FINAL API 653 Inspection Report

PRL 03-12: Internal Inspection of Tank 6, Red Hill

FISC Pearl Harbor, Hawaii

Prepared for:

Air Force Center for Environmental Excellence Worldwide Environmental Restoration and Construction Contract
Contract Number: FA8903-04-D-8681
Task Order: 0176

January 2007

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29 January 2007

Ms. Kim Chang
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RE: Submittal of Final API 653 Inspection Report Internal Inspection of Tank 6 (PRL 03-12) FISC Pearl Harbor, Hawaii
FA8903-04-D-8681, Task Order Number 0176
(CDRL A001A and B010)

Dear Ms. Chang:

Please find the enclosed Final API 653 Inspection Report for the Internal Inspection of Tank 6 project. Hard and electronic copies of this submittal have also been forwarded to the recipients listed below. Please call me at (808) 275-2948, or email me at d.desario@WestonSolutions.com with any questions or comments.

Sincerely,

Daniel F DeSario

Jennifer L. Johnson

Weston Solutions, Inc.

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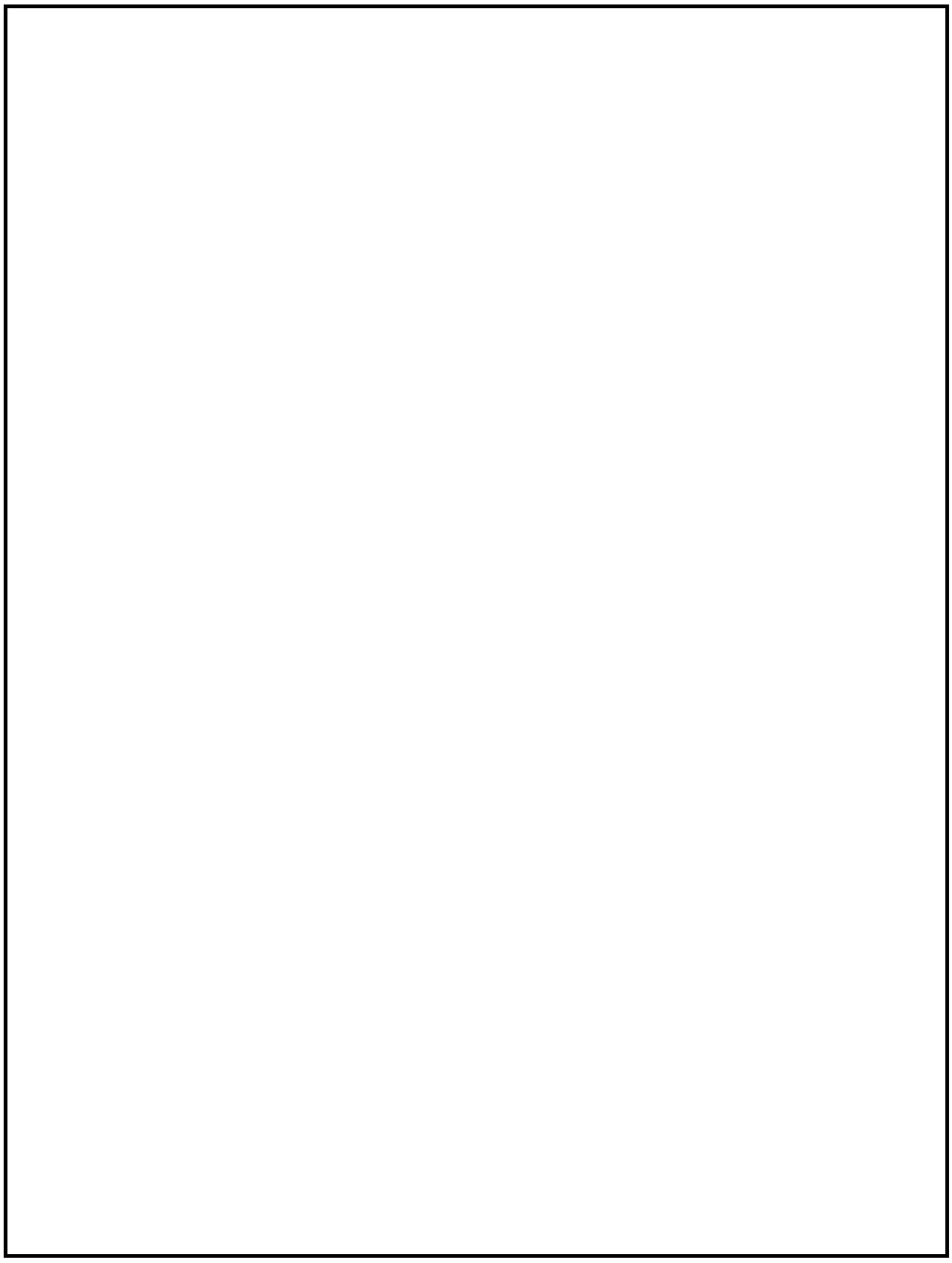
Enclosures
cc: AFCEE – MSCD (w/o att.)
FISC, Pearl Harbor, Terry Strack (2 copies)
Lisa Blandford
Program File
Project File



