Administrative Order on Consent
In the Matter of Red Hill Bulk Fuel Storage Facility
EPA Docket No: RCRA 7003-R9-2015-01
DOH Docket No: 15-UST-EA-01

Section 2

Tank Inspection, Repair, and Maintenance Report

OUTLINE

Prepared by

NAVFAC EXWC

DATE: 29 January 2015

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EXECUTIVE SUMMARY

Being worked separately.

SECTION 1 INTRODUCTION

1-1 BACKGROUND

Since the inadvertent fuel release from Red Hill Tank 5 that occurred from 9 Dec 2013 to 17 Jan 2014 there have been hundreds of phone calls, written communications, and face-to-face meetings among the stakeholders at Navy, DLA, EPA, and HIDOH; interested parties including the Oahu Board of Water Supply, the Honolulu media; state and local elected officials; and the general public. All want to know what happened, why it happened, the nature of the threat to the fresh water aquifer on Oahu, what can be done to stop the fuel before it reaches the aquifer, and what can be done to make sure something like this never happens again. The end result of all the dialogue is the Administrative Order on Consent (AOC) between Navy/DLA and EPA/HIDOH that was finalized and signed in September 2015. The AOC outlines a way forward to answer the questions raised and plans an overall course of action comprised of multiple sub-courses of action to resolve the issues at hand. This report expands on the AOC outline as described in the following paragraph.

1-2 PURPOSE AND SCOPE

The purpose of the TIRM report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/HIDOH in the Administrative Order on Consent (AOC) as important for the future inspection, repair, and maintenance of the Red Hill tanks to insure that the goal of keeping the tanks permanently leak-free going forward can be met. The report examines the pros and cons of past, current, and emerging means and methods for work on the tanks in order to decide on a strategy that can best achieve the goal of leak-free tanks.

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SECTION 2 CURRENT TANK INSPECTION, REPAIR, AND MAINTENANCE PRACTICES

2-1 INTRODUCTION

Provide a brief description of the content included in this section of the report.

This section will address the current TIRM practices for Tank 5, and will discuss any differing practices that were applied to previously inspected tanks.

Provide a listing of all Organizations and Companies and their roles and responsibilities.

Prime Contractor and Subcontractors for Tank 5

Willbros Government Services, LLC (WGS)	Prime Contractor – responsible for entire contract, including quality control, site management, and site safety.
Marine Chemist Hawaii	Marine Chemist services as needed for additional project support.
TesTex	Perform NDE testing of the tank and components
Baker Inspection Group	Magnetic particle and ultrasonic inspections
Engineering & Inspection of Hawaii	NDE testing and inspections as needed for additional project support.
Pacific Commercial Services	Cleaning and disposal services as needed for additional project support. Equipment rental as needed for additional project support.
Hawaii Marine	Cleaning and disposal services as needed for additional project support.
Hawaiian Pumping	Cleaning and disposal services as needed for additional project support.
Interspec, LLC	Tank Calibrations and strapping as needed for project support.
Gauge Point Calibrations	Tank Calibrations and strapping as needed for project support.
Chemitrol	Portable Toilets – Supply, Service & Maintenance
Kealohalani Equip & Rental	Equipment Fuel Supply
Mr. Sandman	Equipment rental as needed for additional project support
FKS	Equipment rental as needed for additional project support.
Hawaiian Rent All	Equipment rental as needed for additional project support.
Rolloffs	Hawaii Site trash containers
Valve Service & Supply	Materials supply and service as needed for project support
Abhe and Svoboda	Not listed in Work Plan, but shown on Daily Reports for surface preparation and coating
CSI Services	Not listed in Work Plan, but shown on Daily Reports for surface preparation inspection and coating inspection

NAVY/DLA

DLA	
Fleet Logistics Center	
NAVFAC EXWC	
NAVFAC Hawaii	

2-2 NON-DESTRUCTIVE TESTING – INSPECTION

The NDT on Red Hill Tank 5 was conducted by TesTex from 18 Aug to 24 Sep 2010. At this point TesTex had already completed identical 100 percent inspections on Red Hill Tanks 15, 16, 6, 2, and 20 using many of the same TesTex technicians. The same supervising engineer led the inspection team on all previous tanks. He developed a standard procedure and order or work which was used for Tank 5.

From Reference 2, Appendix A (TesTex Inspection Report on Red Hill Tank 5 dated October 15, 2010), Section 1.0, Introduction, and the work is described as follows:

> This inspection focused on 100% testing of the Floor, Lower Dome, Barrel, Extension, and Upper Dome areas. The inspection was performed with the TesTex developed ***TS-2000 NDT Multi-channel System*** (for plate scanning) using the principles of the ***Low Frequency Electromagnetic Technique***) and the ***Hawkeye 2000 System*** **(**for weld testing) focusing on surface and subsurface cracking and pinholes. All defected areas found with the above-mentioned TesTex equipment were backed up and sized using regular ***Ultrasonic Technique, Ultrasonic Shear Wave Technique*** and ***Magnetic Particle Technique.*** The ***Ultrasonic Shear Wave Technique*** was an additional service used which measured the depth of detected weld defects, provided they were oriented in a position that could be tested.

