Bottom Coated:	Yes
Containment of Bottom:	Yes
Bottom Leak Detection:	Yes

$$MRT = 0.05 \text{ inches}$$

$$RT_{ip} = 0.25 \text{ inches}$$

$$RT_{bc} = 0.043 \text{ inches}$$

$$StP_r = 0 \text{ inches/year}$$

$$UP_r = 0.010895 \text{ inches/year}$$

$$O_r = \frac{0.043 - 0.05}{0 + 0.010895}$$

Therefore, the in-service interval of operation (years to next internal inspection) is:

$$O_r = \text{Bottom life has expired.}$$

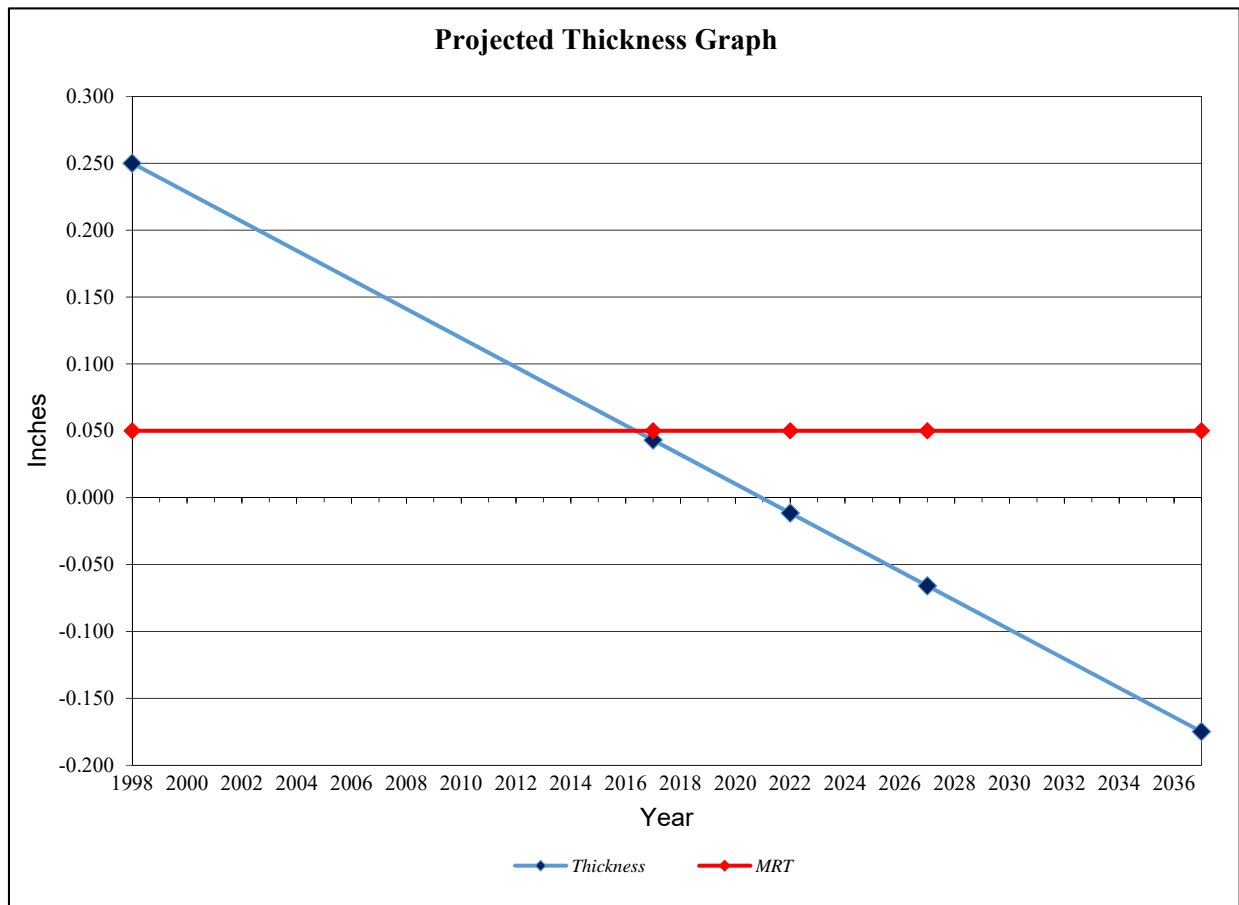
Bottom Service Life Evaluation (Middle Plates)

Present Condition:

2) Projected Thickness Chart and Graph

	Year	Thickness	MRT
Nominal:	1998	0.250	0.05
Current Lowest Remaining Thickness:	2017	0.043	0.05
Anticipated Thickness (5 yrs)*:	2022	-0.011	0.05
Anticipated Thickness (10 yrs)*:	2027	-0.066	0.05
Anticipated Thickness (20 yrs)*:	2037	-0.175	0.05
Anticipated Thickness (30 yrs)*:	2047	-0.284	0.05

*based on same service and corrosion rates.



Shell Life Evaluation

To determine the remaining shell service life and maximum inspection intervals, calculate the corrosion rate and remaining corrosion allowance for each shell course using the following:

$$t_{min} = \left(\frac{2.6(H - 1)DG}{SE} \right)$$

API-653 4.3.3.1a

$$t_{min} = \left(\frac{2.6(H)DG}{SE} \right)$$

API-653 4.3.3.1b

$$t_{min} = \left(\frac{2.6(H)DG}{SE} \right) \quad I_{ut} = \left(\frac{t_{act} - t_{min}}{2C_r} \right) \quad I_v = \left(\frac{t_{act} - t_{min}}{4C_r} \right)$$

Where:

- t_{min} = The minimum acceptable shell thickness for each course, in inches; however, t_{min} shall not be less than 0.1 inch for any tank course.
- t_{norm} = The nominal shell thickness, in inches.
- t_{act} = The current measured shell thickness, excluding pits and corrosion, in inches.
- t_{prev} = The previous measured shell thickness, excluding pits and corrosion or t_{norm} in inches.
- D = The nominal diameter of the tank, in feet.
- H = The height from the bottom of each shell course to the maximum liquid level, in feet.
- t_{prev} = The calculated safe fill height, in feet, for the current product.
- G = The highest specific gravity of the contents.
- Y = Specified minimum yield strength of the plate; use 30,000 pounds per square inch if not known (N/A for riveted tanks).
- T = The smaller of the specified minimum tensile strength of the plate or 80,000 pounds per square inch; use 55,000 psi if not known (N/A for riveted tanks).
- S = The maximum allowable stress, in pounds per square inch. For welded tanks, use the smaller of 0.80Y or 0.429T for the bottom and the second course or the smaller of 0.88Y or 0.472T for all other courses. For riveted tanks, use S = 21,000 psi. For elevated temperatures above 200°F, the maximum allowable stress shall be the smaller of 2/3 the minimum yield strength multiplied by the M-factor (M) of API-650 Appendix M or the product design stress value listed in Table 3-2 of API-650.
- E = The original joint efficiency for the tank. Use Table 2-1 from API Standard 653 if original E is unknown; E = 1.0 when evaluating the retirement thickness in a corroded plate, when away from welds or joints by at least the greater of one inch or twice the plate thickness. For riveted tanks, use E = 1.0 for shell plates when greater than 6 inches from rivets; use the value of E from API-653 Table 2-1 when within 6 inches of rivets.
- C_y = The shell corrosion rate, in inches per year.
- I_{ut} = The inspection interval for the next ultrasonic inspection, in years (not to exceed 15 years).
- I_v = The inspection interval for the next visual external inspection, in years (not to exceed 5 years).
- ΔY = The years between the previous measured shell thickness (t_{prev}) and the current measured shell thickness (t_{act}), in years.

Shell Service Life Evaluation

1) Minimum Required Thickness

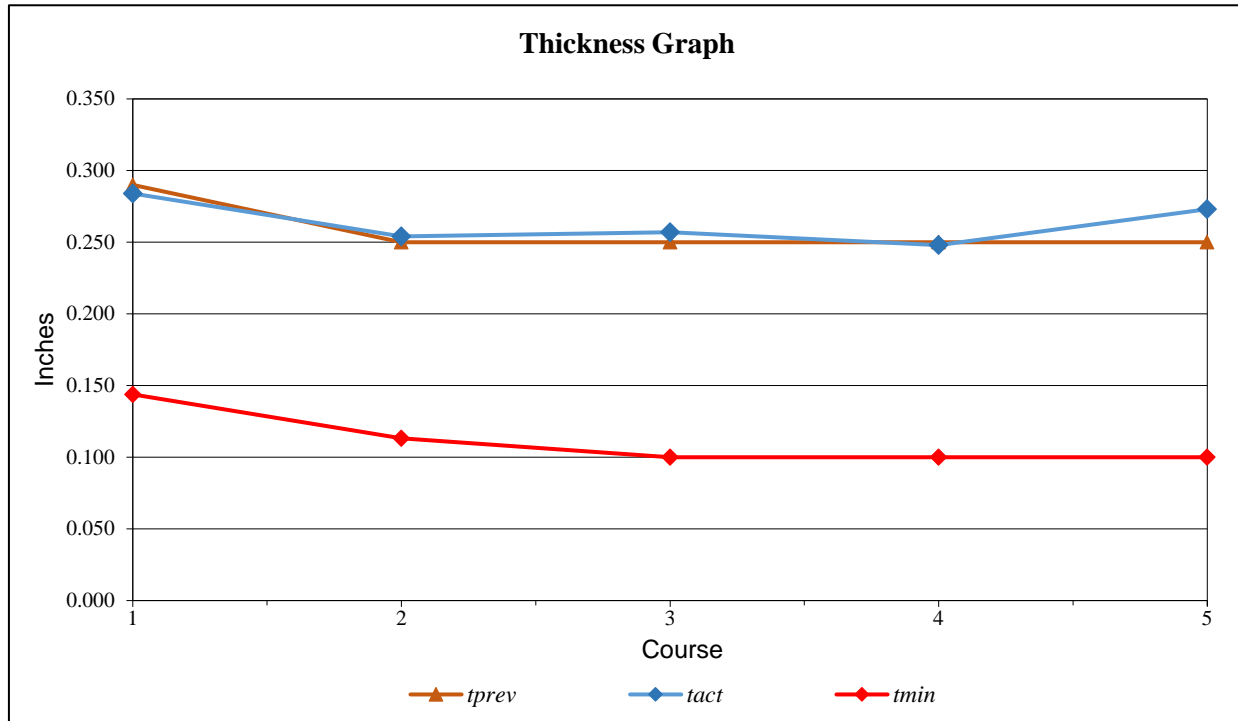
$$D = 43.5 \text{ feet}$$

$$G = 0.84$$

$$\Delta Y = 19 \text{ years}$$

Course No.	Plate Specification	Course Height (feet)	Product Height (feet) (H)	Maximum Allowable Stress (psi) (S)	Joint Efficiency (E)	Minimum Acceptable Thickness (inches) (t_{min})	Previous Measured Thickness (inches) (t_{prev})*	Current Measured Thickness (inches) (t_{act})
1	A 36	8	38.7	24,900	1.00	0.1438414	0.29	0.284
2	A 36	8	30.7	24,900	1.00	0.11331802	0.25	0.254
3	A 36	8	22.7	27,400	1.00	0.1	0.25	0.257
4	A 36	8	14.7	27,400	1.00	0.1	0.25	0.248
5	A 36	10	6.7	27,400	1.00	0.1	0.25	0.273

*The t_{prev} values were based on t_{nom} .



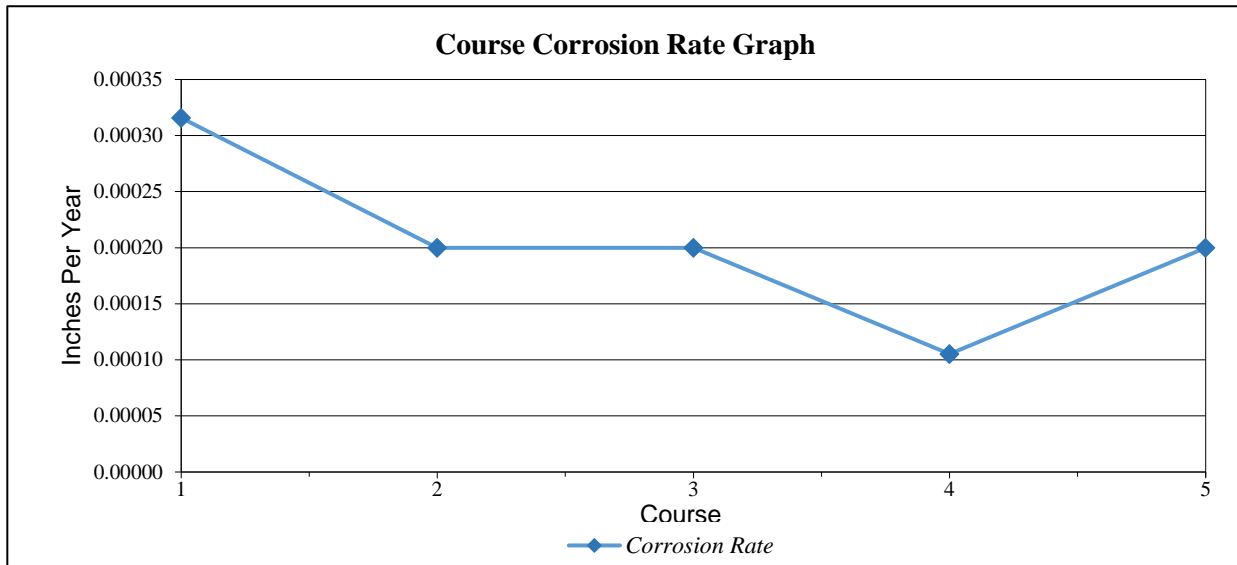
Shell Service Life Evaluation

2) Corrosion Rate, Remaining Life and Inspection Intervals

Course No.	Corrosion Rate (in./yr) (C_r)	Remaining Life (years) (L_r)	Next Visual Inspection (years) (I_v)	Next Ultrasonic Thickness Inspection (years) (I_{ut})
1	0.00032	443	5	15
2	0.0002*	703	5	15
3	0.0002*	785	5	15
4	0.00011	1406	5	15
5	0.0002*	865	5	15

* Let C_r = 0.0002 inches per year for calculation purposes.

Note: The engineering data used to calculate in-service period of operation (Remaining Life) assumes the tank remains in the same service and all corrosion rates remain constant. The maximum safe fill height for the tank is not limited other than by the established maximum operating liquid level and any other appurtenance such as overflow, vents, or firefighting system.