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Prepared By
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841 Bishop Street, Suite 2301
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ACCP	ASNT Central Certification Program
AFCEE	Air Force Center for Environmental Excellence
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non-Destructive Testing
ASTM	American Society for Testing and Materials
BFET	Balance Field Electromagnetic Technique
BPVC	Boiler and Pressure Vessel Code
DESC	Defense Energy Support Center
FISC	Fleet and Industrial Supply Center
LFET	Low Frequency Electromagnetic Technique
MT	Magnetic Particle (testing)
NDE	Non-Destructive Examination
PT	Liquid Penetrant (testing)
TO	Task Order
UT	Ultrasonic Thickness (testing)
VB	Vacuum Box (testing)
VT	Visual Inspection
WPS	Welding Procedure Specifications

Executive Summary

Under contract agreement (Contract No. FA8903-04-D-8681/0176) with the Air Force Center for Environmental Excellence (AFCEE), Weston Solutions, Inc. has prepared this Final API 653 Inspection Report for the Defense Energy Support Center's (DESC) Project PRL 03-12, Internal Inspection of Tank 6 in Red Hill. The facility is part of the Fleet Industrial Supply Center (FISC) Pearl Harbor, Hawaii.

Tank 6 was built in 1942 (completed 1943). Its nominal capacity is 302,000 barrels. The tank, like the others in Red Hill, is an underground concrete tank with a steel liner. The configuration is a vertical cylinder measuring 100 feet in diameter and 250 feet in height. The tank is domed on the lower and upper ends.

This inspection task consisted of an out-of-service, modified API 653 inspection of Tank 6 in Red Hill. The work included nondestructive examination (NDE) and evaluation of data for the upper dome (courses A, B, C, D, E, and F), the extension, the area under the catwalk, the barrel, the lower dome (courses 1, 2, 3, and 4), and the bottom. Eighty percent of the entire tank area underwent NDE, including 100% of the barrel and extension.

Hand held electromagnetic scanners were used for NDE of the steel liner plates of the tank. When defects/flaws were found, then ultrasonic thickness (UT) measurements were taken to establish actual thicknesses in these areas. Welds were inspected with eddy current probes. When defects/flaws were found, then shear wave (angle beam) ultrasonic testing was performed to establish the remaining thickness at the weld flaw locations.

Based on the information gathered during the inspection of Tank Nos. 15 and 16 the corrosion rate has been calculated to be 0.0045 inches per year. Applying this repair threshold to the 684 defects/flaws detected in Tank 6 results in a requirement / recommendation that approximately 476 defects/flaws be repaired for a twenty year re-inspection cycle. An abbreviated summary of the required/recommended repairs of the tank shell/liner is as follows:

Weld Repairs – 268 Patch Plates - 193 (200 flaws) Coating Repair Only - 8

Upon successful completion of the recommended repairs, the next internal and UT inspection of Tank 6 should be performed no later than 3 May 2026. The overall effectiveness of the Dunkin & Bush, Inc. repairs appeared to have satisfactorily addressed flaws detected in Tank 6. Repairs were performed in accordance with the recommendations.