2-2.1 Low-frequency electromagnetic testing (LFET)

2-2.1.1 General description: An electromagnetic driver with two ends is placed on the surface of a metal, and a sensor is placed between the two ends of the driver. The driver emits a low-frequency (3-40 Hz) alternating-current signal, and the sensor detects the magnetic fields between the two poles of the driver. Flaws in the metal distort the magnetic fields; this distortion is recorded in the form of amplitude and phase deviations. The wider the flaw in the metal, the more sensors record shifts in the magnetic signal. The signal is then converted into percentages of material loss using numerical tables. [Ref. 2]

2-2.1.2 Equipment, Equipment Capabilities and Reliability

a. TesTex Falcon Mark II 2000 [2]

(1) Can detect metal plates' surface cracks and back-side corrosion. Tank plates can be covered 100% thanks to "a sixteenth inch modular swath containing 32 probe heads" (p. 359). The incoming signal is processed and translated into percentages of wall loss based on calibration tables. Probability-of-detection (POD) curves, describing the probability of detecting a flaw versus the flaw size, were not supplied in the Willbros or TesTex reports. A swath up to 330 mm (13 in) can be covered in one pass on a flat surface. [7]

(2) Probability-of-detection (POD) curves, describing the probability of detecting a flaw versus the flaw size, were not supplied in the Willbros or TesTex reports. [2] However, LFET in general has, in the past, "demonstrated 100% POD for 25% wall loss isolated pitting at a 3:1 aspect ratio", according to an article concerning nondestructive testing techniques used in inspecting a leaking oil pipeline in Alaska in 2006. [8] Correspondence with Sunil Ramchandran of TesTex suggests that the LFET equipment used in the inspection in Alaska was made and furnished by TesTex. [9]

b. TesTex TS-2000 [1]

(1) 8-channel scanner; multiple sensors allow for greater sensing of cracks and pits. As with the Falcon Mark II 2000, the received signal is transformed into percent-wall-loss data with calibration tables. It can be connected to a computer for further analysis. [2] Because the sensors have diameters of only a few millimeters, tiny defects like pits can be detected, and scanning in general is in high resolution. In addition, hydrogen damage, erosion, cracks, chemical gouging, and corrosion cells are detectable as well. Up to 3,000 linear feet can be inspected by one team of x number of certified technicians in a single 10-12 hour shift in a Red Hill tank. It operates at 10-Hz frequency or lower. [10]

(2) Probability-of-detection (POD)

From Reference 2, Appendix A (TesTex Inspection Report on Red Hill Tank 5 dated October 15, 2010), Appendix C (Test Methods, Procedures and Equipment Description), Detection Accuracy:

> "The ***TesTex, Inc.*** developed lock-in amplifier is capable of measuring very low level signals in the microvolt range and can measure small phase angle changes of a fraction of a degree, even in the presence of a considerable amount of noise. This system, when used in conjunction with the calibration standards:

partial and through-wall pitting, gradual wall thinning. Hydrogen damage, etc. and their respective calibration curves, allows us to measure small gradual wall losses on the order of 10%, pits of diameter 0.062" (1.57mm), and vibration/fret wear of five volume percent."

2-2.1.3 What was inspected: Liner plates' thickness and back-side corrosion thereon, in all portions of the tank body (bottom, lower dome, barrel shell, extension, and upper dome). In addition, the tank bottom's striker plate was inspected. Specific features that were inspected using LFET were pitting, corrosion, areas that needed patching, back-side voids, thinning on the shell nozzles, damaged faces and packing leaks on nozzle valves, and impact areas on elbow-up fill lines in nozzles extended into the tank. [2]

2-2.2 Balanced-field electromagnetic testing (BFET)

2-2.2.1 General description: An electromagnetic probe is placed near a metallic body. The deviation of the electromagnetic field is recorded; the vertical and horizontal components of the signal are phase-shifted to decrease the noise in the measured magnetic field. [2]

2-2.2.2 Equipment, Equipment Capabilities and Reliability Technology used:

a. TesTex Hawkeye 2000. [2]