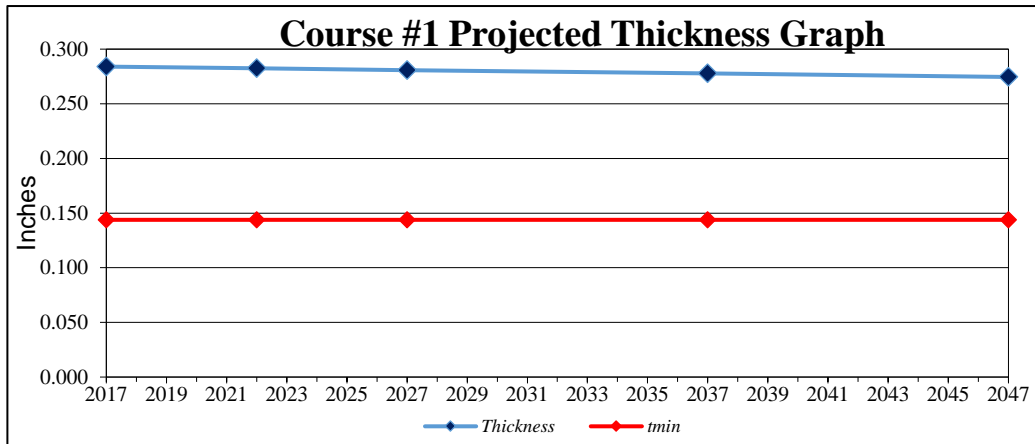
Shell Service Life Evaluation

3) Projected Thickness Chart and Graph

Course #1:

	Year	Thickness	tmin
Current Thickness:	2017	0.284	0.1438414
Anticipated Thickness (5 yrs)*	2022	0.282	0.1438414
Anticipated Thickness (10 yrs)*	2027	0.281	0.1438414
Anticipated Thickness (20 yrs)*	2037	0.278	0.1438414
Anticipated Thickness (30 yrs)*	2047	0.275	0.1438414

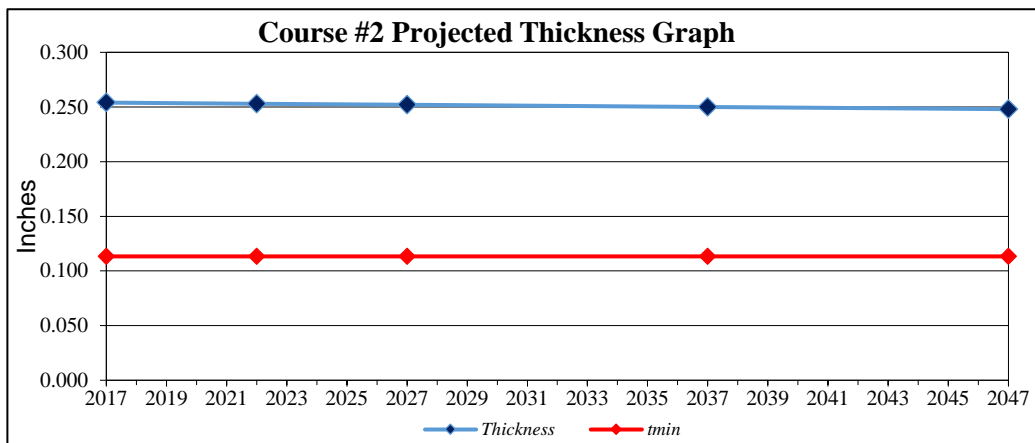
*based on same service and corrosion rates. □



Course #2:

	Year	Thickness	tmin
Current Thickness:	2017	0.254	0.11331802
Anticipated Thickness (5 yrs)*	2022	0.253	0.11331802
Anticipated Thickness (10 yrs)*	2027	0.252	0.11331802
Anticipated Thickness (20 yrs)*	2037	0.250	0.11331802
Anticipated Thickness (30 yrs)*	2047	0.248	0.11331802

*based on same service and corrosion rates. □

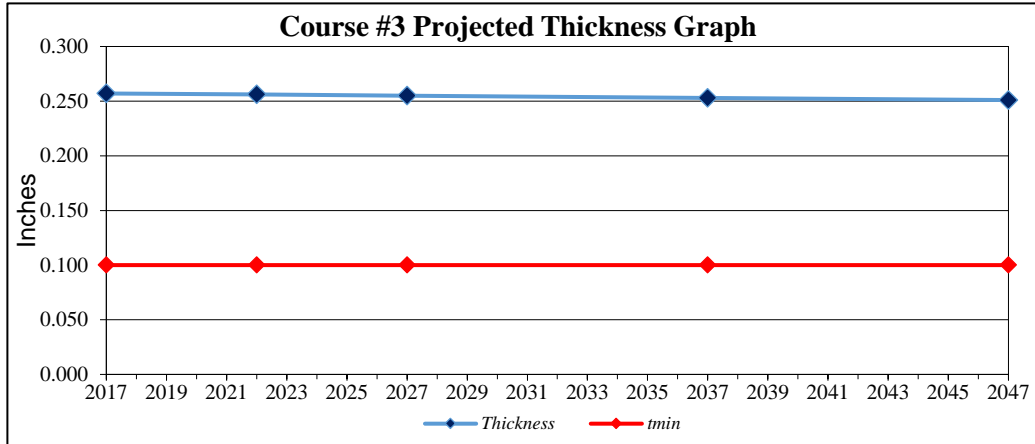


Shell Service Life Evaluation

Course #3:

	Year	Thickness	tmin
Current Thickness:	2017	0.257	0.1
Anticipated Thickness (5 yrs)*	2022	0.256	0.1
Anticipated Thickness (10 yrs)*	2027	0.255	0.1
Anticipated Thickness (20 yrs)*	2037	0.253	0.1
Anticipated Thickness (30 yrs)*	2047	0.251	0.1

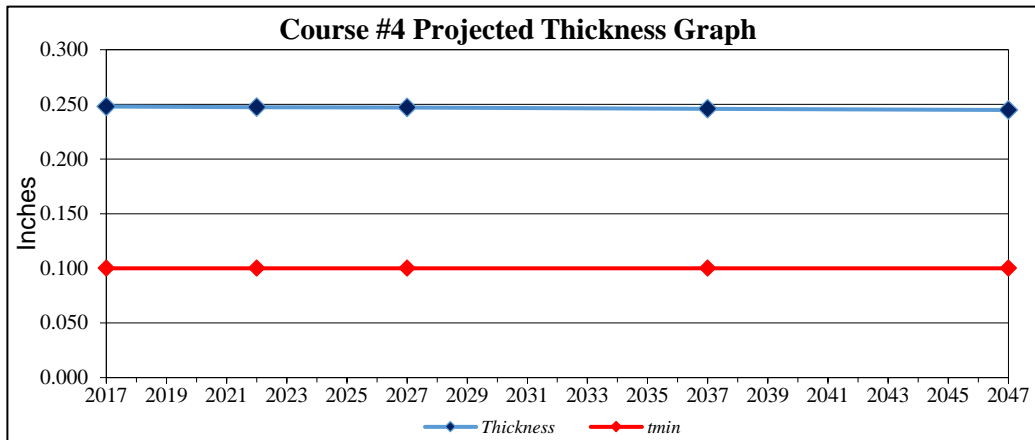
*based on same service and corrosion rates. □



Course #4:

	Year	Thickness	tmin
Current Thickness:	2017	0.248	0.1
Anticipated Thickness (5 yrs)*	2022	0.247	0.1
Anticipated Thickness (10 yrs)*	2027	0.247	0.1
Anticipated Thickness (20 yrs)*	2037	0.246	0.1
Anticipated Thickness (30 yrs)*	2047	0.245	0.1

*based on same service and corrosion rates. □

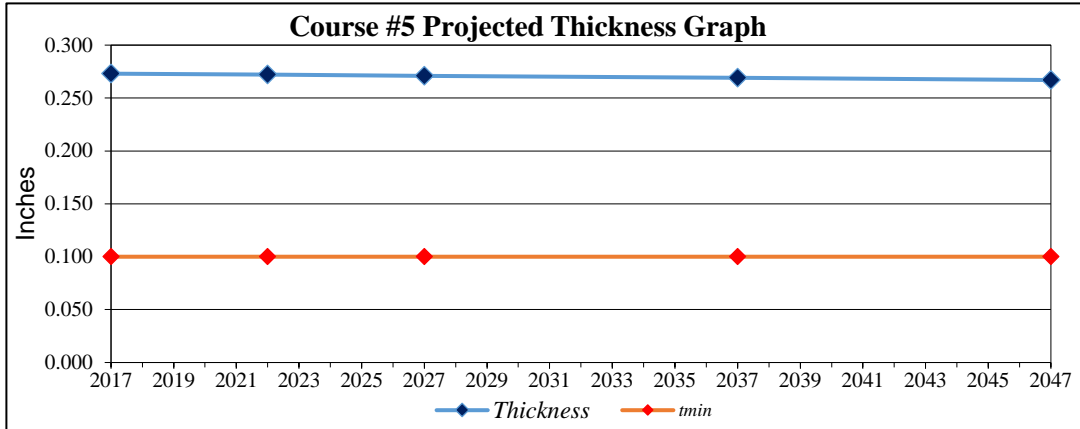


Shell Service Life Evaluation

Course #5:

	Year	Thickness	tmin
Current Thickness:	2017	0.273	0.1
Anticipated Thickness (5 yrs)*	2022	0.272	0.1
Anticipated Thickness (10 yrs)*	2027	0.271	0.1
Anticipated Thickness (20 yrs)*	2037	0.269	0.1
Anticipated Thickness (30 yrs)*	2047	0.267	0.1

*based on same service and corrosion rates. □



Shell Settlement Evaluation

1) Maximum Permissible Out-of-Plane Deflection Calculation

$$S_{max} = \frac{11L^2Y}{2EH}$$

Where:

S_{max} = maximum permissible out-of-plane deflection, in feet.

$L = \pi D / N$ = arc length between measurement points, in feet.

D = tank diameter, in feet

N = number of survey points.

Y = yield strength, in pounds per square inch (psi).

E = young's modulus, in pounds per square inch (psi)

H = tank height, in feet

$$D = 43.5 \text{ feet}$$

$$N = 8$$

$$L = 3.14(43.5)/8 = 43.5 \text{ feet}$$

$$Y = 30,000 \text{ psi}$$

$$E = 29,000,000 \text{ psi}$$

$$H = 42.25 \text{ feet}$$

$$L^2 = 291.8087 \text{ square feet}$$

$$S_{max} = \frac{11(291.8087)(30,000)}{2(29,000,000)(42.25)} = 0.0393 \text{ feet}$$

Shell Settlement Evaluation

1) Out-of-Plane Deflection Calculation

$$|S_i| = U_i - (1/2U_{i-1} + 1/2U_{i+1})$$

Where:

$|S_i|$ = magnitude of the calculated out-of-plane deflection, in feet.

U_i = Out-of-Plane settlement of point "i", in feet

(+) when above cosine curve

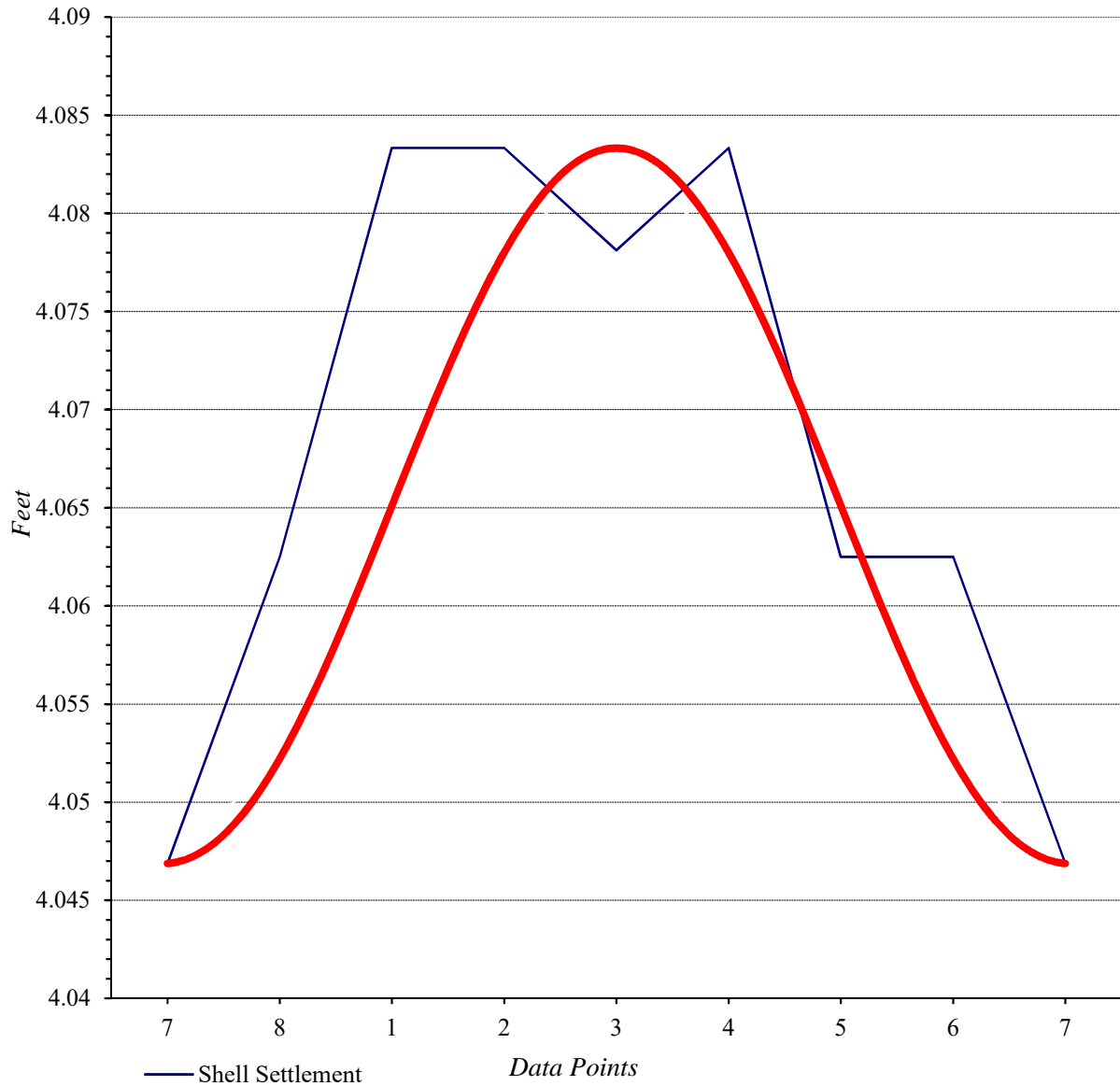
(-) when below cosine curve

Point	Actual	Curve Fit	U_i	U_{i+1}	U_{i-1}	S_i	$ S_i $
1	4.083333	4.065104	0.018229	-0.015494	0.031119	0.031119	0.010417
2	4.083333	4.052214	0.031119	0.018229	0.031250	0.031250	0.006380
3	4.078125	4.046875	0.031250	0.031119	0.031119	0.031119	0.000131
4	4.083333	4.052214	0.031119	0.031250	-0.002604	-0.002604	0.016796
5	4.062500	4.065104	-0.002604	0.031119	-0.015494	-0.015494	0.010417
6	4.062500	4.077994	-0.015494	-0.002604	-0.036458	-0.036458	0.004037
7	4.046875	4.083333	-0.036458	-0.015494	-0.015494	-0.015494	0.020964
8	4.062500	4.077994	-0.015494	-0.036458	0.018229	0.018229	0.006380

The out-of-plane deflection is acceptable.

