Final API-653 Inspection Report

PRL 99-21: Clean, Inspect, and Repair Tank 15, 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

Weston Solutions, Inc.
841 Bishop Street
Suite 2301
Honolulu, Hawaii 96813
808-275-2900 • Fax 808-585-7378

30 January 2007

Ms. Kim Chang
AFCEE IWE
25 E. Street, Suite E-317
Hickam AFB, HI 96853

RE: Submittal of Final API-653 Inspection Report
Clean, Inspect, and Repair Tank 15 (PRL 99-21)
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 Clean, Inspect, and Repair Tank 15 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,
Weston Solutions, Inc.

Daniel F. DeSario
Project Manager
API 653 Inspector – No. 24570
API 570 Inspector – No. 27637

Jennifer Johnson, PE
Fuel System Services, Technical Manager
API 653 Inspector – No. 24694
API 570 Inspector – No. 25784

Enclosures
cc: AFCEE – MSCD (w/o att.)
FISC, Pearl Harbor, Terry Strack (3 copies)
Lisa Blandford
Program File
Project File

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Prepared By
Weston Solutions, Inc.
841 Bishop Street, Suite 2301
Honolulu, HI 96816

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LIST OF ACRONYMS

AFCEE	Air Force Center for Environmental Excellence
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
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)
PT	Liquid Penetrant (testing)
TO	Task Order
UT	Ultrasonic Thickness (testing)
VB	Vacuum Box (testing)
VT	Visual Inspection

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 Defense Energy Support Center (DESC) Project PRL 99-21 Clean, Inspect, and Repair Tank 15 in Red Hill. The facility is part of the Fleet Industrial Supply Center (FISC) Pearl Harbor.

Tank 15 was built in 1942 (completed in 1943). Its nominal capacity is 302,000 barrels (listed as 302,536 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 task consisted of the continuation of an out-of-service, modified API 653 inspection of Tank 15 in Red Hill, initiated through another contracting mechanism. The work included non-destructive examination (NDE) and evaluation of the data for the upper dome (courses A, B, C, D, E, and F), the extension, the area under the catwalk, barrel, the lower dome (courses 1, 2, 3 and 4), and the bottom. Eighty-three percent of the entire tank area underwent NDE, including 100% of the tank barrel and extension. Inspection for the tank bottom and lower dome were done under a separate contract prior to Weston's involvement.

Hand held electromagnetic scanners were used to test 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 15 the corrosion rate has been calculated to be 0.0045 inches per year. Applying this repair threshold to the 198 defects/flaws detected, results in a requirement / recommendation that approximately 109 defects/flaws be repaired for a twenty year re-inspection cycle. An abbreviated summary of the required/recommended repairs on the tank shell/liner is as follows:

Weld Repairs – 31 Patch/Insert Plates – 58 (78 flaws)

Upon successful completion of the recommended repairs, the next internal and UT inspection of Tank 15 should be performed no later than 25 August 2025. The overall effectives of the Dunkin & Bush, Inc. repairs appeared to have satisfactorily addressed flaws detected in Tank 15. 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 Defense Energy Support Center (DESC) Project PRL 99-21 Clean, Inspect, and Repair Tank 15 in Red Hill. The facility is part of the Fleet Industrial Supply Center (FISC) Pearl Harbor. Weston Solutions, Inc. 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 15 was built in 1942 (completed in 1943). Its nominal capacity is 302,000 barrels (listed as 302,536 barrels). The tank, like the others 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 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 task consisted of the continuation of an out-of-service, modified API-653 inspection of Tank 15 in Red Hill, initiated through another contracting mechanism. The work included evaluation of courses A, B, C, D, E, and F of the upper dome, the extension, the area under catwalk, barrel, and the lower dome (courses 1, 2, 3 and 4). Inspection for the tank bottom and lower dome were done under a separate contract prior to Weston's involvement.

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 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. Certain weld flaws were also inspected using the vacuum box method. UT testing of all of the 3-inch grout nozzles performed.