(1) The TesTex Hawkeye 2000 is a probe that is able to detect flaws on and immediately below the surfaces of welds. [2] It is advantageous to use for locations that are difficult to reach. [2] Its frequency range is 5 Hz to 30 kHz, and in one pass, it can assess both sides of a butt weld, covering 101 mm (4 in). Features it can detect include porosity, slag, undercuts, and cracks. As for cracks in particular, they can be found up to 3 mm or 0.125 inch deep from the surface of carbon steel. It works much faster than magnetic-particle and dye-penetrant testing, capable of scanning up to 0.3 m/s (1 ft/s). [11]

2-2.2.4 What was tested: Welds, particularly defects including leaks and corrosion. Locations include shelf-bottom interfaces, roof supports in bottom interior, and the reinforcing pads and supports in the fixed drain line on the tank bottom. [2]

2-2.3 Longitudinal Ultrasonic Testing (UT)

2-2.3.1 General description: A transducer emits high-frequency sound waves, also called ultrasonic waves, which are propagated through the material being scanned. The transducer records the time between when the waves are released and when the waves' echoes are received into the transducer. If there is a flaw in the material, the time between release and echo is shortened (compared to the same amount of time for a non-flawed material) because the wave is propagated across a shorter distance. [12] In UT, particles in the material can collectively oscillate in response to the energy present in the sound waves being propagated. One way they can oscillate is by moving back and forth in the same direction as the sound waves, or in other words, in the longitudinal direction. [13]

2-2.3.2 Equipment, Equipment Capabilities and Reliability Technology used:

a. Krautkramer USN-60 [2]

15-Hz to 6-kHz pulse repetition frequency, 250-kHz to 25-MHz frequency range; steel scanning range of 1 mm to 28 m (0.040" to 1100"). Echoes can be adjusted using Multiple Curve Distance Amplitude Curve/Time Corrected Gain. Up to 16 points can be recorded. Test modes include dual-, thru-, and pulse echo-transmission. [14]

2-3.3.3 What was tested: Willbros Government Services Tank 5 Inspection Report Rev. E states in paragraph 5.5 that "traditional ultrasonic longitudinal and shearwave inspection (was used) for proofing areas". In addition, emails from Larry McDougal of TesTex revealed that longitudinal UT was implemented "to confirm suspected defect areas found with the Falcon 2000 and TS 2000 and to give wall remaining at these spots". [15] [16]

2-2.4 SHEAR WAVE ULTRASONIC TESTING

2-2.4.1 General description: Shearwave UT operates on the same principle as longitudinal-wave UT as described above, but the materials' particles move perpendicular to the direction of the sound waves. [13] Shearwave testing is also called angle beam testing. It is used to determine flaws' dimensions and their depth within a material, primarily for defects that are not parallel to the material's surface. [2]

2-2.4.2 Equipment, Equipment Capabilities and Reliability used: [2]

a. Krautkramer USN-60

(1) 15-Hz to 6-kHz pulse repetition frequency, 250-kHz to 25-MHz frequency range; steel scanning range of 1 mm to 28 m (0.040" to 1100"). Echoes can be adjusted using Multiple Curve Distance

Amplitude Curve/Time Corrected Gain. Up to 16 points can be recorded. Test modes include dual-, thru-, and pulse echo-transmission. [14]

(2) The Willbros report mentions that the Krautkramer USN-60 was used for shearwave UT, but neither the TesTex report or the reports by Baker Inspection Group mention it. [2] However, Baker does mention that their angle beam ultrasonic inspections were performed with the following equipment:

b. Avenger EZ instrument

(1) Range of 0.1016-8636 mm (0.4”-340”). 300-Hz pulser. Calibration modes are delay, range, zero, and velocity. 500-kHz to 15-MHz frequency range. Automatic probe recognition, single- or dual-element. Angle, delay, contact, single, and dual operational modes. Simultaneous display of A-trace and B-scan possible. [17]

(2) NDT Systems, the producer of the Avenger EZ, was asked for POD curves; a representative of NDT Systems, Jerry Rutherford, responded that POD depends on the material’s grain structure as well as the transducer’s frequency and size. [18] Holley Baker, head of Baker Inspection Group, was contacted on 14 January 2016, but he did not have Avenger EZ’s POD data. [19]

c. Panametrics transducer: Part of UT equipment

d. Sonotech couplant: Required to form couplant between transducer and metal

e. ASME calibration block: Used to calibrate UT equipment.

2-2.4.3 What was tested: All possible locations of weld flaws in the tank that had been scanned using BFET, in all regions other than the interface between the floor and lower dome. At the floor-lower dome interface, only the first 6 inches of welds between Course 1’s plates, immediately above the interface, were scanned using UT shearwave. (Defects on the welds hidden by cover plates on the floor-lower dome interface did not undergo shearwave inspection.) [2] Per Larry McDougal at TesTex, all welds that were accessible were inspected.