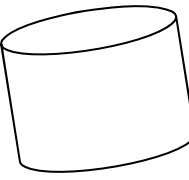
Shell Settlement Evaluation

Shell Settlement Graph



— Shell Settlement

— Optimum Cosine Curve



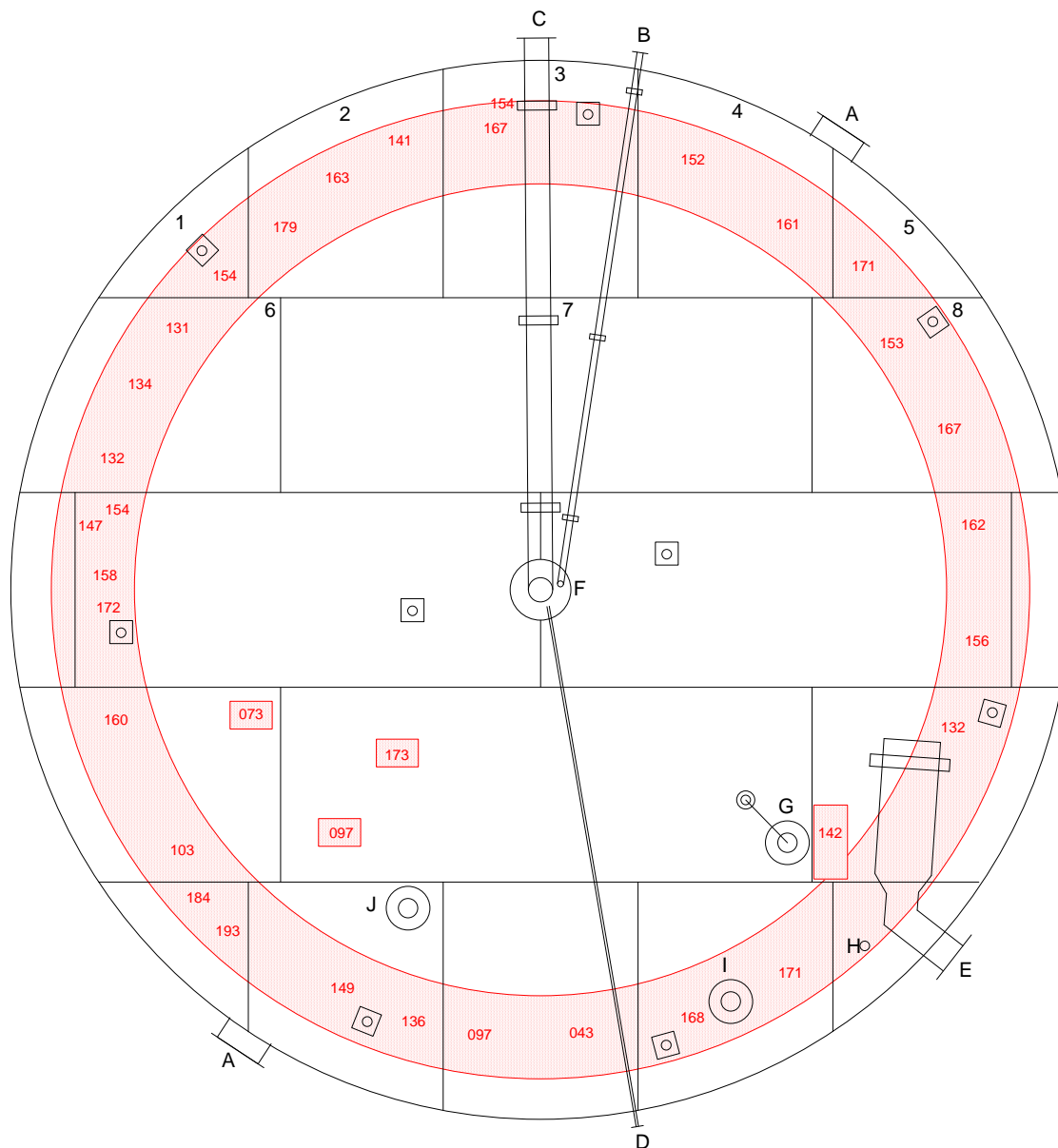
Min. Settlement at (Pt 7)

Max. Settlement at (Pt 1)

Appendix B

Engineering Drawings

1. Bottom Layout
2. Shell Layout
3. Roof Layout
4. Secondary Containment Layout



Remarks/Legend:

Nominal Diameter is 43'-6"
Bottom has 20 plates.

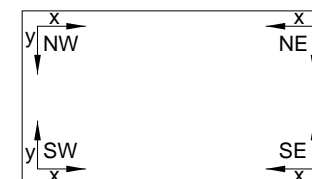
A - 36" Manhole
B - 4" Drain
C - 12" Issue Line
D - 1" Water Draw-Off
E - 8" Receipt Line
F - 30" Sump
G - Internal ladder w/ 8" Sample Hatch
H - Floating Roof Anti-rotation Device
I - 8" ENRAF Stilling Well
J - 8" Sample Stilling Well

- Floating Roof Leg w/ Sticker Pad

- Heavy Underside Corrosion

162 - Remaining Metal Thickness in mils.
(1000 mils = 1 inch)

XY Orientation



XY Orientation is in reference to Plan North

Owner/Operator:

Andrews AFB

Inspection Firm:

InterSpec LLC

Date:

10/31/17

Revision Number:

N/A

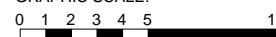
Revision Date:

N/A

Drawing Title:

Bottom Layout

GRAPHIC SCALE:



Dimensions are in feet.

Tank Description:

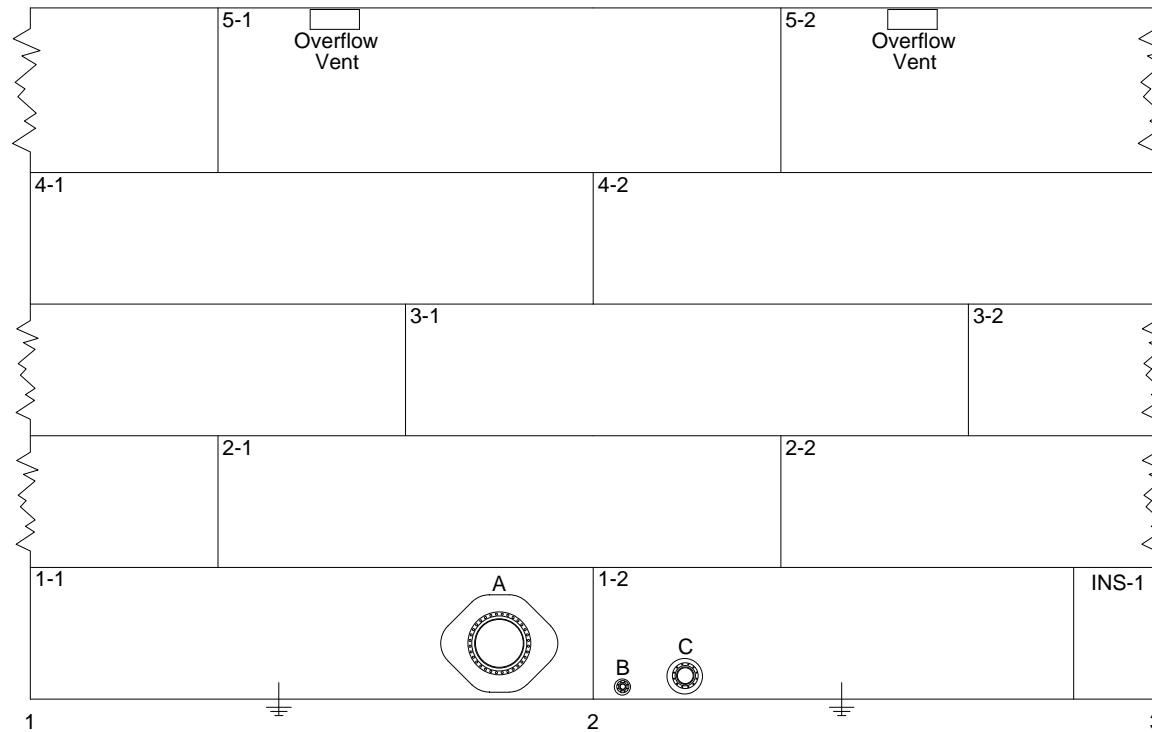
Facility 5025 (Tank #25)

Drawing Number:

B-1

Remarks/Legend:

Seam #1 is the first seam left of the first manhole left of the stairway in the first shell course viewing from the outside. The number in the upper left corner of each plate identifies the plate by the course and position of the plate in that course.



A - 36" Manhole
B - 4" Drain
C - 12" Issue Line

Owner/Operator:

Andrews AFB

Inspection Firm:

InterSpec LLC

Date:

10/31/17

Revision Number:

N/A

Revision Date:

N/A

Drawing Title:

Shell Layout

Tank Description:

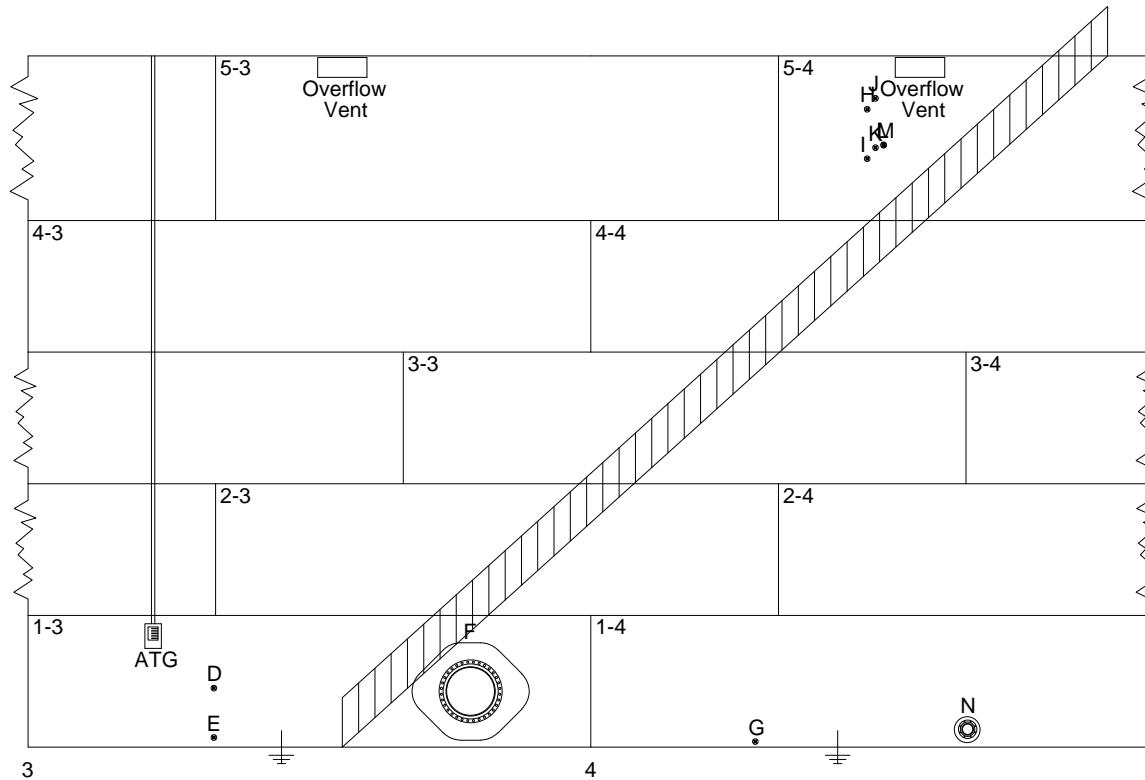
Facility 5025 (Tank #25)

Drawing Number:

S-1

Remarks/Legend:

Seam #1 is the first seam left of the first manhole left of the stairway in the first shell course viewing from the outside. The number in the upper left corner of each plate identifies the plate by the course and position of the plate in that course.



- D - 1" Low Level Alarm Assembly
- E - 1" Low Level Alarm Assembly
- F - 36" Manhole
- G - 1" Water Draw-Off
- H - 1" High Level Alarm Assembly
- I - 1" High Level Alarm Assembly
- J - 1" High Level Shut-Off Assembly
- K - 1" High Level Shut-Off Assembly
- L - 1" High-High Level Alarm Assembly
- M - 1" High-High Level Alarm Assembly
- N - 8" Receipt Line

Owner/Operator:

Andrews AFB

Inspection Firm:

InterSpec LLC

Date:

10/31/17

Revision Number:

N/A

Revision Date:

N/A

Drawing Title:

Shell Layout

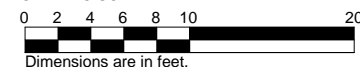
Tank Description:

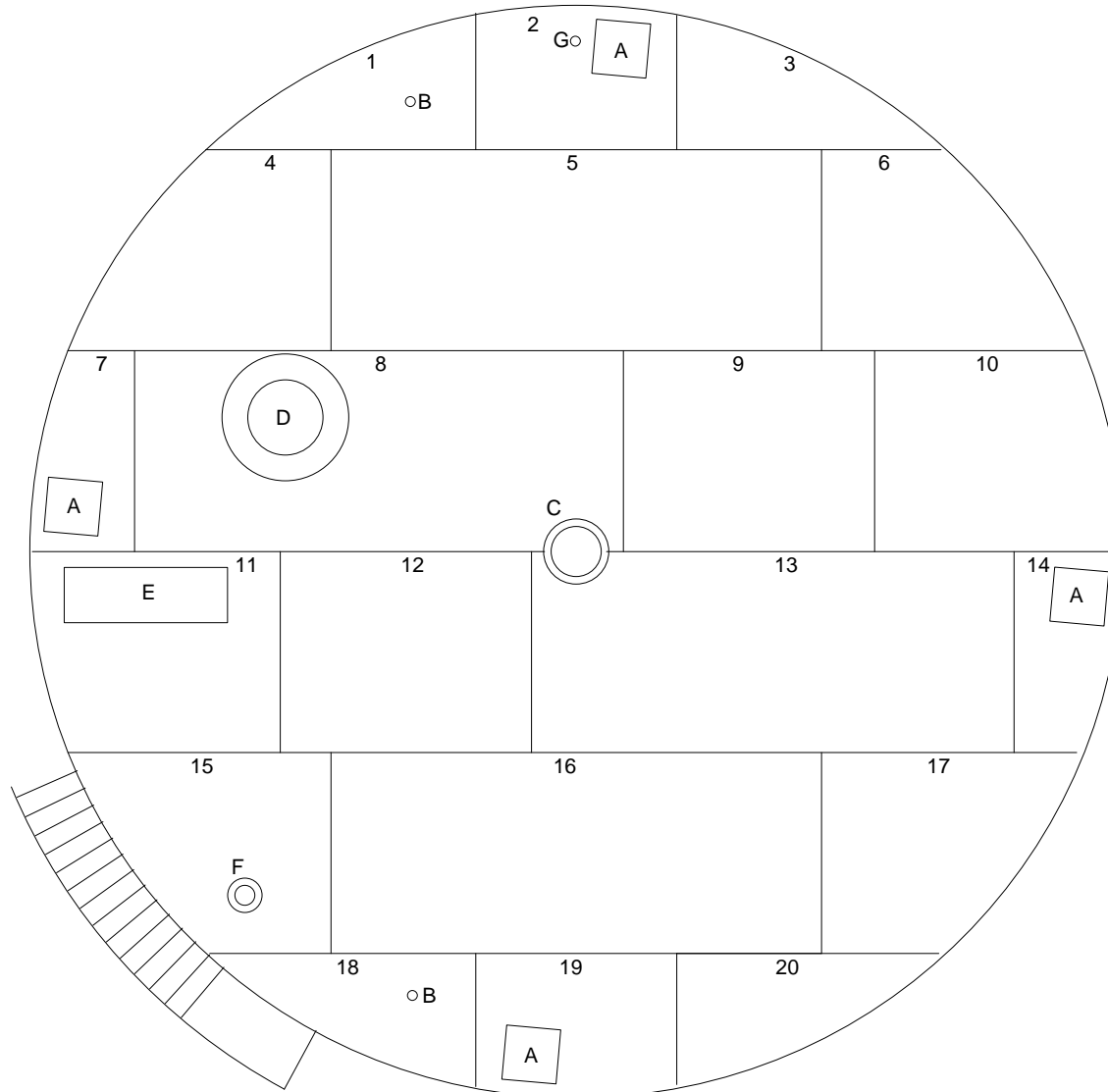
Facility 5025 (Tank #25)

Drawing Number:

S-2

GRAPHIC SCALE:



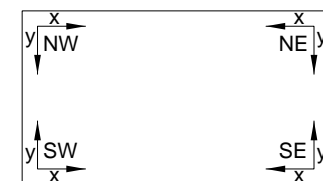


Remarks/Legend:

Nominal Diameter is 43'-6"
Fixed roof has 20 plates.