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1.0 INTRODUCTION

Under contract agreement (Contract No. FA8903-04-D-8681/0176) with the Air Force Center for Environmental Excellence (AFCEE), Weston Solutions, Inc. has prepared this Final API 653 Inspection Report for the Defense Energy Support Center's (DESC) Project PRL 03-12, Internal Inspection of Tank 6 in Red Hill. The facility is part of the Fleet Industrial Supply Center (FISC) Pearl Harbor. Weston Solutions, Inc. is/was under contract to perform a modified API 653 Inspection, develop new calibration tables, and install a datum plate.

The Red Hill Fuel Facility is located on the island of Oahu, Hawaii and is used to store fuel in support of military operations on Oahu, in the mid-Pacific area, and other areas as required. The site is located within the ridgeline between South Halawa Valley and Moanalua Valley. The site is built into the ridgeline, encasing a network of 20 subterranean tanks. Access to the facility is through secure Navy property, and access to the fuel tanks and piping is by elevator and the upper and lower tunnels.

Tank 6 was built in 1942 (completed in 1943). Its nominal capacity is 302,000 barrels (listed as 302,286 barrels). The tank, like other tanks in Red Hill, is a concrete tank with a steel liner. The configuration is a vertical cylinder measuring 100 feet in diameter and 250 feet in height. The tank is domed on the lower and upper ends. The primary access point to the tank is from the upper tunnel which is at the 200 foot level of the tank. The tank has a center tower extending from the top to the bottom that is connected to the access point by a catwalk. Cleaning, inspection, and repair of the shell liner (including the domes) are made possible by boom suspended scaffolding that is operated from the center tower and the suspended baskets.

This API 653 Inspection Report outlines the inspection approach, the evaluation methodology, and the findings/recommendations.

Inspection Approach

This inspection task consisted of an out-of-service modified API 653 inspection of Tank 6 in Red Hill. The work included evaluation of Courses A, B, C, D, E, and F of the upper dome, the extension, the area under the catwalk, 100% of the barrel, courses 1, 2, 3, and 4 the lower dome, and the bottom.

Electromagnetic inspection/testing was followed by Ultrasonic Thickness (UT) measurement prove-ups. The electromagnetic inspections utilized hand scanners capable of low frequency electromagnetic technique (LFET) for the shell liner and balance field electromagnetic technique (BFET) on the welds.

Hand held electromagnetic scanners were used to test the steel liner plates of the tank. When defects/flaws were found, then UT measurements were taken to establish actual thicknesses in these areas. Welds were inspected with BFET eddy current probes. When defects/flaws were

found, then shear wave ultrasonic testing was performed to establish the remaining thickness at the weld flaw locations. Furthermore, the cover plates covering the joints and backing bars throughout the extension and upper dome were UT measurement tested every foot. Existing patch plates located throughout the tank were UT measurement tested.

Evaluation Methodology

API 653 can be implemented when the tank design/construction is in accordance with API 650 or API 12C and the tank is aboveground. Tank 16 is an underground concrete tank with an internal steel liner. Due the design / construction of the tank all of the principles and checklists provided in API 653 cannot be used for this tank inspection. For example, the steel liner which is interlocked or embedded to the concrete acts as a barrier between the product and the concrete 'shell'. Since Tank 6 is not a free-standing aboveground storage tank, the API 653 calculations evaluating the minimum shell thickness is not applicable to evaluate the steel liner. However it is feasible to implement the API 653 calculations for minimum bottom plate thickness to evaluate the steel liner located throughout the barrel, expansion joint, extension, domes, and bottom. Therefore, for this inspection the applicable portions of API 653 have been utilized, resulting in a modified API 653 inspection.

A review of available historical information was performed. Visual inspection/evaluation of existing conditions throughout the tank was also conducted. Inspection of the 32" inlet/outlet line and visual inspection of the tank bottom were also performed.