2-2.5 General: Unspecified If Longitudinal or Shearwave UT

2-2.5.1 Equipment, Equipment Capabilities and Reliability Technology used:

a. Krautkramer DMS-2 (both the Willbros report and the TesTex report mention this equipment, but neither specifies whether it was used for longitudinal-wave testing, shearwave testing, or both). [2]

(1) Can measure thickness independently of material defects, and can measure and display thicknesses of metals and their coatings separately at the same time. Can detect back-side corrosion and minor pitting. Probe is zeroed automatically according to inspection conditions. Measuring range is 0.2 mm to 635 mm (0.008" to 25.00") for steel. Test mode is only ultrasonic pulse-echo, but measurement modes include Dual Multi, MIN Capture, and dual- and single-element. [20]

2-2.5.2 What was tested: Discolorations on surfaces, particularly on bottom interior; locations of defects that had been tested using LFET (i.e., metal plates and their thickness and corrosion) and needed to be proved up with ultrasonic thickness testing; welds between plates in upper dome; coating thicknesses and defects, specifically, gaps, decay, discoloration, and disbondment of coatings on the shell seams and plate, on the bottom interior surface, on the handrails, on the deck plate, and on the platform frame. [2]

2-3 NON-DESTRUCTIVE TESTING – REPAIR

2-3.1 VISUAL INSPECTION

From Reference 2, Section 7 (Repair Recommendations),Table 7-1 (Summary of Tank Repairs):

Note(s): 1. Typical repair plate is 6" dia. X ¼" thk, A36 carbon steel. 2. Where one or more repair locations are adjacent to one another, a larger plate will be selected to cover all of the affected area(s), extending at a minimum of 1" past the edge of all repair locations. 3. The tank is located underground and there is no way to determine the back side of the plate is in a safe and gas free environment. WGS will drill a ¼" dia. hole for gas testing on all repairs that could provide sufficient back wall surface heating to ignite any hydrocarbons. This is a safety requirement since hydrocarbons have been found in contact with the back wall surfaces in the past tanks. The test port will be located so the new patch plate will cover the test port location. 4. NDE Testing and Inspection – a. A visual inspection will be made on all repairs. b. Leak / Vacuum box / Pressure testing will be performed on all applicable repairs where the joint or repair configuration will allow testing.

c. Magnetic Particle (MT) or Dye Penetrant testing will be performed on all repairs where leak or pressure testing could not be performed due to configuration.
5. All integral structural repairs made to the pressure retaining components will have material test reports provided in the final repair report. All materials shall be marked with the applicable MTR heat numbers for proper identification.

2-3.2 Magnetic-particle testing (MT)

2-3.2.1 General description: The location being inspected is magnetized, and iron particles are deposited to the surface. These particles can be dry or in a liquid suspension. If a defect exists, the particles will collect around the flaw because the defect has created a magnetic flux leakage field to which the particles are attracted. [21]

2-3.2.2 Equipment, Equipment Capabilities and Reliability used:

a. Parker DA 400. A dry powder was used; its color would differ from its surroundings around a defect. [2]

   (1) The Parker DA 400, a portable contour probe, can apply both half-wave rectified DC or constant AC magnetic fields and can demagnetize when testing is concluded. It can be utilized with both wet and dry magnetic particles. Almost all surfaces of a material can be inspected. [22]

   (2) Parker Research Corporation was contacted in a request for POD curves; a representative from Parker, Matt Parker, replied that POD curves vary partly depending on the material and geometry of the object being tested. [23] Holley Baker of Baker Inspection Group was also contacted regarding the POD for the Parker DA 400, but did not have knowledge of it. [19]

2-3.2.3 What was tested: “Upper and lower fillet welds” (p. 374) around a cover plate in the interface between the floor and lower dome. These welds were inspected with MT because pressure testing and leak testing could not be positioned around the welds. Furthermore, shearwave UT could not be performed either because the cover plates hid the intersection welds. [2]

2-3.3 Dye-penetrant testing (note: Reference 2 does not mention that this was performed)

2-3.3.1 General description: A colored substance, called a penetrant, is placed on and around a location that has a possible flaw, like a crack, that is not readily apparent to the unaided eye. The penetrant stays on the surface for some time; afterward, the excess penetrant is removed, and a developer is placed on the flaw location and surroundings to make the flaw more visible. [24]

2-3.3.2 What was tested: Nothing. WGS mentions that either MT or dye-penetrant testing would be conducted on areas at which pressure or leak testing equipment could not fit, but no other mention is made of dye-penetrant testing in any part of Reference 2, so it can be assumed that MT was used in all cases for prove-up.

2-3.4 Vacuum testing: Although Reference 2 does not mention that this was performed, a NACE inspector's handwritten notes reveal WGS's planned use of a vacuum box for testing tank-bottom-plate welds prior to coating.