- A - Roof Circulation Vent/Inspection Hatch
- B - 2" Cap
- C - 24" Cner Vent w/ VITO Water probe
- D - 36" Hatch
- E - Hatch
- F - 8" ENRAF ATG
- G - Manual Tape Level gauge

XY Orientation



XY Orientation is in reference to Plan North

Owner/Operator:

Andrews AFB

Inspection Firm:

InterSpec LLC

Date:

10/31/17

Revision Number:

N/A

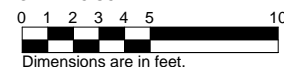
Revision Date:

N/A

Drawing Title:

Fixed Roof Layout

GRAPHIC SCALE:



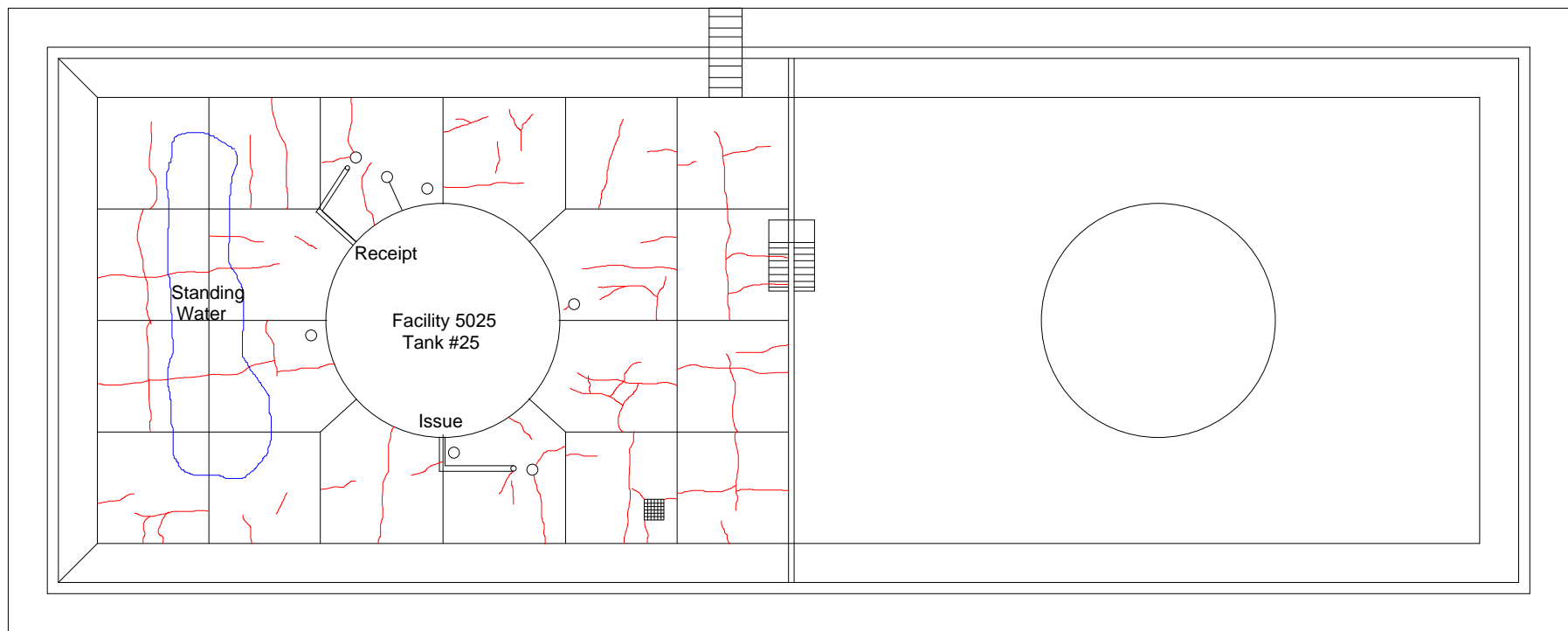
Dimensions are in feet.

Tank Description:

Facility 5025 (Tank #25)

Drawing Number:

R-1



— Secondary Containment Cracks

Company:		
Andrews AFB		
Drawn By:		
InterSpec LLC		
Date:	Rev. No.:	Scale:
10/31/17	N/A	1/520 feet

Drawing Title:

Secondary Containment Layout

Tank Description:

Facility 5025 (Tank #25)

Appendix C

Engineering Data

1. Bottom Plate Thickness Measurements
2. Bottom Settlement Measurements
3. Shell Settlement Measurements
4. Shell Plate Thickness Measurements
5. Shell Nozzle, Nozzle Reinforcement, and Insert Measurements
6. Floating Roof Rim Spacing and Seal Gap Measurements
7. Fixed Roof Plate Thickness Measurements

Bottom Plate Thickness Measurements

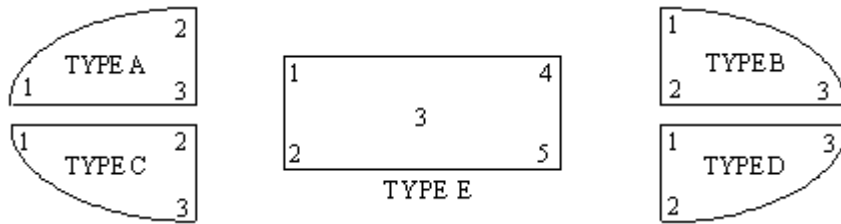


Plate Number	Plate Location	Plate Type	Nominal Thickness	Point Number				
				1	2	3	4	5
1	Sketch	A	0.25	0.246	0.248	0.249		
2	Sketch	E	0.25	0.250	0.249	0.248	0.247	0.251
3	Sketch	E	0.25	0.248	0.248	0.247	0.248	0.248
4	Sketch	E	0.25	0.247	0.246	0.249	0.251	0.245
5	Sketch	B	0.25	0.249	0.248	0.249		
6	Middle	E	0.25	0.249	0.248	0.249	0.248	0.247
7	Middle	E	0.25	0.248	0.247	0.248	0.247	0.249
8	Sketch	E	0.25	0.240	0.247	0.248	0.250	0.248
9	Sketch	E	0.25	0.246	0.245	0.249	0.248	0.247
10	Middle	E	0.25	0.241	0.216	0.242	0.247	0.246
11	Middle	E	0.25	0.245	0.249	0.250	0.249	0.249
12	Sketch	E	0.25	0.245	0.249	0.249	0.247	0.247
13	Sketch	E	0.25	0.246	0.240	0.248	0.247	0.248
14	Middle	E	0.25	0.246	0.246	0.246	0.243	0.247
15	Sketch	E	0.25	0.244	0.247	0.244	0.249	0.250
16	Sketch	C	0.25	0.250	0.247	0.250		
17	Sketch	E	0.25	0.242	0.246	0.247	0.244	0.248
18	Sketch	E	0.25	0.248	0.248	0.247	0.247	0.246
19	Sketch	E	0.25	0.246	0.248	0.204	0.248	0.248
20	Sketch	D	0.25	0.251	0.230	0.250		

NOTE: The lowest UT measurements are in **RED**, and the highest UT measurements are in **GREEN** for each Plate Location.

Bottom Settlement Measurements

Point No.	Distance From Shell	Radial Number							
		1	2	3	4	5	6	7	8
1	0'	49	49	48.9375	49	48.75	48.75	48.5625	48.75
2	10'	54	54	54.25	55.5	55.75	55.75	55.25	56
3	20'	58.75	58.75	59	59.25	59.5	59.25	59	58.5

NOTE: The Rod Heights are based on the actual height of the transit at the time of the data collection. This data should only be used for this report. Radial #1 and Point #1 are located at Vertical Shell Seam #1. The radials are numbered to the left as viewed facing the shell internally. The points along each radial start at the shell and are numbered toward the center of the tank.

Shell Settlement Measurements

Point No.	Rod Height (inches)
1	49
2	49
3	48.9375
4	49
5	48.75
6	48.75
7	48.5625
8	48.75

NOTE: The Rod Heights are based on the actual height of the transit at the time of the data collection. This data should only be used for this report. Point #1 is located at Vertical Shell Seam #1.

Shell Plate Thickness Measurements

Shell Plate Number 1-1									
0.286	0.287	0.288	0.287	0.289	0.289	0.290	0.285	0.284	0.286

Shell Plate Number 1-2									
0.299	0.300	0.299	0.286	0.286	0.286	0.286	0.288	0.288	0.289

Shell Plate Number 1-3									
0.299	0.302	0.300	0.292	0.291	0.291	0.290	0.308	0.308	0.301

Shell Plate Number 1-4									
0.291	0.291	0.291	0.287	0.287	0.287	0.289	0.298	0.297	0.301

NOTE: The bottom two rows are thicknesses across the bottom of the shell plate. The vertical thicknesses are at the vertical seams and in the middle of the plate. The thickness measurements are in inches and were taken randomly. The lowest UT measurements are in **RED**, and the highest UT measurements are in **GREEN** for each shell course.

Shell Plate Thickness Measurements

Point No.	Course #1	Course #2	Course #3	Course #4	Course #5
1	0.287	0.254	0.257	0.249	0.273
2	0.289	0.255	0.257	0.248	0.274
3	0.290	0.254	0.258	0.249	0.275
4	0.290	0.255	0.258	0.248	0.278
5	0.290	0.255	0.258	0.248	0.277
6	0.289	0.256	0.258	0.251	0.280
7	0.289	0.256	0.258	0.249	0.279
8	0.288	0.257	0.259	0.248	0.276

NOTE: Thickness measurements are evenly spaced down each course along the path of each drop. The thickness measurements are in inches. The lowest UT measurements are in **RED**, and the highest UT measurements are in **GREEN** for each shell course.

Shell Nozzle, Nozzle Reinforcement, and Insert Measurements

Nozzle Measurements									
Noz Desig.	Sheet No.	Nozzle Description	X-Axis (feet)	Y-Axis (feet)	Thickness Measurements (inches)				
					Nom.	0°	90°	180°	270°
A	1	36" Manhole	28.5	3.38	0.500	0.496	0.509	0.495	0.504
B	2	4" Drain	1.8	0.75	0.337	0.331	0.326	0.327	0.335
C	2	12" Issue Line	5.6	1.42	0.500	0.499	0.499	0.506	0.499
D	3	1" Low Level Alarm Assembly	11.3	3.58	NA	NA	NA	NA	NA
E	3	1" Low Level Alarm Assembly	11.3	0.58	NA	NA	NA	NA	NA
F	3	36" Manhole	26.9	3.38	0.500	0.495	0.496	0.493	0.495
G	4	1" Water Draw-Off	10	0.33	NA	NA	NA	NA	NA
H	4	1" High Level Alarm	16.8	38.75	NA	NA	NA	NA	NA
I	4	1" High Level Alarm	16.8	35.75	NA	NA	NA	NA	NA
J	4	1" High Level Shut-Off	17.3	39.42	NA	NA	NA	NA	NA
K	4	1" High Level Shut-Off	17.3	36.42	NA	NA	NA	NA	NA
L	4	1" High-High Level Alarm	17.8	36.58	NA	NA	NA	NA	NA
M	4	1" High-High Level Alarm	17.8	36.58	NA	NA	NA	NA	NA
N	4	8" Receipt Line	22.9	1.08	0.500	0.526	0.537	0.525	0.515

Nozzle Reinforcement Measurements									
Noz Desig.	Sheet No.	Reinforcement Description	Width (inches)	Length (inches)	Thickness Measurements (inches)				
					Nom.	0°	90°	180°	270°
A	1	Diamond with Round Corners	98	71	0.290	0.303	0.305	0.299	0.306
B	2	Circular	12	12	0.290	0.301	0.299	0.300	0.302
C	2	Circular	26	26	0.290	0.298	0.306	0.299	0.303
F	3	Diamond with Round Corners	96	71	0.290	0.305	0.303	0.304	0.303
N	4	Circular	19	19	0.290	0.304	0.303	0.303	0.306

Insert Measurements									
Insert Desig.	Sheet No.	Insert Description	Width (inches)	Length (inches)	Thickness Measurements (inches)				
					Nom.	0°	90°	180°	270°
INS-1	2	Rectangular	60.00	96.00	0.290	0.287	0.288	0.291	0.298

NOTE: The Sheet Number corresponds to the shell plate in the first shell course. The X-Axis is measured from the Seam #1 in the first shell course to the center of the nozzle. Seam #1 is the first seam left of the first manhole left of the stairway in the first shell course viewing from the outside. The Y-Axis is measured from the tank bottom to the center of the nozzle.

Floating Roof Rim Spacing and Seal Gap Measurements

Point Number	Rim Spacing (in inches)	Seal Gap (in inches)		Point Number	Rim Spacing (in inches)	Seal Gap (in inches)
1	5	0	Points are opposite of each other	5	5	0
2	5	0	Points are opposite of each other	6	6	0
3	4.75	0	Points are opposite of each other	7	6	0
4	5	0	Points are opposite of each other	8	6	0

NOTE: Point #1 is at Seam #1 and each point is 17.5 feet apart to the left viewing from inside. Seam #1 is the first seam left of the first manway left of the stairway base in the first shell course viewing from the outside.