Recommendations

The findings (defects/flaws) are listed in table format, depicted in photographs when applicable, and discussed as necessary. The recommendations are based on the evaluation of the data and the principles of API 653. In areas where the principles of API 653 do not apply, decisions were made based on sound engineering judgment.

Recommendations of required repairs were submitted for government review and approval on 18 May 2007. Dunkin & Busch performed the repairs.

2.0 PRELIMINARY API 653 INSPECTION

2.1 LFET SHELL AND BFET WELD SCANNING AND UT MEASUREMENTS

The scanning and testing effort, beginning on March 27, 2006 and completing on May 2, 2006, consisted of scanning by TesTex, Inc. under contract to Weston Solutions, Inc. This scanning was performed on Courses A, B, C, D, E, F (upper dome), the extension, the area under the catwalk, 100% of the barrel, courses 1, 2, 3, and 4 of the lower dome, the bottom, and UT measurements on the 32" and 18" inlet/outlet lines.

The scanning was performed using the TesTex developed *TS-2000 NDT Multichannel System* for plate scanning and the principles of the LFET. The *Hawkeye Digital Inspection System* was used for weld scanning. Shear wave ultrasonic thickness measurement equipment was used to further evaluate weld flaws. A total of 684 defects/flaws were located during this inspection/testing effort.

The TesTex, Inc. report for the inspection/testing effort is provided in Appendix A. Photographs depicting conditions of certain features in the tank as well as the scanning task are provided in Appendix B.

2.2 API 653 EVALUATION

History

Tank 6 was built in 1942 (completed in 1943). Its nominal capacity is 302,000 barrels. The tank is a concrete tank with a steel liner. The configuration is a vertical cylinder measuring 100 feet in diameter and 250 feet in height (internal). The tank is domed on the lower and upper ends. The primary access point to the tank is from the upper tunnel which is at the 200 foot level of the tank. The nominal plate thickness is ¼-inch throughout the upper dome, extension, barrel, and lower dome the nominal plate thickness on the bottom is ½-inch. The tank was coated in the early 1980s with a thin film polyurethane coating.

The tank history information (Appendix C) indicates that the tank developed its first potential leak from a location on the collector ring. This potential leak was discovered and repaired on July 23, 1952.

In 1963 suspect leaks in the telltale system were addressed by smoke tracer testing, pressure testing, and physical repairs. The telltale systems in the Red Hill tanks were actually problematic and created releases from the tank into the telltale system. The telltale system in Tank 6 was removed and the openings created by the removal were closed with lap patch plates.

The interior of the tank was coated during a contract repair cycle in 1981 and 1982. No specific details regarding other potential repairs performed at that time are available.

Along with the patch plates used to close the telltale system, interspersed patch plates were also found adjacent to and on welds of the shell liner. These patch plates located near or on welds do not indicate backside corrosion so much as they were likely repairs to the welds themselves. There is no documented information that would indicate that back side corrosion has resulted in a through hole in the tank. However, there is a possibility that backside corrosion resulted in a through hole that was subsequently repaired during the 1998 repair cycle.

Repair Threshold for Plate and Weld Flaws

While this inspection revealed no definitive evidence of a backside corrosion resulting in a through hole, as a conservative measure the corrosion rate/repair threshold that was used for Tanks 15 and 16 has been applied to this tank. This results in a calculated corrosion rate of 0.0045 inches per year based on a suspected backside corrosion through hole in 1998 (0.25 in / (1998-1943)). This rate establishes a 20 year internal inspection interval resulting in a minimum remaining plate thickness of 0.1 inches with a ***repair threshold of 0.190 inches since an internal coating system is in-place to eliminate internal corrosion.***

The following information was used to determine the corrosion rate and repair threshold:

Nominal Shell (steel liner) Thickness		0.25 inches
Minimum Remaining Thickness at Or	MRT	0.1 inches
In-service Interval of Operation	Or	20 years

Year of Construction		1943 year
Year of Inspection (underside corrosion extends through full thickness)		1998 year
Maximum Corrosion Rate (underside)	UPr	0.0045 inches/year