2-3.4.1 General description: A mass spectrometer in a leak detector is connected via a tube to a system that pumps out air to form a vacuum inside the hollow area being pumped. The gas that was present inside the inspected area before the vacuum was formed enters the leak detector through the spectrometer tube. Helium is sprayed on the outside of the object being inspected. If there is a flaw, the helium will enter the object, and the spectrometer will detect the helium. [25]

2-3.4.2 Technology used: Not specified anywhere in Reference 2.

2-3.4.3 What was tested: The WGS tank-inspection checklist mentions several items that would involve vacuum testing, but these items were marked "NA" for "Not applicable/accessible" (p. 407). [2] However, as noted above, WGS planned to test the welds on the tank-bottom plates.

2-4 TEST PERSONNEL AND CERTIFICATIONS

From Reference 1, Section 5.0, Personnel Certifications:

KEY PERSONNEL

POSITION	PERSONNEL NAME	QUALIFICATIONS
Project Manager /API 653 Inspector	Tim Anderson	B.S., Mechanical Engineering API 653 Cert - #494 Tank Inspector API 570 Cert - #1080 Piping Inspector API 510 Cert - #5034 Pressure Vessel Inspector AWS CWI Welding Inspector ASNT Level II – UT, MT, PT, RT, VT, LT 23 years POL facilities experience including work in remote Syrian and Omani deserts. 23 years industry experience DOT Registered Tank Inspector /

		Engineer
Project Engineer	Gene Humes, P.E.	M.S., Civil Engineering 35 years engineering and construction of piping systems experience. Professional Engineer - #10844
Site Manager / Field Superintendent	Reed Cavin	7 years POL Facilities and Industrial Construction and Maintenance experience. SPCC C-7 Certification Hazardous Waste, Confined Space, Lead, Scaffolding Operator Certified. Construction and Site Superintendent at Redhill – Completing 6 tank projects. Experience in the coordination of multiple personnel and subcontractors performing in limited areas.
Tanks – Subject Matter Expert	Doug Bayles, P.E.	Professional Engineer - #11288-C HI Professional Engineer – Reg. 47 States API 653 Cert - #1904 Tank Inspector API Committee Member 20 years POL Facilities and Industrial Construction and Maintenance experience..

Other Significant Personnel Involved:

API 653 Inspector	Kenneth McNamara	(Additional Inspection Support as Needed) 12 years experience inspections in the POL industry including work in remote areas. 2 Years Inspecting Tanks in Red Hill Facility for FISC.

It appears that only a few of the WGS, TesTex, and Baker Inspection personnel listed in Reference 1, the Work Plan, are the same ones listed in Reference 2, the Inspection Report.

Tim D. Anderson (Willbros) [2]

b. Pressure-test technicians

Reed Cavin (company not specified) [2]

Robert Chapman (company not specified) [2]

Pat Collins (company not specified) [2]

c. ASNT NDE Level II technicians

Jassel Bolden (company not specified) [2]

Pat Hayden (company not specified) [2]

Chris Kocher (company not specified) [2]

Boyd Magil (company not specified) [2]

Larry McDougal (TesTex) [2]

Joe Wolfe (Baker Inspection) [2]

d. Magnetic-particle and ultrasonic technician

Joe Wolfe (Baker Inspection) [5]

2-5 Tank Inspection Process

a. Following the initial flaw detection by TesTex, Joe Wolfe of Baker Inspection Group performed shearwave ultrasonics on all floor-to-Lower Dome Course 1 welds, and backed up and sized all weld flaw indications found with TesTex Hawkeye system.

b. Provide a narrative on the documentation in the Inspection Report, Appendix A, that shows the results of the LFET, but does not state who performed the actual testing on each plate. (We will check to see if the daily reports or TESTEX has information on the inspector for each plate.)

c. Regardless of what QC oversight WGS did or did not do as called for by their QC plan (Appendix B) to monitor the work of their subcontractor, TesTex; the process that TesTex followed in executing the tank inspection is inherently self-checking. First, they scan the plates and welds throughout the tank to locate flaws. Second, other TesTex technicians prove up the flaws that were located in plates throughout the tank. Third, an independent company, Baker Inspection Group, re-tests all floor-to-Lower Dome Course 1 welds, and backs up and sizes all weld flaw indications throughout the tank that TesTex located with the Hawkeye system. All work is done entirely by highly qualified certified technicians.