Fixed Roof Plate Thickness Measurements

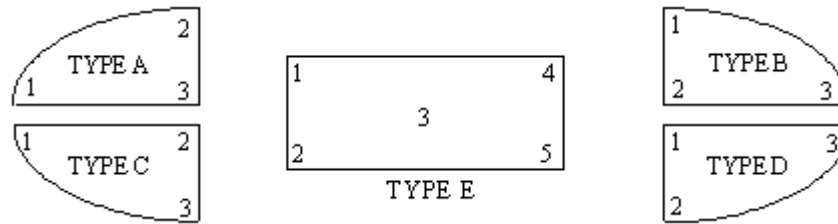


Plate Number	Point No.					Plate Type
	1	2	3	4	5	
1	0.250	0.248	0.248			A
2	0.248	0.248	0.250	0.247	0.247	E
3	0.248	0.247	0.248			B
4	0.249	0.249	0.250	0.250	0.247	E
5	0.246	0.247	0.245	0.246	0.251	E
6	0.248	0.247	0.249	0.248	0.248	E
7	0.247	0.247	0.248	0.248	0.250	E
8	0.249	0.247	0.251	0.250	0.251	E
9	0.249	0.249	0.249	0.246	0.245	E
10	0.248	0.248	0.250	0.249	0.250	E
11	0.250	0.251	0.251	0.247	0.247	E
12	0.248	0.248	0.248	0.247	0.249	E
13	0.248	0.250	0.251	0.250	0.249	E
14	0.247	0.247	0.250	0.248	0.248	E
15	0.248	0.252	0.251	0.249	0.249	E
16	0.249	0.246	0.251	0.254	0.249	E
17	0.248	0.249	0.249	0.247	0.247	E
18	0.248	0.248	0.248			C
19	0.247	0.249	0.250	0.249	0.247	E
20	0.250	0.248	0.247			D

NOTE: The lowest UT measurements are in **RED**, and the highest UT measurements are in **GREEN**.

Appendix D

API Checklists

1. In-Service Checklist
2. Out-of-Service Checklist

TANK INSPECTION CHECKLIST (IN-SERVICE AND OUT-OF-SERVICE)
ABOVEGROUND STORAGE

TANK INSPECTION CHECKLIST

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
Tank In-Service Inspection Checklist				
C.1.1	FOUNDATION			
	Measure foundation levelness and bottom elevations.	✓		
C.1.1.1	CONCRETE RING			
	a) Inspect for broken concrete, spalling, and cracks, particularly under backup bars used in welding butt-welded annular rings under the shell.	✓	Cracks	See report
	b) Inspect drain openings in ring, back of waterdraw basins, and top surface of ring for indications of bottom leakage.	✓	Full of Water	Keep Dry
	c) Inspect for cavities under foundation and vegetation against bottom of tank.	✓		
	d) Check that runoff rainwater from the shell drains away from tank.	✓	Sloped to Tank	
	e) Check for settlement around perimeter of tank.	✓		
C.1.1.2	ASPHALT			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	a) Check for settling of tank into asphalt base which would direct runoff rain water under the tank instead of away from it.		N/A	
	b) Look for areas where leaching of oil has left rock filler exposed, which indicates hydrocarbon leakage.		N/A	
C.1.1.3	OILED DIRT OR SAND			
	Check for settlement into the base which would direct runoff rain water under the tank rather than away from it.		N/A	
C.1.1.4	ROCK			
	Presence of crushed rock under the steel bottom usually results in severe underside corrosion. Make a note to do additional bottom plate examination (ultrasonic, hammer testing, or turning of coupons) when the tank is out of service.		N/A	
C.1.1.5	SITE DRAINAGE			
	a) Check site for drainage away from the tank and associated piping and manifolds.	✓		
	b) Check operating condition of the dike drains.	✓		
C.1.1.6	HOUSEKEEPING			
	Inspect the area for buildup of trash, vegetation, and other inflammables buildup.	✓		
C.1.1.7	CATHODIC PROTECTION			
	Review cathodic protection potential readings.	✓	Heavy Bottom Corrosion	Not Effective
C.1.2	SHELLS			
C.1.2.1	EXTERNAL VISUAL INSPECTION			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	a) Visually inspect for paint failures, pitting, and corrosion.	✓		
	b) Clean off the bottom angle area and inspect for corrosion and thinning on plate and weld.	✓		
	c) Inspect the bottom-to-foundation seal, if any. Visually inspect for grooving, corrosion, pitting, and coating failures.	✓	Deteriorated	Replace
C.1.2.2	INTERNAL (FLOATING ROOF TANK)			
	Visually inspect for grooving, corrosion, pitting, and coating failures.	✓		
C.1.2.3	RIVETED SHELL INSPECTION			
	a) Inspect external surface for rivet and seam leaks.		N/A	
	b) Locate leaks by sketch or photo (location will be lost when shell is abrasive cleaned for painting).		N/A	
	c) Inspect rivets for corrosion loss and wear.		N/A	
	d) Inspect vertical seams to see if they have been full fillet lap-welded to increase joint efficiency.		N/A	
	e) If no record exists of vertical riveted seams, dimension and sketch (or photograph) the rivet pattern: number of rows, rivet size, pitch length, and note whether the joint is butt-riveted or lap-riveted.		N/A	
C.1.2.4	WIND GIRDER (FLOATING ROOF TANKS)			
	a) Inspect wind girder and handrail for corrosion damage (paint failure, pitting, corrosion product buildup), especially where it occurs at tack-welded junction, and for broken welds.		N/A	
	b) Check support welds to shell for pitting, especially on shell plates.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	c) Note whether supports have reinforcing pads welded to shell.		N/A	
C.1.3	SHELL APPURTENANCES			
C.1.3.1	MANWAYS AND NOZZLES			
	a) Inspect for cracks or signs of leakage on weld joints at nozzles, man ways, and reinforcing plates.	✓		
	b) Inspect for shell plate dimpling around nozzles, caused by excessive pipe deflection.	✓		
	c) Inspect for flange leaks and leaks around bolting.	✓		
	d) Inspect sealing of insulation around manways and nozzles.		N/A	
	e) Check for inadequate manway flange and cover thickness on mixer manways.		N/A	
C. 1.3.2	TANK PIPING MANIFOLDS			
	a) Inspect manifold piping, flanges, and valves for leaks.	✓		
	b) Inspect fire-fighting system components.		N/A	
	c) Check for anchored piping which would be hazardous to the tank shell or bottom connections during earth movement.	✓		
	d) Check for adequate thermal pressure relief of piping to the tank.	✓		
	e) Check operation of regulators for tanks with purge gas systems.		N/A	
	f) Check sample connections for leaks and for proper valve operation.		N/A	
	g) Check for damage and test the accuracy of temperature indicators.		N/A	
	h) Check welds on shell-mounted davit clips above valves 6 in. and larger.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
C.1.3.3	AUTOGAUGE SYSTEM			
	a) Inspect autogauge tape guide and lower sheave housing (floating swings) for leaks.		N/A	
	b) Inspect autogauge head for damage.		N/A	
	c) Bump the checker on autogauge head for proper movement of tape.	✓	Anchored to IFR	Modify w/ Weight
	d) Identify size and construction material of autogauge tape guide (floating roof tanks).		N/A	
	e) Ask operator if tape tends to hang up during tank roof movement (floating roof tanks).		N/A	
	f) Compare actual product level to the reading on the autogauge (maximum variation is 2 in.).	✓	MTG reads 99	Calibrate
	g) On floating roof tanks, when the roof is in the lowest position, check that no more than two feet of tape are exposed at the end of the tape guide.		N/A	
	h) Inspect condition of board and legibility of board-type autogauges.		N/A	
	i) Test freedom of movement of marker and float.		N/A	
C.1.3.4	SHELL-MOUNTED SAMPLE STATION			
	a) Inspect sample lines for function of valves and plugging of lines, including drain or return-to-tank line.		N/A	
	b) Check circulation pump for leaks and operating problems.		N/A	
	c) Test bracing and supports for sample lines and equipment.		N/A	
C.1.3.5	HEATER (SHELL MANWAY MOUNTED)			
	Inspect condensate drain for presence of oil indicating leakage.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
C.1.3.6	MIXER			
	a) Inspect for proper mounting flange and support.		N/A	
	b) Inspect for leakage.		N/A	
	c) Inspect condition of power lines and connections to mixer.		N/A	
C.1.3.7	SWING LINES: WINCH OPERATION			
	a) Nonfloating. Raise, then lower the swing line with the winch, and check for cable tightness to confirm that swing line lowered properly.		N/A	
	b) Floating. With tank half full or more, lower the swing line, then let out cable and check if swing has pulled cable tight, indicating that the winch is operating properly.		N/A	
	c) Indicator. Check that the indicator moves in the proper direction: Floating swing line indicators show a lower level as cable is wound up on the winch. Non-floating swing line indicators show the opposite.		N/A	
C.1.3.8	SWING LINES: EXTERNAL GUIDE SYSTEM			
	Check for leaks at threaded and flanged joints.		N/A	
C.1.3.9	Swing Lines: Identify Ballast Varying Need			
	Check for significant difference in stock specific gravity.		N/A	
C.1.3.10	Swing Lines: Cable Material and Condition			
	a) For non-stainless steel cable, check for corrosion over entire length.		N/A	
	b) All cable: check for wear or fraying.		N/A	
C.1.3.11	Swing Lines: Product Sample Comparison		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	Check for water or gravity differences that would indicate a leaking swing joint.		N/A	
C.1.3.12	SWING LINES: TARGET			
	Target should indicate direction of swing opening (up or down) and height above bottom where suction will be lost with swing on bottom support.		N/A	
C.1.4	ROOFS			
C.1.4.1	DECK PLATE INTERNAL CORROSION			
	For safety, before accessing the roof, check with ultrasonic instrument or lightly use a ball peen hammer to test the deck plate near the edge of the roof for thinning. (Corrosion normally attacks the deck plate at the edge of a fixed roof and at the rafters in the center of the roof first.)	✓		
C.1.4.2	Deck Plate External Corrosion			
	Visually inspect for paint failure, holes, pitting, and corrosion product on the roof deck.	✓		
C.1.4.3	ROOF DECK DRAINAGE			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	Look for indication of standing water. (Significant sagging of fixed roof deck indicates potential rafter failure. Large standing water areas on a floating roof indicate inadequate drainage design or, if to one side, a nonlevel roof with possible leaking pontoons.)	✓		
C.1.4.4	LEVEL OF FLOATING ROOF			
	At several locations, measure distance from roof rim to a horizontal weld seam above the roof. A variance in the readings indicates a nonlevel roof with possible shell out-of-round, out-of-plumb, leaking pontoons, or hang-up. On small diameter tanks, an unlevel condition can indicate unequal loading at that level.	✓		
C.1.4.5	Gas Test Internal Floating Roof			
	Test for explosive gas on top of the internal floating roof. Readings could indicate a leaking roof, leaking seal system, or inadequate ventilation of the area above the internal floating roof.		N/A	
C.1.4.6	ROOF INSULATION			
	a) Visually inspect for cracks or leaks in the insulation weather coat where runoff rain water could penetrate the insulation.		N/A	
	b) Inspect for wet insulation under the weather coat.		N/A	
	c) Remove small test sections of insulation and check roof plate for corrosion and holes near the edge of the insulated area.		N/A	
C.1.4.7	FLOATING ROOF SEAL SYSTEMS			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	<p>a) Inspect the condition of the seal, measure and record maximum rim spaces and seal-to-shell gaps around the full roof circumference at the level of inspection.</p> <p>NOTE Inspection of the seal and measurement of the rim spaces and seal-to-shell gaps at more than one level may be necessary to more fully determine if any problems exist at other levels of tank operation).</p>	✓	Fuel Soaked	Replace
	b) Measure and record annular space at 30-ft spacing (minimum of four quadrants) around roof and record. Measurements should be taken in directly opposite pairs.	✓		
	<p>1) _____ Opposite pair 1.</p> <p>2) _____ Opposite pair 2.</p>	✓	See Appendix C	
	c) Check if seal fabric on primary shoe seals is pulling shoes away from shell (fabric not wide enough).		N/A	
	d) Inspect fabric for deterioration, holes, tears, and cracks.	✓	Tears	Replace
	e) Inspect visible metallic parts for corrosion and wear.	✓		
	f) Inspect for openings in seals that would permit vapor emissions.	✓		
	g) Inspect for protruding bolt or rivet heads against the shell.	✓		
	h) Pull both primary and secondary seal systems back all around the shell to check their operation.	✓	Deteriorated	Replace
	i) Inspect secondary seals for signs of buckling or indications that their angle with the shell is too shallow.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	j) Inspect wedge-type wiper seals for flexibility, resilience, cracks, and tears.		N/A	
C.1.5	ROOF APPURTENANCES			
C.1.5.1	SAMPLE HATCH			
	a) Inspect condition and functioning of sample hatch cover.	✓		
	b) On tanks governed by Air Quality Monitoring District rules, check for the condition of seal inside hatch cover.		N/A	
	c) Check for corrosion and plugging on thief and gauge hatch cover.	✓		
	d) Where sample hatch is used to reel gauge stock level, check for marker and tab stating hold-off distance.	✓	Not Legible	Re-Stencil
	e) Check for reinforcing pad where sample hatch pipe penetrates the roof deck.	✓		
	f) On floating roof sample hatch and recoil systems, inspect operation of recoil reel and condition of rope.	✓		
	g) Test operation of system.	✓		
	h) On ultra clean stocks such as JP4, check for presence and condition of protective coating or liner inside sample hatch (preventing rust from pipe getting into sample).		N/A	
C.1.5.2	GAUGE WELL			
	a) Inspect visible portion of the gauge well for thinning, size of slots, and cover condition.	✓		
	b) Check for a hold-off distance marker and tab with hold-off distance (legible).	✓	Not Legible	Re-Stencil
	c) On floating roofs, inspect condition of roof guide for gauge well, particularly the condition of the rollers for grooving.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	d) If accessible, check the distance from the gauge well pipe to the tank shell at different levels.		N/A	
	e) If tank has a gauge well washer, check valve for leakage and for presence of a bull plug or blind flange.		N/A	
C.1.5.3	FIXED ROOF SCAFFOLD SUPPORT			
	Inspect scaffold support for corrosion, wear, and structural soundness.		N/A	
C.1.5.4	Autogauge: Inspect Hatch and Guides			
	a) Check the hatch for corrosion and missing bolts.		N/A	
	b) Check tape cable for wear or fraying caused by rubbing on the cover.		N/A	
C.1.5.5	AUTOGAUGE: FLOAT WELL COVER			
	a) Inspect for corrosion.		N/A	
	b) Check tape cable for wear or fraying caused by rubbing on the cover.		N/A	
C.1.5.6	Sample Hatch (Internal Floating Roof)			
	a) Check overall conditions.		N/A	
	b) When equipped with a fabric seal, check for automatic sealing after sampling.		N/A	
	c) When equipped with a recoil reel opening device, check for proper operations.		N/A	
C.1.5.7	Roof-mounted Vents (Internal Floating Roof)			
	Check condition of screens, locking and pivot pins.		N/A	
C.1.5.8	GAUGING PLATFORM DRIP RING			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	On fixed roof tanks with drip rings under the gauging platform or sampling area, inspect for plugged drain return to the tank.		N/A	
C.1.5.9	EMERGENCY ROOF DRAINS			
	Inspect vapor plugs for emergency drain: that seal fabric discs are slightly smaller than the pipe ID and that fabric seal is above the liquid level.		N/A	
C.1.5.10	REMOVABLE ROOF LEG RACKS			
	Check for leg racks on roof.		N/A	
C.1.5.11	VACUUM BREAKERS			
	Report size, number, and type of vacuum breakers. Inspect vacuum breakers. If high legs are set, check for setting of mechanical breaker in high leg position.	✓	20"	
C.1.5.12	RIM VENTS			
	a) Check condition of the screen on the rim vent cover.		N/A	
	b) Check for plating off or removal of rim vents where jurisdictional rules do not permit removal.		N/A	
C.1.5.13	PONTOON INSPECTION HATCHES			
	a) Open pontoon inspection hatch covers and visually check inside for pontoon leakage.		N/A	
	b) Test for explosive gas (an indicator of vapor space leaks).		N/A	
	c) If pontoon hatches are equipped with locked down coves, check for vent tubes. Check that vent tubes are not plugged up. Inspect lock-down devices for condition and operation.		N/A	
C.1.6	ACCESSWAYS			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	See Tank Out-of-service Inspection Checklist, Item C.2.12.		N/A	
Tank Out-of-Service Inspection Checklist				
C.2.1	OVERVIEW			
	a) Check that the tank has been cleaned, is gas free, and safe for entry.	✓		
	b) Check that the tank is completely isolated from product lines, electrical power, and steam lines.	✓		
	c) Check that roof is adequately supported, including fixed roof structure and roof legs.	✓		
	d) Check for presence of falling object hazards (e.g., corroded-through roof rafters, asphalt stalactites, and trapped hydrocarbons in unopened or plugged equipment or appurtenances, ledges).	✓		
	e) Inspect for slipping hazards on the bottom of the tank.	✓		
	f) Inspect structural welds on accessways and clips.	✓		
	g) Check surfaces needing inspection for a heavy-scale buildup and check weld seams and oily surfaces where welding is to be done. Note areas needing more cleaning, including blasting.	✓		
	h) Review cathodic protection potential readings.	✓	Not Effective	
C.2.2	TANK EXTERIOR			
	a) Inspect appurtenances opened during cleaning (such as lower floating swing sheave assemblies, nozzle interiors [after removal of valves]).	✓		
	b) Hammer test or ultrasonically test the roof.	✓		