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 15 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 15 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 history information was performed. Visual inspection/evaluation of existing conditions throughout the tank was conducted. Inspection of the 32" inlet/outlet line and visual inspection of the tank bottom were also performed. Reviews of the initial inspection (scanning and UT testing) conducted in January 2005 and the subsequent repairs 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 28 September 2005. Dunkin & Bush, Inc. performed the repairs.

2.0 FINAL API 653 INSPECTION

2.1 LFET SHELL AND BFET WELD SCANNING AND UT MEASUREMENTS

Initially, a random inspection was conducted on Tank 15 from January 17th to the 28th, 2005. The percentage of the tank inspected at that time was considered to be 11% and a total of 89 defects/flaws were found. This work was performed by TesTex, Inc. under contract to Thermal Engineering Corp.

The subject scanning and testing effort, beginning on July 25 and completing August 25, 2005, consisted of a continuation of the scanning by TesTex, Inc. under contract to Weston Solutions, Inc. This continuation included evaluation of courses A, B, C, D, E, and F of the upper dome, the extension, the area under the catwalk, barrel, courses 1, 2, 3 and 4 of the lower dome, and UT measurements on the 18" and 32" inlet/outlet lines. Inspection for the tank bottom and lower dome were done under a separate contract prior to Weston's involvement.

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 198 defects/flaws were located during this inspection/testing effort.

The TesTex, Inc. report for the subject 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 ELVAULATION

History

Tank 15 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 leaked badly on July 19, 1981 shortly after being put back into service after approximately one year of cleaning, inspection, and repair work. No information, other than the leak was likely at the 185' level, is provided in the tank history information document. A detailed visual inspection of the 185' level and the

expansion joint (186.5' to 188') level was performed in an effort to possibly determine the repairs made at that time. Notable observations made during this particular inspection included what appears to be the repair of approximately three feet of vertical weld at the 185' level, a patch plate on the underside of the expansion joint, and the repair of an expansion joint vertical weld. No conclusions were drawn other than the leak was eventually repaired.

The telltale system that was previously located in the tank has been removed and the openings created by the removal were closed with lap patch plates. 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.

In 1997/1998 the tank was inspected, repaired, and returned to service. There is no documented information that would indicate that back side corrosion has resulted in a through hole in the tank prior to 1998. However, due to the repairs made in 1998 on the flaws detected during that inspection, it is feasible that back side corrosion had resulted in a through hole in the 1998 timeframe.

Repair Threshold for Plate and Weld Flaws

A documented through hole in the tank resulting from underside corrosion establishes the corrosion rate. The suspected through hole in 1998 will be used to establish the corrosion rate. The calculated corrosion rate is 0.0045 inches per years (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 198 defects/flaws detected, results in a requirement / recommendation that approximately 109 defects/flaws be repaired. Of the 109 flaws, 78 will require repair by the installation of 58 patch plates. Several patch plates will be used to repair multiple flaws. The remaining 31 flaws will require weld repair. The Patch Plate and Weld Repair Summary are 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 for 4 hours and no pressure loss was observed. The evaluation of the tank included observations of the internal portion of the 32-inch inlet/outlet line. The observation revealed that portions of the circumferential butt weld have incomplete penetration. The circumferential butt welds on the 32-inch line that have incomplete penetration require repair (see repair sketches in Appendix D). A photograph of the incomplete penetration is provided in Appendix B.

Anchors, Clips, and Angles

Inspection of the bottom of the tank revealed the presence of elevator attachments including three anchors for the step and platform, four anchors for elevator cables, and two angles that previously acted as a stopping point for the elevator. An additional eight anchors/clips, for other tank appurtenances that are no longer present, are also located on the bottom of the tank. History information on the tank indicates that a telemeter system was previously installed in the tank which served as the automatic tank gauging (ATG) system. It is believed that some of the additional eight anchors/clips were previously used to for the telemeter system which is no longer present. The available tank history information is provided in Appendix C. All unused anchors, clips, and angles require proper removal from the tank. The recommended repair was 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 are not easily coated. The pipe supports and reinforcing pads (2 each) for the 18-inch 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 no pressure loss was observed. The 4-inch slop line failed to maintain pressure during its pressure test and was repaired.