2-6 TANK INSPECTION TEST ORDER OF WORK

2-6.1 General

a. Thickness measurements, flaws, and corrosion were found by LFET; these results were proved up by UT, especially for conditions of welds and of walls. [2]

b. Welds were inspected for cracks using BFET; test results were proved up by magnetic-particle tests and UT shearwave inspections. [2]

2-6.2 Scheduling

a. Week 1: Surface-area scans on the floor plates, Course 1, and part of Course 2 using TS-2000 (LFET). Weld scans in the same area using Hawkeye 2000 (BFET).

b. Week 2: LFET and BFET scans, with baskets, on courses 2, 3, and 4 of the lower dome were performed. The barrel scan was commenced.

c. Week 3: Barrel scan (LFET and BFET) continued to 50% completion at end of week.

d. Week 4: Barrel scan (LFET and BFET) continued to 95% completion at end of week.

e. Week 5: Barrel scan including the area of tank shell located directly beneath the catwalk (LFET and BFET) was finished. LFET scanner could not access Course F, so an ultrasonic trolley was used instead. The extension was also scanned (LFET and BFET).

f. Week 6: Courses B, C, and D of the upper dome were inspected (LFET and BFET). In addition, the upper dome's course E was inspected, but as with Course F, an ultrasonic trolley was employed instead of an LFET scanner. Moreover, a UT technician used MT on the welds of the interface between the lower dome and the floor and shearwave UT on parts of the weld between the plates of Course 1. BFET inspection was conducted on welds all over the tank, and defect locations were confirmed.

g. Unspecified in schedule: BFET scan was conducted on all welds in the upper dome. UT spot checks were performed in the lower tunnel's 32" and 18" lines. LFET scans were done on the inside and cover of the manway.

2-7 BASKET POSITIONING (SCAFFOLDING)

a. General usage note: The Willbros report states, “After all of the structural repairs (on the center tower) were completed and checked, Willbros installed two (2) boom systems on the tower structure with man baskets. The man baskets were utilized to access all the internal surfaces areas of the tank for testing and inspection” (p. 19). [2]

(1) Telescoping box booms. Two booms are attached to opposite legs of the center tower. The attachment/pivot point on the tower leg for the inner end of the boom is approximately 3-feet above the catwalk level. The outer end of the boom is raised and lowered by a cable that runs over a sheave attached to the same tower leg near the top of the tower. A cable hangs from the outer end of the boom on which an industrial man-basket climbs up and down to access the tank shell. From the pivot point each boom rotates horizontally 180-degrees to cover half of the Upper Dome, Barrel, and upper (steep) section of the Lower Dome; and vertically 90-degrees to cover half of the Upper Dome from the spring line to near the top of the tank. The boom and man-basket are powered by compressed air-driven motors and winches. The man-basket is able to access most, but not all areas of the tank shell.

(a) History. The first telescoping box booms for use at Red Hill were designed and built by Hawaiian Dredging in 1980 for use in the leak search/leak repair phase in the latter part of FY-78 MILCON Project P-060. The initial phase of P-060 used two much more robust scaffold systems to access the tank shell. They are described in section 5-4.4 of the report. All follow-on Red Hill tank projects since 1994 have used the telescoping box booms and man-baskets exclusively. The telescoping box booms built by Hawaiian Dredging were provided or offered to contractors as GFE. Drawings of the boom have been provided. Refer to NAVFAC Drawing Nos. 7947873 and 7947875. Some contractors have designed and built their own telescoping box booms.

(b) Advantages

- Relatively light weight and easy to install and remove from the tank.

(c) Disadvantages

- Limited boom lift capacity must be strictly adhered to.

- Low lift capacity limits size of man-basket, number of personnel, and amount of portable equipment in basket. Man-basket approximately 8-feet by 3-feet.
- Smaller man-basket requires more “drops” to cover tank shell.
- Drops are overly time consuming – work on tank shell stops, boom telescopes in, man-basket is lowered or raised, boom telescopes back out to tank shell, scanning and/or shell repairs resume.
- Cannot scan complete shell plate in one drop. Scan limited to 8-foot length of man-basket. Shell plates in tank Barrel are 19.6-feet long by 5-feet high.
- Limited access to Courses E and F in Upper Dome. Scans done by remotely operated “crawler”.
- Limited access to shell plates in Barrel directly beneath catwalk.

b. Use in lower dome: According to TesTex, the baskets were set up to access Courses 3 and 2 of the Lower Dome because the slopes of the tank shell plates are too steep to be accessed safely on foot from Course 1, the first ring of sloping plates. [2]

c. Use in barrel: The basket was dropped along vertical columns on the barrel’s inner surface. These columns were 8 feet wide, the basket’s width. Two drops were conducted per day. [2]

d. Use in upper dome: Because of the configuration of Courses E and F, the baskets could not be safely placed in proximity to walls; rather, ultrasonic trolleys were employed. [2]

e. Positioning: [15]

   i. In Courses 2 and 3 and the lower part of Course 4 of the lower dome, the baskets were flush against the wall plates.
   ii. However, in the upper part of Course 4 and in the lower regions of the barrel, the basket was held against the walls with magnets to prevent them from hanging 2-3 feet from the wall.
   iii. As the basket was positioned higher along the barrel, magnets were needed less because they could hang closer to the wall without magnets.
   iv. In the upper dome, magnets were once again utilized.