API 653 Reference	Item	Completed	Findings	Comments/Recommendations (No response indicates finding is acceptable)
	c) Enter and inspect the floating roof pontoon compartments.		N/A	
C.2.3	BOTTOM INTERIOR SURFACES			
	a) Using a flashlight held close to and parallel to the bottom plates, and using the bottom plate layout as a guide, visually inspect and hammer test the entire bottom.	✓		
	b) Measure the depth of pitting and describe the pitting appearance (e.g., sharp edged, lake type, dense, scattered).	✓		
	c) Mark areas requiring patching or further inspection.	✓	Underside Corr.	Replace Bottom
	d) Mark locations for turning coupons for inspection.		N/A	
	e) Inspect all welds for corrosion and leaks, particularly the shell-to-bottom weld.	✓		
	f) Inspect sketch plates for corrosion.	✓	Underside Corr.	Replace Bottom
	g) Check condition of internal sump, if applicable. Standing liquid should be removed from the sump to allow for complete inspection and vacuum testing of weld seams as appropriate. Sump bottom and sidewall plate and seams need to be evaluated for both product-side and soil-side corrosion.	✓		
	h) Locate and mark voids under the bottom.		N/A	
	i) Record bottom data on a layout sketch using the existing bottom plates as a grid. List the number and sizes of patches required.	✓		
	j) Vacuum test the bottom lap welds.		N/A	
	k) Ultrasonically examine any slightly discolored spots or damp areas.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	l) Check for reinforcing pads under all bottom attached clips, brackets, and supports.	✓		
	n) Check the column bases of fixed roof supports for adequate pads and restraining clips.		N/A	
	o) In earthquake Zones 3 and 4, check that roof supports are not welded down to the tank bottom, but are only restrained from horizontal movement.		N/A	
	p) Check area beneath swing line cable for indications of cable cutting or dragging.		N/A	
	q) Mark old oil and air test connection for removal and patching.		N/A	
	r) Identify and report low areas on the bottom that do not drain adequately.		N/A	
	s) Inspect coating for holes, disbonding, deterioration, and discoloration.	✓		
C.2.4	SHELL SEAMS AND PLATES			
	a) On cone up bottoms, closely inspect and gauge the depth of metal loss on the lower 2 in. to 4 in. of the shell (area of standing water).		N/A	
	b) Measure the depth of pitting on each course.		N/A	
	c) Inspect and estimate the amount of metal loss on the heads of rivets and bolts.		N/A	
	d) Inspect shell-to-bottom riveted lap joints.		N/A	
	e) Inspect for vertical grooving damage from seal assembly protrusions.	✓		
	f) Inspect existing protective coatings for damage, deterioration, and disbonding.	✓		
	g) Check for areas of rubbing (indicating too much pressure by the seal assembly shoes or inadequate annular space).	✓		

API 653 Reference	Item	Completed	Findings	Comments/Recommendations (No response indicates finding is acceptable)
	h) Visually inspect the shell plates and seams for indications of leakage.	✓		
	i) If the shell has riveted or bolted seams, record the leak locations by film or chart in case the locations are lost during surface preparation for painting.		N/A	
	j) Measure annular space at 40-foot intervals.	✓		
	k) Survey the shell to check for roundness and plumb.	✓		
C.2.5	SHELL-MOUNTED OVERFLOWS			
	a) Inspect overflow for corrosion and adequate screening.	✓		
	b) Check location of overflow that it is not above any tank valves or equipment.	✓		
C.2.6	ROOF INTERIOR SURFACE			
C.2.6.1	GENERAL		N/A	
	a) Visually inspect the underside surface of the roof plates for holes, scale buildup, and pitting.	✓		
	b) Ultrasonically examine to check for thin areas, particularly at edge of roof on cone roof tank.	✓		
	c) Check all clips, brackets, braces welded to the roof deck plate for welded reinforcing pads and see that they have not broken free.	✓		
	d) If no pad is present, penetrant test for cracking of the weld or deck plate.		N/A	
	e) Inspect for protective coating for breaks, disbondment, and deterioration.	✓		
	f) Spark test the interior surface coating if recoating is not planned.		N/A	
C.2.6.2	FIXED ROOF SUPPORT STRUCTURE			
	a) Inspect the support columns for thinning in the upper 2 ft.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	b) On API columns (two channels welded together) check for corrosion scale breaking the tack welds, unless the joint between the channels is completely seal welded.		N/A	
	c) Check that the reinforcing pad on the bottom is seal-welded to the tank bottom with horizontal movement restraining clips welded to the pad.		N/A	
	d) Determine if pipe column supports are concrete filled or open pipe. If open pipe, check for a drain opening in the bottom of the pipe.		N/A	
	e) Inspect and gauge rafters for thinning, particularly near the center of the roof. Report metal loss.	✓		
	f) Check for loose or twisted rafters.	✓		
	g) Inspect girders for thinning and check that they are attached securely to the top of the columns.	✓		
	h) Report if the columns have cross bracing in the area between the low pump out of the top of the shell (for future internal floating roof installation).		N/A	
	i) Inspect and report presence of any roof-mounted swing line bumpers.		N/A	
	j) Photograph the roof structure if no rafter layout drawing exists.	✓		
C.2.7	FIXED ROOF APPURTENANCES			
C.2.7.1	INSPECTION AND LIGHT HATCHES			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	a) Inspect the hatches for corrosion, paint and coating failures, holes, and cover sealing.	✓		
	b) On loose covers, check for a safety chain in good condition.		N/A	
	c) On light hatches over 30 in. across, check for safety rods.		N/A	
	d) Inspect the condition of the gaskets on bolt or latched down hatch covers.		N/A	
C.2.7.2	STAGING SUPPORT CONNECTION			
	Inspect the condition of the staging support for corrosion.		N/A	
C.2.7.3	BREATHERS AND VENTS			
	a) Inspect and service the breather.	✓		
	b) Inspect screens on vents and breathers.	✓		
C.2.7.4	EMERGENCY P/V HATCHES			
	a) Inspect and service pressure/vacuum hatches. (Setting should be high enough to prevent chattering of breather during normal operation. See breather manufacturer's guide.)		N/A	
	b) Inspect liquid seal hatches for corrosion and proper liquid level in the seal.		N/A	
C.2.7.5	SAMPLE HATCH			
	a) Inspect sample hatch for corrosion.	✓		
	b) Check that the cover operates properly.	✓		
	c) If the tank has no gauge well, check for a hold-off distance marker and check measurement.	✓		
C.2.8	FLOATING ROOF			
C.2.8.1	ROOF DECK			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	a) Hammer test the area between roof rim and shell. (If access for hammer testing is inadequate, measure the distance from the bottom edge of the roof to the corroded area and then hammer test from inside the pontoon.)		N/A	
	b) In sour water service, clean and test all deck plate weld seams for cracking unless the lower laps have been seal-welded.		N/A	
	c) Check that either the roof drain is open or the drain plug in the roof is open in case of unexpected rain.		N/A	
	d) On flat bottomed and cone bottom roof decks, check for a vapor dam around the periphery of the roof. The dam should be continuous without break to prevent escape of vapors to the seal area from under the center of the roof.		N/A	
C.2.8.2	FLOATING ROOF PONTOONS			
	a) Visually inspect each pontoon for liquid leakage.		N/A	
	b) Run a light wire through the gooseneck vents on locked down inspection hatch covers to make sure they are open.		N/A	
	c) Inspect lockdown latches on each cover.		N/A	
	d) Check and report if each pontoon is:			
	1) Vapor tight (bulkhead seal welded on one side on bottom, sides, and top),		N/A	
	(1) Liquid tight (seal-welded on bottom and sides only), or		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	(2) Unacceptable (minimum acceptable condition is liquid tight).		N/A	
C.2.8.3	FLOATING ROOF CUTOUTS			
	a) Inspect underside of cutouts for mechanical damage.		N/A	
	b) Inspect welds for cracks.		N/A	
	c) Inspect plate for thinning, pitting, and erosion.		N/A	
	d) Measure mixer cutouts and record plate thickness for future mixer installation or replacement. Plate thickness _____.		N/A	
C.2.8.4	FLOATING ROOF SUPPORTS			
	a) Inspect fixed low and removable high floating roof legs for thinning.	✓		
	b) Inspect for notching at bottom of legs for drainage.	✓		
	c) Inspect for leg buckling or felling at bottom.	✓		
	d) Inspect pin hole in roof guide for tears.	✓		
	e) Check plumb of all legs.	✓		
	f) Inspect for adequate reinforcing gussets on all legs through a single portion of the roof.	✓		
	g) Inspect the area around the roof legs for cracking if there is no internal reinforcing pad or if the topside pad is not welded to the deck plate on the underside.	✓		
	h) Inspect the sealing system on the two-position legs and the vapor plugs in the fixed low leg for deterioration of the gaskets.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/Recommendations (No response indicates finding is acceptable)
	i) On shell-mounted roof supports, check for adequate clearance based on the maximum floating roof movement as determined by the position of the roof relative to the gauge well and/or counter-rotational device.		N/A	
C.2.9	FLOATING ROOF SEAL ASSEMBLIES			
C.2.9.1	PRIMARY SHOE ASSEMBLY			
	a) Remove four sections of foam log (foam-filled seals) for inspection on 90° locations.	✓	Fuel Soaked	Replace
	b) Inspect hanger attachment to roof rim for thinning, bending, broken welds, and wear of pin holes.		N/A	
	c) Inspect clips welded to roof rim for thinning.		N/A	
	d) Shoes—inspect for thinning and holes in shoes.		N/A	
	e) Inspect for bit-metal bolts, clips, and attachments.	✓	N/A	
	f) Seal fabric—inspect for deterioration, stiffening, holes, and tears in fabric.	✓	Deteriorated	Replace
	g) Measure length of fabric from top of shoe to roof rim, and check against maximum anticipated annular space as roof operates.		N/A	
	h) Inspect any modification of shoes over shell nozzles, mixers, etc., for clearance.		N/A	
	i) Inspect shoes for damage caused by striking shell nozzles, mixers, etc.		N/A	
C.2.9.2	PRIMARY TOROIDAL ASSEMBLY			
	a) Inspect seal fabric for wear, deterioration, holes, and tears.		N/A	
	b) Measure and chart seal-to-shell gaps.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	c) Visually inspect seam from below, looking for holes as evidenced by light.		N/A	
	d) Inspect fabric for deterioration and stiffness.		N/A	
	e) Inspect for mechanical damage, corrosion, and wear on tip in contact with shell.		N/A	
	f) Inspect for contact with obstructions above top of shell.		N/A	
C.2.10	FLOATING ROOF APPURTENANCES			
C.2.10.1	ROOF MANWAYS			
	a) Inspect walls of manways for pitting and thinning.	✓		
	b) On tanks with interface autogauges, check seal around gauge tape cable and guide wires through manway cover.		N/A	
	c) Inspect cover gasket and bolts.		N/A	
C.2.10.2	RIM VENT			
	a) Check rim vent for pitting and holes.		N/A	
	b) Check vent for condition of screen.		N/A	
	c) On floating roof tanks where the environmental rules require closing off the vent, check the vent pipe for corrosion at the pipe-to-rim joint and check that the blinding is adequate.		N/A	
C.2.10.3	VACUUM BREAKER, BREATHER TYPE			
	a) Service and check operation of breather valve.	✓		
	b) Check that nozzle pipe projects no more than 1/2 in. below roof deck.	✓		
C.2.10.4	VACUUM BREAKER, MECHANICAL TYPE			