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 304,775.68 barrels. Weston Solutions, Inc. retained Dunkin & Bush, Inc. to install a datum plate on the bottom beneath the mass tank gauge (MTG) probe.

3-inch Grout Nozzles

There are approximately 306 3-inch grout nozzles located throughout the tank. The general position of these nozzles are as follows:

Upper Dome – 43, Extension – 109, Barrel – 51, Lower Dome – 103

The nozzles are closed on the end by a ¼-inch round steel plate welded to the end of the nozzle. The nominal wall thickness is apparently schedule 40 which is equal to approximately 0.226 inches. This thickness is less than the nominal thickness of the steel shell liner of the tank. Approximately half way through July/August 2005 inspection/testing effort it became evident that UT measurements should be obtained to evaluate the wall thicknesses of the nozzles. On August 8th the inspection/testing of the tank began including UT measurements on the 3-inch grout nozzles. The nozzles located on the portion of the tank already inspected and throughout the lower dome were not UT tested as the majority of the lower dome was inspected/tested during the January 2005 effort. It is estimated that 50% of the grout nozzles in the barrel and all the nozzles in the lower dome have not been UT tested. All remaining nozzles, approximately 130, should be UT tested. The shell to nozzle weld should also be checked with an eddy current probe (*Hawkeye*). If flaws are found in the shell to nozzle weld the flaw should be further evaluated using shear wave ultrasonic thickness measurement equipment. The recommended testing was completed.

Results from this testing revealed that numerous nozzles had varying levels of corrosion or coating failure present. A qualitative inspection of the condition of the coating on the nozzles was performed. The level of coating failure on the nozzle was considered to be one of the following qualitative ratings. It should be noted that these qualitative ratings were relative to these nozzles only.

No observed failure – 166 nozzles

Minor coating failure (few small blisters) – 56 nozzles

Moderate coating failure (many small blisters) – 51 nozzles

Moderate-to-severe failure (blisters with rust stains) – 22 nozzles

Severe failure (many blisters with rust stains and/or cracked coating) – 11 nozzles

Table 2-2 Grout Nozzle Condition Summary, lists the findings of this qualitative inspection. Grout nozzles with no observed coating failure are not listed on the table. The coating failures on the 3-inch grout nozzles should be repaired in accordance with a NACE inspector's or coating specialist's recommendations. Nozzles with moderate-to-severe or severe ratings should also be vacuum box tested after the failed coating is removed. The nozzle coating and testing recommendations were completed; required repairs resulting from the vacuum box testing is discussed in paragraph entitled Repair Inspections.

Repair Inspections

Weston Solutions, Inc. re-visited Tank 15 on numerous occasions to complete additionally recommended testing, clarify repair recommendations, and evaluate the repair process. The following summarizes the additional/follow-up inspections performed by Weston Solutions, Inc.:

3-inch Grout Nozzles

On December 8, 2005 Weston Solutions, Inc. re-visited Tank 15 to complete additionally recommended UT testing on the 3-inch grout nozzles. Of the remaining nozzles (approximately 130) inspected, 23 had underside corrosion flaws detected. Of the 23 flaws, 5 are considered repairable as the remaining wall thickness in these nozzles was found to be below 0.190 inches. These 23 flaws have been added to the Patch Plate and Weld Repair Summary. These additional flaws were repaired per the recommendations.

On December 19, 2005 Weston Solutions, Inc. re-visited Tank 15 to assist Dunkin & Bush, Inc. in determining which grout nozzles will require coating repair since all UT testing on the nozzles had been completed. A total of 112 x 3-inch nozzles were observed with varying degrees coating failure that require repair. The locations of the nozzles are as follows: lower dome – 82, barrel – 28, extension – 2, and upper dome – 0. The repair should include the proper appropriate surface preparation. The coating material should be a flexible Novalac epoxy coating. The recommended coating repairs were performed.