2-8 PROCESS OF VERIFYING PROPER OPERATION OF TEST EQUIPMENT

a. In general, the TesTex equipment (Falcon 2000, TS-2000, and Hawkeye 2000) is prepared for inspection with calibration standards. These standards are "0.250" thick, carbon steel plate samples with certain pit diameters and depths and gradual wall losses machined into them," according to emails from Larry McDougal of TesTex. Every day of inspection, before each shift, after each work stoppage, and after each loss of power, TesTex's equipment is checked against these standards. [15] [16]

b. The TS-2000 is positioned directly on a horizontal or vertical plate. Its software, "TS 2000 PLATE SCAN", has an auto-set function that zeroes the scanner's measurements, "selects the right time constant, sets the gains of the internal amplifiers, and ensures that the data is displayed on the screen as it is being collected" (p. 359). [2]

c. TesTex notes in its inspection procedure that "The [Hawkeye] probe should be used on the calibration plate periodically to assure proper function" (p. 399). However, it does not say if the probe was actually calibrated in this way. [2]

d. Baker's Ultrasonic Inspection Report for the floor "T" joints, which involved a UT tool called the Avenger EZ, notes that "Calibration was performed at the beginning of the shift 12:23 PM on 9/21/2010 and verified at 5:23 PM 9/21/2010." (The inspection was performed 21-25 September 2010.) An ASME calibration block was used. No further details were given. Similar notes are provided in Baker's other Ultrasonic Inspection Reports, which used the same test equipment and calibration block. [2]

e. In a telephone conversation, Holley Baker of Baker Inspection Group noted that test equipment was calibrated against standards before and after each workday. [19]

f. No other details are given in the reports by Willbros, TesTex, or Baker. [1] [2] [5] [7]

2-9 DESTRUCTIVE TESTING

a. No specific destructive Testing was performed on Tank 5.

b. A section of shell plate that was removed from Tank 16 in May 2006 by Dunkin and Bush resides in Pittsburgh with TesTex and has been used by them to test and calibrate their LFET equipment. The plate section was removed because it was covered with backside corrosion. The average remaining thickness was 0.153-inch and ranged from 0.000-inch (two holes) to 0.200-inch. Dimensions of the plate were 10-feet high by 4 to 7-feet wide. The report on Tank 16 by Weston Solutions with photos of the plate in question is available on EPA's Red Hill website.

2-10 QUALITY CONTROL DURING INSPECTION AND TESTING

a. For a description of WGS three phases of control for in-process inspection, refer to Appendix B, paragraphs 4.8.3 to 4.8.6.

b. Provide narrative of the subcontractors' QC Plan.

c. For the complete WGS quality control plan, refer to Appendix B.

2-11 OTHER INSPECTIONS

a. Provide a narrative of other inspections that were performed in the tank.
   (1) The following information was taken from CSI Services Daily Coating Inspection Report on Red Hill Tank 5 dated 11/6/2012 by Frank Bringas. Subject: Surface preparation of Lower Dome and actual soluble salt testing.

Comments. Assumed duties as CSI QC Inspector at Tank # 5 Red Hill. I accomplished the pre-blast inspections including the and degrease check throughout the lower bowl section of Tank 5 using the visual and clean white rag method. The checks were sat.

The contractor accomplished the soluble salt testing on various locations throughout the tank. No salts were detected on any surfaces with the exception of one test on the bottom flat part of the tank which measured 1 µg/cm. Upon further inspection of the lower flat part of the tank I noticed visible salts. Upon inquiry of why there would be salts in that area, I was told that a hydro test was conducted on a pipe using firemain (salt) water and some had leaked out due to improper purging of the line. The contamination appeared to be localized. The contractor cleaned the area with Chor-id but was not re-tested.

Due to safety concern with FLP any further surface preparation has been postponed. The information reported was obtained using visual observations and testing believed to be accurate. The information reported represents the data obtained from the specific representative areas inspected, tested, and/or verified.

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(2) The water/fire main at Red Hill supplies fresh water not salt water, so that could not be the source of the salt.

(3) It appears the tank bottom (Lower Dome) and possibly other parts of the tank may not have been re-tested for chlorides before it was coated. Reason: The few reports by the NACE inspector list only a couple of chloride tests. From Reference 5:

Soluble Salts Test At randomly selected locations, soluble salts testing will be conducted at a rate of three (3) tests for the first 1000 ft² and one (1) test for every 2000 ft² thereof. Concentrate testing of bare steel at area of corrosion pitting. Approximately 30% of the tests on bare steel will be performed at welds, divided equally between horizontal and vertical welds. The concentration of soluble salts will be measured and utilized to dictate the necessity of chloride, sulfate, or nitrate ion removal.

b. Provide a summary of the results of the coating inspections.