Minimum Remaining Thickness (after repairs) 0.190 inches

Applying this repair threshold to the 684 defects/flaws detected, results in a requirement / recommendation that approximately 476 defects/flaws be repaired. Of the 476 flaws, 200 will require repair by the installation of 193 patch plates. Several patch plates will be used to repair multiple flaws. Another 268 flaws will require weld repair. The remaining eight flaws require coating repair only. An additional 57 flaws detected could not be tested by straight or angle beam UT to determine the remaining thickness due to their locations. These flaws should be tested by vacuum box. There are two locations that will require magnetic particle (MT) testing. The Patch Plate and Weld Repair Summary is provided as Table 2-1. Repair sketches are provided in Appendix D.

32-inch Inlet/Outlet Line

The 32-inch line from the internal flange to the 20-inch flange in the lower tunnel was pressured tested by Dunkin & Bush, Inc. at 150 PSIG and pressure loss was observed. A leak was noted on the weld on the underside of the tunnel side flange. This leak requires repair and follow-up non-destructive examination (NDE). The evaluation of the tank also included observations of the internal portion of the 32-inch inlet/outlet line. The observation revealed that portions of the circumferential butt welds have incomplete penetration. The circumferential butt welds on the 32-inch line that have incomplete penetration require repair (see repair sketches in Appendix D). There is an unused ¾-inch pipe inside the 32-inch line. The ¾-inch pipe and the internal supports should be removed and the internal opening should be seal welded. After all required repairs and NDE, the 32-line will need to be pressure tested again. The repairs were completed.

18-inch Inlet/Outlet line

There is an 18-inch inlet/outlet line on the bottom of the tank. The line from the internal flange to the 12-inch flange in the lower tunnel was pressured tested by Dunkin & Bush, Inc. at 150 PSIG for 4 hours and no pressure loss was observed. The supports and reinforcing plate are corroding, are undersized, and were constructed in a manner that produced angles that cannot be easily coated. The pipe supports and reinforcing pads (2 each) for the 18-inch line should be repaired by replacement. The repair was completed.

Four ¾-inch Sample Lines and 4-inch Slop (water draw-off) Line

The 4 x ¾-inch sample lines were pressure tested at 150 PSIG for 4 hours and pressure loss was observed in one sample line. It is recommended that all four sample lines be replaced to complete this required repair (see repair drawing in Appendix D). The sample lines were replaced as recommended. The 4-inch slop line failed to maintain pressure during the pressure test and was repaired.

Coating Evaluation

The coating throughout the lower dome will require repair. Isolated locations where the coating has failed in the upper dome will require repair. All patch plate and weld repair locations will require coating repair. Grout nozzles located in the extension and upper dome that are not scheduled for repair will require evaluation for possible coating repairs.

Strapping and Installation of a Datum Plate

Weston Solutions, Inc. retained Gauge Point Calibration to develop calibrated capacity tables for the Tank (Appendix E). The total capacity was determined to be 301,491.58 barrels. WESTON retained Dunkin & Bush, Inc. to install a datum plate on the bottom beneath the mass tank gauge (MTG) probe.

Repair Inspections

Weston Solutions, Inc. re-visited Tank 6 on several occasions to clarify repair recommendations and evaluate the repair process. The following summarizes the additional/follow-up inspections performed by Weston Solutions, Inc.:

Flaw No. 30

On June 27, 2006 Weston Solutions, Inc. re-visited Tank 6 to clarify the recommendation on how to repair Flaw No. 30. During the process of the repairs the welder had noted an eight inch crack running through the center of the weld. The repair was recommendation was modified to include the installation of a tombstone shaped patch plate after the recommended repair was completed. Repairs were completed in accordance with the recommendations.

Flaw No. 547

On August 23, 2006 Weston Solutions, Inc. re-visited Tank 6 to clarify the recommendation on how to repair Flaw No. 547. During the repair process it was noted that existing weld to new weld spacing would be better served by the use of a tombstone shaped patch plate. The recommendation was changed from an eight inch round patch plate to an eight tombstone patch plate. The repair was completed in accordance with the recommendations.