32-Inch Inlet/Outlet Nozzle

On December 29, 2005 Weston Solutions, Inc. re-visited Tank 15 to clarify the recommendation on how to repair the flaws in the 32-inch nozzle. The inside of the nozzle was re-inspected and a sketch was produced to illustrate the repair locations (Appendix D). The recommended repairs were completed.

2.3 FINDINGS/RECOMMENDATIONS

1. Install 58 patch plates to repair 78 flaws as listed on Table 2-1 Patch Plate and Weld Repair Summary. The patch plates shall be ASTM A-36 carbon steel rolled to the nominal radius of the tank. 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 31 weld repairs on weld flaws as listed on Table 2-1 Patch Plate and Weld Repair Summary. Weld repairs shall be examined by vacuum box, liquid penetrant, and visual methods.

3. Remove all unused anchors, clips, and angles on the bottom of the tank. The items are to be ground off and the bottom is to be ground smooth. The locations are to be examined/tested by the magnetic particle or liquid penetrant, and visual methods.

4. 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.

5. Perform weld repair on approximately four feet of circumferential butt weld on the inside of the 32-inch inlet/outlet line to correct the lack of penetration condition. The weld repairs shall be examined/tested by the liquid penetrant and visual methods.

6. The remaining 130 3-inch grout nozzles that have not been examined should be UT tested. The shell to nozzle weld should also be checked with an eddy current probe (*Hawkeye*). If flaws are found in the shell to nozzle weld the flaw should be further evaluated using shear wave ultrasonic thickness measurement equipment.

7. The coating failures on the 3-inch grout nozzles should be repaired in accordance with a NACE inspector's or coating specialist's recommendations. Nozzles with moderate-to-severe or severe ratings should also be vacuum box tested after the failed coating is removed.

8. 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, grout nozzles, the expansion joint, scattered areas in the lower dome, and scattered areas in lower portion of the barrel will require coating repair.

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 15 should be performed no later than 25 August 2025. The overall effectives of the Dunkin & Bush, Inc. repairs appeared to have satisfactorily addressed flaws detected in Tank 15. Repairs were performed in accordance with the recommendations.

Barrel	13	28	3	Topside Pit	8" x 8" x 1/4" patch plate, 2" radius corners
Barrel	19	25	4A	0.215"	No Repair
Barrel	19	25	4	0.220"	No Repair
Barrel	12	8/9	53	Pinhole / 0.163"	Weld Repair
Barrel	12	14	54	Pinhole / 0.160"	Weld Repair
Barrel	12	14	55	Pinhole / 0.180"	Weld Repair
Expansion	13	E-4	66	0.180"	12" x 14.375" x 1/4" patch plate, see sketch
Barrel	14	1	67	Pinhole / 0.190"	No Repair
Barrel	15	4	68	Pinhole / 0.165"	Weld Repair
Barrel	15	5	69	Pinhole ~1/8" Dia. / 0.175"	Weld Repair
Barrel	16	22	70	Pinhole ~1/32" Dia. / 0.190"	No Repair
Barrel	16	14	71	Pinhole ~1/8" Dia. / 0.185"	Weld Repair
Barrel	16	14	72	Pinhole ~1/8" Dia. / 0.190"	No Repair
Barrel	16	15/16	73	Pinhole ~1/32" Dia. / 0.200"	No Repair
Barrel	18	17	89	0.195"	No Repair
Barrel	18	13	90A	Pinhole ~1/32" Dia. / 0.190"	Weld Repair
Barrel	18	13	90	Pinhole ~1/32 Dia. / 0.185"	Weld Repair
Expansion	18	E-4	91	0.170"	9" x 10" x 1/4" patch plate, see sketch
Extension	14	E-3	153	0.180"	28" x 48" x 1/4" patch plate, see sketch
Extension	14	E-3	150	0.170"	Repair with Flaw 153
Extension	14	E-3	152	0.160"	Repair with Flaw 153