API 653 Reference	Item	Completed	Findings	Comments/Recommendations (No response indicates finding is acceptable)
	Inspect the stem for thinning. Measure how far the vacuum breaker cover is raised off the pipe when the roof is resting on high or low legs.		N/A	
	a) On high legs: _____ .		N/A	
	b) On low legs: _____ .		N/A	
C.2.10.5	ROOF DRAINS: OPEN SYSTEMS, INCLUDING EMERGENCY DRAINS			
	a) Check liquid level inside open roof drains for adequate freeboard. Report if there is insufficient distance between liquid level and top of drain.		N/A	
	b) If tank comes under Air Quality Monitoring District rules, inspect the roof drain vapor plug.		N/A	
	c) If emergency drain is not at the center of the roof, check that there are at least three emergency drains.		N/A	
C.2.10.6	CLOSED DRAIN SYSTEMS: DRAIN BASINS			
	a) Inspect for thinning and pitting.		N/A	
	b) Inspect protective coating (topside).		N/A	
	c) Inspect basin cover or screen for corrosion.		N/A	
	d) Test operation of check valve.		N/A	
	e) Check for presence of check valve where bottom of basin is below product level.		N/A	
	f) Inspect drain basin(s) to roof deck welds for cracking.		N/A	
	g) Check drain basin(s) outlet pipe for adequate reinforcement to roof deck (including reinforcing pad).		N/A	
C.2.10.7	CLOSED DRAIN SYSTEMS: FIXED DRAIN LINE ON TANK BOTTOM			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	a) Hammer test fixed drain line on tank bottom for thinning and scale/debris plugging.		N/A	
	b) Inspect supports and reinforcing pads for weld failures and corrosion.		N/A	
	c) Check that pipe is guided, not rigidly locked to support, to avoid tearing of tank bottom plate.		N/A	
C.2.10.8	CLOSED DRAIN SYSTEMS: FLEXIBLE PIPE DRAIN			
	a) Inspect for damage to exterior of pipe.		N/A	
	b) Check for obstructions that pipe could catch on.		N/A	
	c) Inspect shields to protect pipe from snagging.		N/A	
	d) Inspect results of hydrostatic test on flexible roof drain system.		N/A	
C.2.10.9	CLOSED DRAIN SYSTEMS: ARTICULATED JOINT DRAIN			
	a) Hammer test rigid pipe in flexible joint systems for thinning and scale/debris plugging.		N/A	
	b) Inspect system for signs of bending or strain.		N/A	
	c) Inspect results of system hydrostatic test.		N/A	
	d) Inspect landing leg and pad.		N/A	
C.2.10.10	AUTOGAUGE SYSTEM AND ALARMS			
	a) Check freedom of movement of tape through autogauge tape guide.		N/A	
	b) Inspect sheaves for freedom of movement.		N/A	
	c) Test operation checker.		N/A	
	d) Inspect tape and tape cable for twisting and fraying.	✓		

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	e) Test the tape's freedom of movement through guide sheaves and tape guide pipe.		N/A	
	f) On open-top tanks, check that gate tapes with cables have no more than one foot of tape exposed with float at lowest point.		N/A	
	g) Check float for leakage.		N/A	
	h) Test float guide wire anchors for spring action by pulling on wire and releasing.		N/A	
	i) Inspect floatwells in floating roofs for thinning and pitting of walls just above the liquid level.		N/A	
	j) Check that the autogauge tape is firmly attached to the float.	✓	Attached	
	k) Inspect the tape cable and float guide wire fabric seals through the float well cover.		N/A	
	l) Inspect the bottom guide wire attachment clip: inspect for a temporary weighted bar instead of a permanent welded down clip.		N/A	
	m) Inspect board-type autogauge indicators for legibility and freedom of movement of indicator.		N/A	
	n) Measure and record these distances to determine if seal damage will occur if tank is run over from:			
	1) Shell top angle to underside of tape guide system.		N/A	
	2) Liquid level on floating top to top of secondary seal.		N/A	
	o) Identify floating roofs where the tape is connected directly to the roof.	✓	Direct connect	
	p) Overfill alarm: Inspect tank overfill prevention alarm switches for proper operation.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
C.2.11	COMMON TANK APPURTENANCES			
C.2.11.1	GAUGE WELL			
	a) Inspect gate well pipe for thinning at about two-thirds distance above the bottom: look for thinning at the edge of the slots.	✓		
	b) Check for corrosion on the pipe joint. Check that sample cords, weights, thermometers, etc., have been removed from the pipe.		N/A	
	c) Check for cone at bottom end of pipe about one foot above the bottom.		N/A	
	d) Check condition of well washer pipe and that its flared end is directed at the near side of the hold off pad.		N/A	
	e) Check that supports for gauge well are welded to pad or to shell and not directly to bottom plate.	✓	Hard Bolted	
	f) Check operation of gauge well cover.	✓		
	g) Check presence of a hold-off distance marker in well pipe and record hold-off distance. Hold-off distance.	✓		
	h) Identify and report size and pipe schedule, and whether pipe is solid or slotted. Report slot size.	✓	8" & 2" SCH 40	
	i) Check that the hold-off distance plate is seal-welded to the bottom and that any gauge well supports are welded to the plate and not directly to the bottom.	✓	Not legible	Re-Stencil
	j) Inspect vapor control float and cable.		N/A	
	k) Check for presence and condition of gauge well washer.		N/A	
	l) Check for bull plug or plate blind on gauge well washer valve.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	m) Inspect gauge well guide in floating roof for pitting and thinning.		N/A	
	n) Inspect the guide rollers and sliding plates for freedom of movement.		N/A	
	o) Inspect condition of gauge well pipe seal system.		N/A	
	p) On black oil and diesel services: if gauge well is also used for sampling, check for presence of a thief- and gauge-type hatch to avoid spillage.		N/A	
	q) Visually inspect inside of pipe for pipe weld protrusions which could catch or damage vapor control float.	✓		
C.2.11.2	Sampling Systems: Roof Sample Hatches			
	a) Inspect roof-mounted sample hatches for reinforcing pads and cracking.	✓		
	b) Inspect cover for operation.	✓		
	c) For tanks complying with Air Quality Monitoring District rules, inspect sample hatch covers for adequate sealing.		N/A	
	d) Check horizontal alignment of internal floating roof sample hatches under fixed roof hatches.		N/A	
	e) Inspect the sealing system on the internal floating roof sample hatch cover.	✓		
	f) Inspect floating roof sample hatch cover recoil reel and rope.		N/A	
C.2.11.3	SHELL NOZZLES			
	a) Inspect shell nozzles for thinning and pitting.	✓		
	b) Inspect hot tap nozzles for trimming of holes.		N/A	
	c) Identify type of shell nozzles.	✓		

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	d) Identify and describe internal piping, including elbow-up and elbow-down types.	✓		
C.2.11.4	For Nozzles Extended Into the Tank			
	a) Inspect pipe support pads welded to tank bottom.	✓		
	b) Inspect to see that pipe is free to move along support without strain or tearing action on bottom plate.	✓		
	c) Inspect nozzle valves for packing leaks and damaged flange faces.	✓		
	d) Inspect heater stream nozzle flanges and valves for wire cutting.		N/A	
	e) Report which nozzles have thermal pressure relief bosses and valves.	✓		
	f) In internal elbow-down fill line nozzles, inspect the wear plate on the tank bottom.		N/A	
	g) On elbow-up fill lines in floating roof tanks, check that opening is directed against underside of roof, not against vapor space. Inspect impact area for erosion.		N/A	
C.2.11.5	Diffusers and Air Rolling Systems			
	a) Inspect diffuser pipe for erosion and thinning.	✓		
	b) Check holes in diffuser for excessive wear and enlargement.		N/A	
	c) Inspect diffuser supports for damage and corrosion.	✓		
	d) Check that diffuser supports restrain, not anchor, longitudinal line movement.	✓		
	e) Inspect air spiders on bottom of lube oil tanks for plugging and damaged or broken threaded joints.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
C.2.11.6	SWING LINES			
	a) Inspect flexible joint for cracks and leaks.		N/A	
	b) Scribe the flexible joint across the two moving faces and raise end of swing line to check the joint's freedom of movement, indicated by separation of scribe marks.		N/A	
	c) Check that flexible joints over 6 in. are supported.		N/A	
	d) Inspect the swing pipe for deep pitting and weld corrosion.		N/A	
	e) Loosen the vent plugs in the pontoons and listen for a vacuum. Lack of a vacuum indicates a leaking pontoon.		N/A	
	f) Check the results of air test on pontoons during repairs.		N/A	
	g) Inspect the pontoons for pitting.		N/A	
	h) Inspect the pull-down cable connections to the swing.		N/A	
	i) Inspect the condition of the bottom-mounted support, fixed roof limiting bumper, or shell-mounted limiting bumper for wood condition, weld and bolt corrosion, and seal welding to bottom or shell.		N/A	
	j) Inspect safety hold-down chain for corrosion and weak links.		N/A	
	k) Check that there is a welded reinforcing pad where the chain connects to the bottom.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	l) If the floating swing in a floating or internal floating roof tank does not have a limiting device preventing the swing from exceeding 60 degrees, measure and calculate the maximum angle possible with the roof on overflow. Max. angle on overflow: _____. (If the calculated angle exceeds 65 degrees, recommended installation of a limiting bracket.)		N/A	
	m) Inspect pull-down cable for fraying.		N/A	
	n) Inspect for three cable clamps where cable attaches to end of swing line (single reeved) or to roof assembly (double-reeved). Inspect sheaves for freedom of movement.		N/A	
	o) Inspect winch operation and check the height indicator for legibility and accuracy.		N/A	
	p) Inspect bottom-mounted sheave assembly at end of pontoon for freedom of rotation of sheave.		N/A	
	q) Inspect shell-mounted lower sheave assembly for freedom of rotation of sheave, corrosion thinning, and pitting of sheave housing.		N/A	
	r) Inspect upper sheave assembly for freedom of movement of sheave.		N/A	
	s) Inspect the cable counterbalance assembly for corrosion and freedom of operation.		N/A	
C.2.11.7	MANWAY HEATER RACKS			
	a) Inspect the manway heater racks for broken welds and bending of the sliding rails.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	b) Measure and record the length of the heater and length of the track.		N/A	
C.2.11.8	MIXER WEAR PLATES AND DEFLECTOR STANDS			
	a) Inspect bottom and shell plates and deflector stands.		N/A	
	b) Inspect for erosion and corrosion on the wear plates. Inspect for rigidity, structural soundness, corrosion, and erosion of deck plates and reinforcing pads that are sealwelded to the bottom under the deflector stand legs.		N/A	
	c) Measure for propeller clearance between the bottom of deflector stand and roof when the roof is on low legs.		N/A	
C.2.12	ACCESS STRUCTURES			
C.2.12.1	HANDRAILS			
	a) Identify and report type (steel pipe, galvanized pipe, square tube, angle) and size of handrails.	✓	Pipe	
	b) Inspect for pitting and holes, paint failure.	✓		
	c) Inspect attachment welds.	✓		
	d) Identify cold joints and sharp edges. Inspect the handrails and midrails.	✓		
	e) Inspect safety drop bar (or safety chain) for corrosion, functioning, and length.	✓		
	f) Inspect the handrail between the rolling ladder and the gaging platform for a hazardous opening when the floating roof is at its lowest level.		N/A	
C.2.12.2	PLATFORM FRAME			

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
	a) Inspect frame for corrosion and paint failure.	✓		
	b) Inspect the attachment of frame to supports and supports to tank for corrosion and weld failure.	✓		
	c) Check reinforcing pads where supports are attached to shell or roof.		N/A	
	d) Inspect the surface that deck plate or grating rests on, for thinning and holes.	✓		
	e) Check that flat-surface-to-flat-surface junctures are seal-welded.	✓		
C.2.12.3	DECK PLATE AND GRATING			
	a) Inspect deck plate for corrosion-caused thinning or holes (not drain holes) and paint failure.	✓		
	b) Inspect plate-to-frame weld for rust scale buildup.	✓		
	c) Inspect grating for corrosion-caused thinning of bars and failure of welds.	✓		
	d) Check grating tie down clips. Where grating has been retrofitted to replace plate, measure the rise of the step below and above the grating surface and compare with other risers on the stairway.		N/A	
C.2.12.4	STAIRWAY STRINGERS			
	a) Inspect spiral stairway stringers for corrosion, paint failure, and weld failure. Inspect attachment of stairway treads to stringer.	✓		
	b) Inspect stairway supports to shell welds and reinforcing pads.	✓		
	c) Inspect steel support attachment to concrete base for corrosion.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
C.2.12.5	ROLLING LADDER		N/A	
	a) Inspect rolling ladder stringers for corrosion.		N/A	
	b) Identify and inspect ladder fixed rungs (square bar, round bar, angles) for weld attachment to stringers and corrosion, particularly where angle rungs are welded to stringers.		N/A	
	c) Check for wear and corrosion where rolling ladder attaches to gaging platform.		N/A	
	d) Inspect pivot bar for wear and secureness.		N/A	
	e) Inspect operation of self-leveling stairway treads.		N/A	
	f) Inspect for corrosion and wear on moving parts.		N/A	
	g) Inspect rolling ladder wheels for freedom of movement, flat spots, and wear on axle.		N/A	
	h) Inspect alignment of rolling ladder with roof rack.		N/A	
	i) Inspect top surface of rolling ladder track for wear by wheels to assure at least 18 in. of unworn track (track long enough).		N/A	
	j) Inspect rolling ladder track welds for corrosion.		N/A	
	k) Inspect track supports on roof for reinforcing pads seal-welded to deck plate.		N/A	
	l) Check by dimensioning, the maximum angle of the rolling ladder when the roof is on low legs. Max angle _____.		N/A	

API 653 Reference	Item	Completed	Findings	Comments/ Recommendations (No response indicates finding is acceptable)
m)	If rolling ladder track extends to within 5 feet of the edge of the roof on the far side, check for a handrail on the top of the shell on that side.		N/A	