Furthermore, during the Weston Solutions, Inc. re-visits to Tank 6, the Dunkin & Bush, Inc. repair efforts were qualitatively evaluated when required for clarification of recommendations. All repairs performed on the tank underwent non-destructive examination (NDE). If a repair failed the NDE, the repairs were reworked until it passed the NDE. Dunkin & Bush, Inc. reported that they maintained a log of all repairs made, NDE performed, and re-work required.

Weston Solutions, Inc. visually inspected the repair work and found the workmanship to be of an acceptable quality (satisfactory). This is reasonable given the complexity of performing tank repairs in Red Hill, i.e. making repairs from suspended scaffolding. The overall difficulty of the task of completing the repairs does not lend itself to regularly achieving exceptional workmanship results.

2.3 FINDINGS/RECOMMENDATIONS

1. Install 193 patch plates to repair 200 flaws as listed on Table 2-1 Patch Plate and Weld Repair Summary. The patch plates shall be ASTM A-36 carbon steel. Install patch plates with toe-to-toe weld spacing as indicated on repair sketches, noted on the summary table, and in accordance with the requirements of API 653 when the sketches and summary table are not specific. Patch plates shall be examined/tested by vacuum box, liquid penetrant, and visual methods in accordance with written procedures complying with ASME BPVC Section V, AWS, and/or API 650.

2. Perform 268 weld repairs on weld flaws as listed in Table 2-1, Patch Plate and Weld Repair Summary. Weld repairs shall be examined by vacuum box, liquid penetrant, and visual methods.

3. Perform eight additional coating repairs as listed in Table 2-1, Patch Plate and Weld Repair Summary.

4. Perform vacuum box testing on 57 flaws as listed in Table 2-1, Patch Plate and Weld Repair Summary.

5. Perform MT testing at two locations as listed in Table 2-1, Patch Plate and Weld Repair Summary.

6. Repair by replacing the supports and reinforcing plates (2 each) for the 18-inch inlet/outlet line. Shop drawings are to be prepared, provided, and approved prior to the completion of the repair. Reinforcing plate welds shall be examined by vacuum box, liquid penetrant, and visual methods.

7. Perform weld repair on approximately 40 feet of circumferential butt weld on the inside of the 32-inch inlet/outlet line to correct the lack of penetration condition. Repair the leak on the weld on the underside of the tunnel side flange per the repair sketch in Appendix D. The internal ¾-inch pipe and the internal supports should be removed and the internal opening should be seal welded. After all required repairs and NDE the 32-line will need to be pressure tested again. The weld repairs shall be examined/tested by the liquid penetrant and visual methods.

8. Repair the ¾-inch sample line(s) per the repair drawing in Appendix D.

9. The coating in the tank should be repaired in accordance with a NACE inspector's or coating specialist's recommendations (not necessarily re-coated entirely). A coating present on the interior surface allows for the exclusion of stock side corrosion rate when calculating an operational life for the tank. Patch plates, weld repairs, most of the lower dome, and portions of the upper dome will require coating repair. Grout nozzles located in the extension and upper dome that are not scheduled for repair will require evaluation for possible coating repairs.

The repair contractor shall utilize Welding Procedure Specifications (WPS) proven by Procedure Qualification Records (PQR). Welders shall be certified in accordance with ASME Boiler and Pressure Vessel Code (BPVC) Section IX.

In accordance with API 650 and ASME BPVC Section V non-destructive examination (NDE) technicians/examiners shall be certified per: (1) SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing; or (2) ANSI/ASNT CP-189, ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel; or (3) ACCP, ASNT Central Certification Program.

2.4 CONCLUSIONS

Upon successful completion of the recommended repairs, the next internal and UT inspection of Tank 6 should be performed no later than 3 May 2026. The overall effectiveness of the Dunkin & Bush, Inc. repairs appeared to have satisfactorily addressed flaws detected in Tank 6. Repairs were performed in accordance with the recommendations.