Appendix E

Photographs



E1: General View of Tank



E2: General View of Tank



E3: General View of Secondary Containment



E4: General View of Secondary Containment



E5: General View of Secondary Containment



E6: General View of Secondary Containment



E7: General View of Secondary Containment



E8: Bottom Leak Detection Monitoring Well



E9: Cracks in Secondary Containment Floor



E10: Cracks in Secondary Containment Floor



E11: Cracks in Secondary Containment Floor



E12: Cracks in Secondary Containment Floor



E13: Secondary Containment Drain



E14: General View of Concrete Ringwall



E15: General View of Concrete Ringwall



E16: Ringwall-to-Chime Sealant Failure



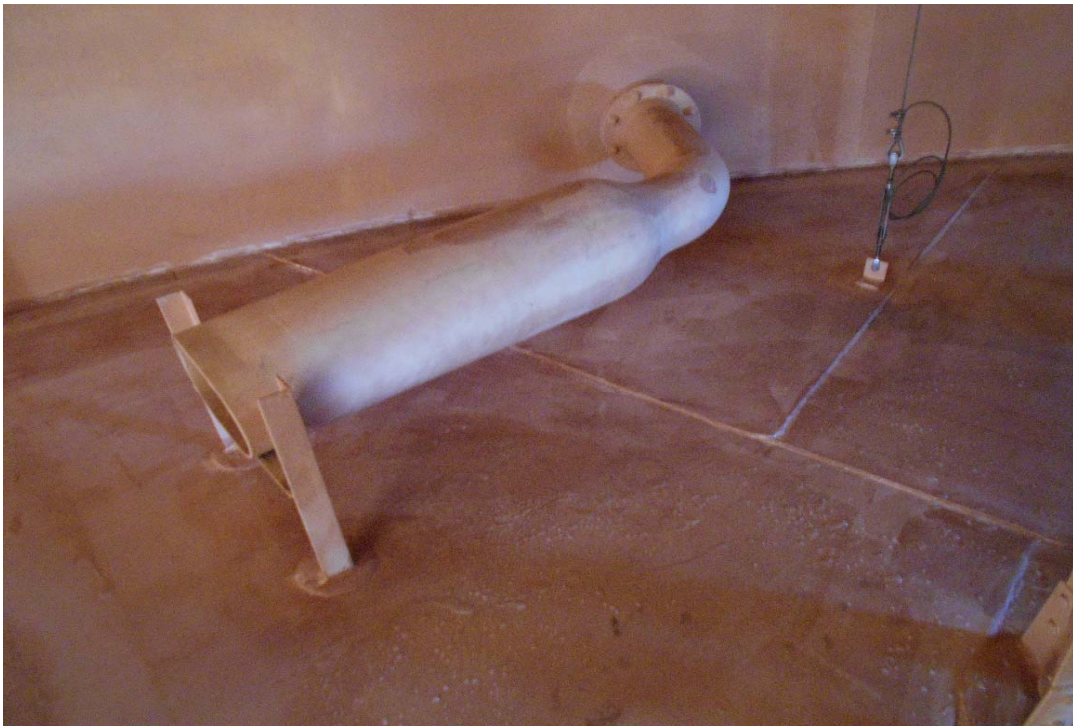
E17: General View of Bottom



E18: General View of Bottom



E19: General View of Issue Line and Drain Line



E20: General View of Diffuser



E21: Diffuser NOT Resting on Pipe Support



E22: General View of Floating Roof Striker Plate



E23: Sample Stilling Well Hard Bolted to Bottom



E24: ENRAF ATG Stilling Well Hard Bolted to Bottom



E25: Internal Ladder with Sample Stilling Well



E26: Bottom Sump Area



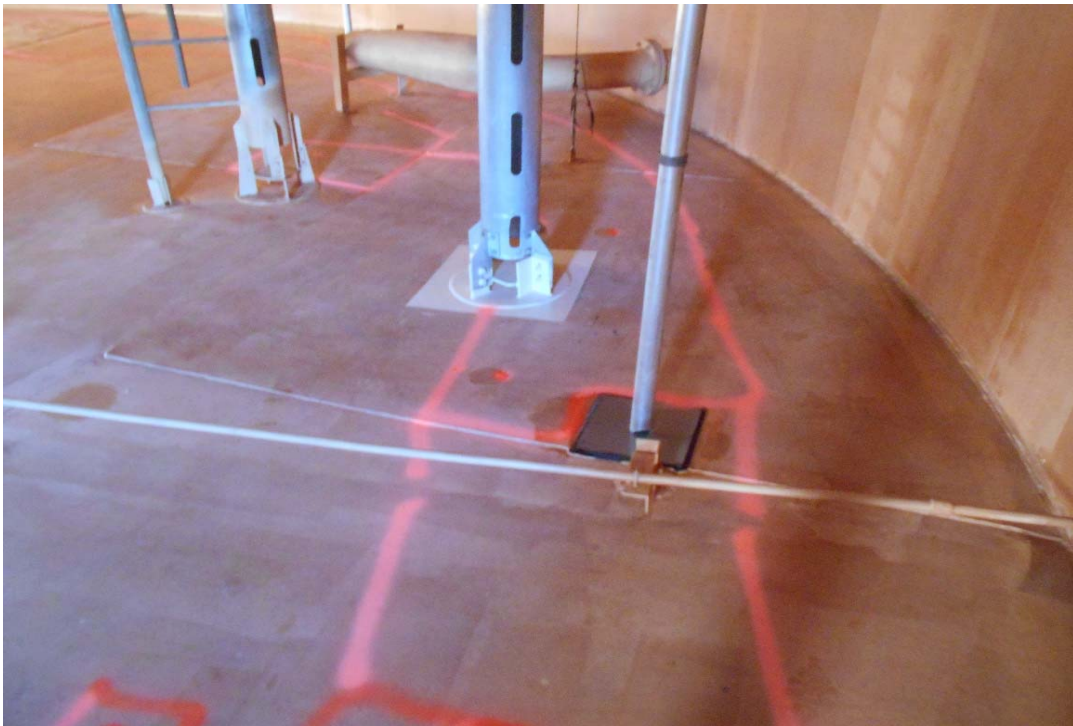
E27: General View of Heavy Underside Corrosion Band



E28: General View of Heavy Underside Corrosion Band



E29: General View of Heavy Underside Corrosion Band



E30: General View of Heavy Underside Corrosion Band



E31: General View of Heavy Underside Corrosion Band



E32: General View of Heavy Underside Corrosion Band



E33: Underside Corroded Areas Outside Corrosion Band



E34: General View of Tank Data Plate



E35: General View of Manway



E36: General View of Drain Nozzle



E37: General View of Issue Line Nozzle



E38: SAHND&JURS Manual Tape Level Gauge



E39: General View of Low Level Alarm Assembly



E40: General View of Manway



E41: General View of Product Saver Tank



E42: General View of Receipt Line Nozzle



E43: General View of High Level Control Assemblies



E44: High-High Level Alarm Assembly Drain without Blank on Flange



E45: General View of Circumferential Stairway Base



E46: General View of Circumferential Stairway



E47: General View of Underside of Circumferential Stairway



E48: Inadequate Stairway Clearance



E49: Deteriorated Floating Roof Foam Log Seal



E50: Deteriorated Floating Roof Foam Log Seal



E51: Deteriorated Floating Roof Foam Log Seal



E52: Deteriorated Floating Roof Foam Log Seal



E53: General View of Floating Roof



E54: General View of Floating Roof



E55: Deteriorated Floating Roof Foam Log Seal



E56: Deteriorated Floating Roof Foam Log Seal



E57: General View of Fixed Roof



E58: General View of Fixed Roof



E59: General View of Shell Circulation Vent/Inspection Hatch



E60: General View of Center Circulation Vent with VITO Water Probe



E61: General View of Access Hatch for Internal Ladder



E62: General View of Sample

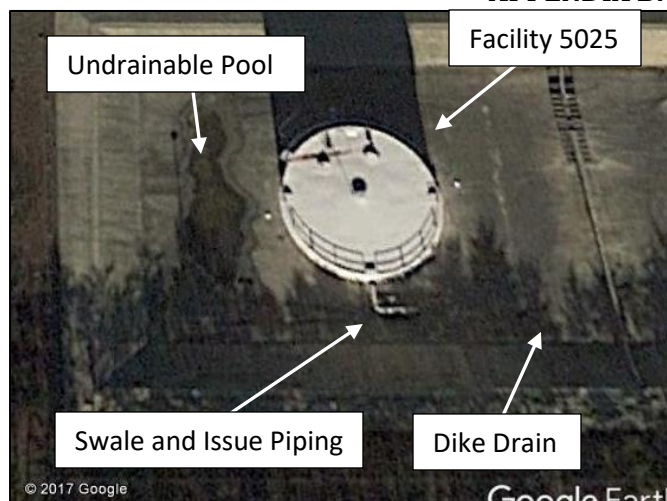


E63: General View of Fixed Roof

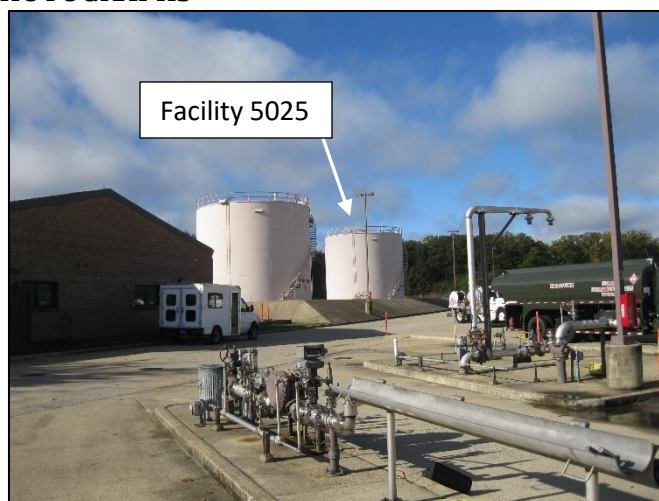


E64: General View of Underside of Fixed Roof

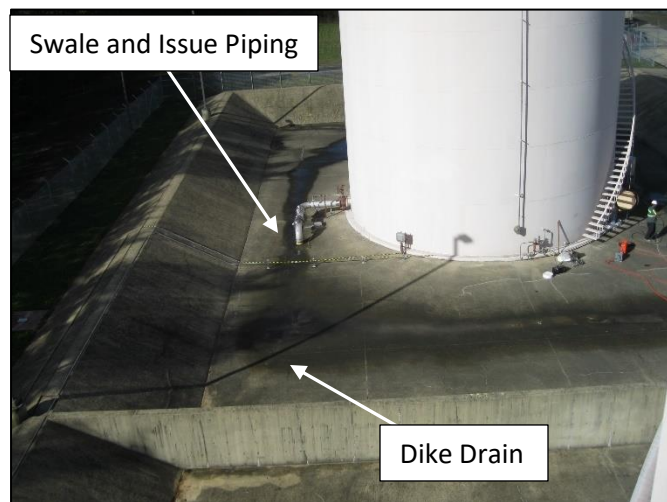
APPENDIX B: PHOTOGRAPHS



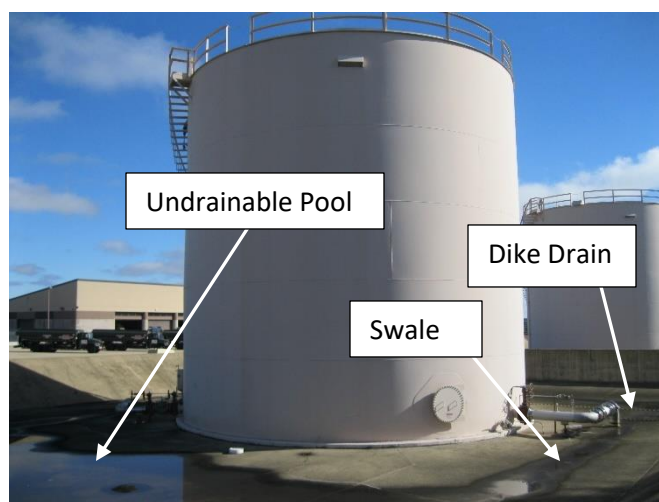
B.1: Google Earth View



B.2: View of Tank from the Northeast



B.3: View of Dike Area from East



B.4: Dike Basin Pond



B.5: Receipt Piping and Undrainable Pool



B.6: Damaged Leak Detection Well Cover



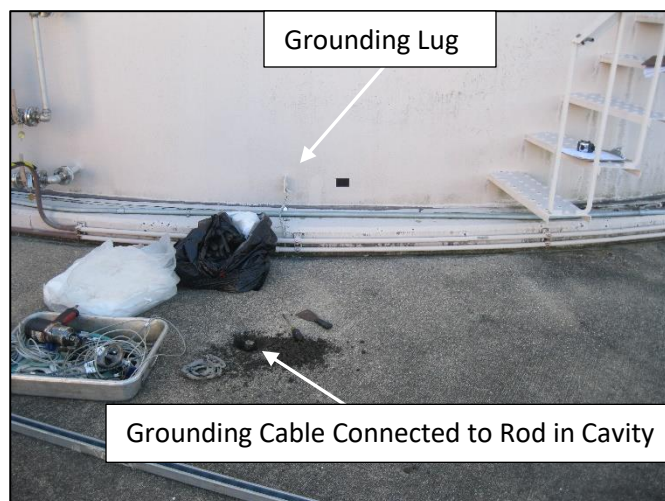
B.7: Algae on Underside of Manhole Neck



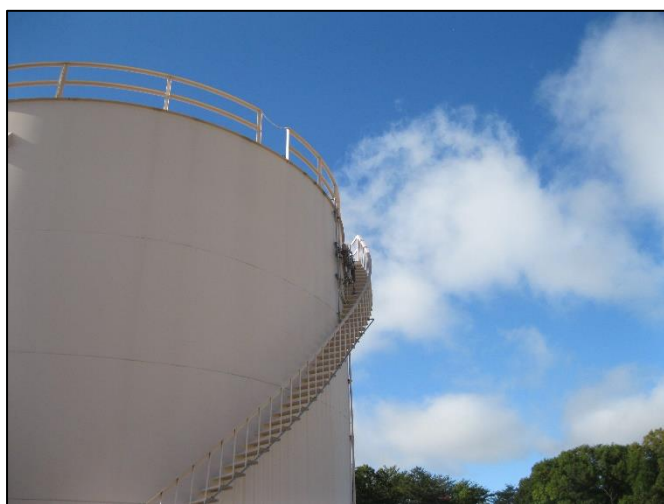
B.8: Sub Low Level Alarm



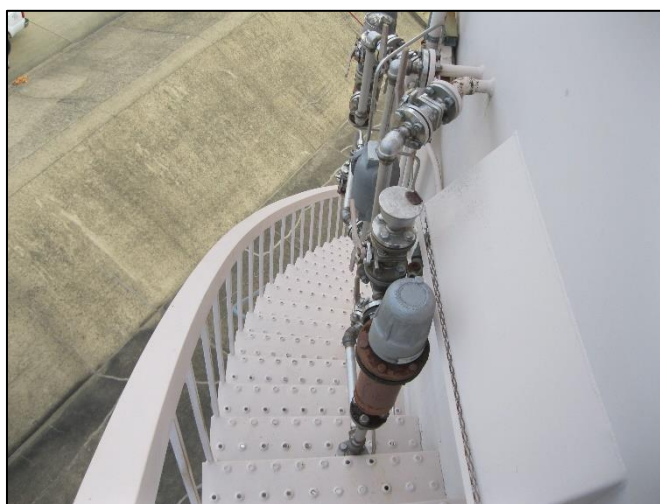
B.9: Ground Cable to Rod Connection in Cavity



B.10: Ground Rod Connection and Stairway



B.11: Upper Stairway Blocked by Alarm Chambers



B.12: Alarm and Control Chambers



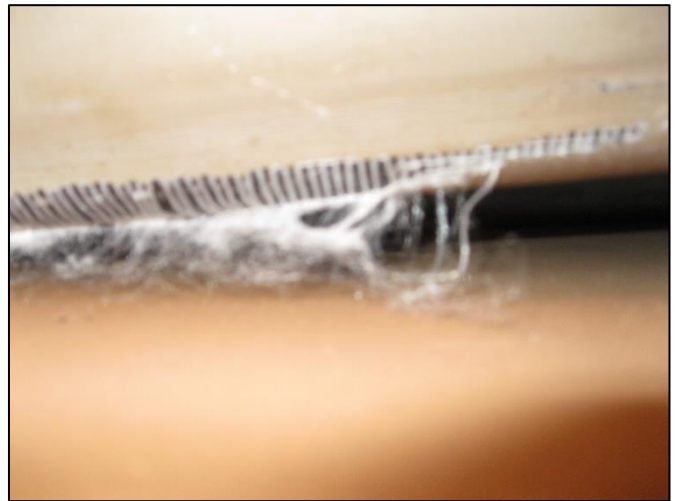
B.13: Floating Plug Retriever



B.14: Roof Center Vent and Vito Probe Box



B.15: Bottom Sump, Piping, and Vito Probe



B.16: Pan Primary Perimeter Seal



B.17: Anti-rotation Cable Connection to Tank Bottom



B.18: Underside of Tank Roof

APPENDIX C: DESIGN DRAWINGS