(1) The surface preparation and coating inspection reports are shown in Appendix C.

(2) Performed by NACE inspector

(3) Prior to the new coating applied under this project, the existing coating was applied in 1982 under FY-78 MILCON Project P-060. Tank 5 was emptied, cleaned, repaired, and the entire tank shell was sandblasted and coated with a thin film polyurethane formulated by the Naval Research Laboratory. The 20-foot diameter flat plate at the center of the tank bottom and a few feet up the first ring of sloping plates was sandblasted and coated with flame sprayed aluminum before the polyurethane was applied. It was thought that the polyurethane would adhere better to the more porous aluminum in the presence of tank bottom water. Inspection of other Red Hill tanks that received the flame sprayed aluminum found that over time the aluminum sacrificed itself to the steel forming aluminum oxide, and with no aluminum to adhere to, the polyurethane coating dis-bonded from the steel plates at the center of the tank bottom.

c. Provide a summary of the structural integrity of the center column, and any repairs that were required prior to inspection of the tank.

d. Provide a summary of the API 653 “Tank Out-of-Service Inspection checklist.

(1) Provide a narrative of the “Modified out of service inspection” procedure (Statement of Work).

(2) Provide API 653 Inspector’s certification as an Appendix D.

(3) Provide any recommendations of repair.

2-12 NOZZLE INSPECTIONS

2-12.1 Provide a narrative of the nozzles: Receipt & Issue, their sizes & Lengths, and how they penetrate thru the concrete. Refer to the table and sketches in Appendix C that describe the nozzle pipes and other pipes that extend from the tank bottom to the Lower Access Tunnel beneath the tank.

Can we provide a photo or sketch?

2-12.2 Provide a narrative of the pressure test procedure. Include Pressure Test Procedure as an Appendix E(located on P:/Red Hill AOC)

2-12.3 Provide a narrative of the Results for the pressure test. Include the Executive Summary as an Appendix F. (located on P:/Red Hill AOC)

2-12.4 Provide a narrative of any other testing and repairs that were performed on the nozzles. IE: casing pipe (secondary containment) for the sample lines. Was any work done on the damaged coupling on the casing pipe (secondary containment) for the new slop line.

2-13 REPAIR RECOMMENDATIONS

2-13.1 Provide a narrative of the process of scoping the repairs, after the Government received the inspection report.

a. Provide a ½ page excerpt of the table from the SOW that lists the areas that need repair.

b. Provide paragraph in SOW that states how to repair the pits, gouges, etc. Include the paragraph that references API 653, etc.

2-13.2 Provide the paragraph from Willbro’s Work Plan that states how they plan to repair the tank.

2-13.3 Provide the paragraph from Willbro’s Work Plan that states their QC process for the repairs.

a. 3-phase process per NAVFAC Instruction.

2-14 REPAIRS – WELDING

2-14.1 Provide a narrative of what needed to be welded, and the type of weld that is required (ie: fillet weld).

a. Discuss the drilling of the hole in the tank prior to welding. Why it was done.

2-14.2 Provide an Appendix G of the Welder Qualifications, Weld Procedure Qualifications, and Weld Procedure Records. – The PQR & WPS's are on EPA's web site. Can we find the Welder Qualifications?

2-14.3 Provide a narrative of how each weld was marked by each welder, and then also included in Willbros' QC log.

2-14.4 Provide a narrative of how each weld was visually inspected and documented in Willbros' QC log. Provide QC log as an Appendix H

2-14.5 Provide a narrative of the Government's QA inspection of Willbros' QC log.

2-15 TANK REPAIRS – MISCELLANEOUS

2-15.1 Provide a list of other repairs that were required.

2-15.2 Provide description of how the repairs were performed.

2-15.3 Provide a description of Willbros's QC

2-15.4 Provide a description of Government's QA.

2-16 RECOMMISSIONING

2-16.1 Provide a narrative of documentation received from Willbros stating that the tank was suitable for service and that it can go back into service. This statement is a requirement of the SOW (include excerpt from SOW and the suitability for service statement).

2-16.2Provide a narrative of how the filling process was monitored.

2-16.3 Reference MO-230 and UFC 3-460-03 if applicable.

2-17 RECORD KEEPING

2-17.1 Provide a narrative of the documents that are required to be kept as part of the Contract file. Reference the Instruction (I need that training again) that mandates this requirement.

2-17.2 Provide a narrative of the documents that are required to be kept per API 653 and/or the State of Hawaii (33CFR??).

2-17.3 Provide how these documents are stored. FLC???

2-18 MAINTENANCE OF TANKS IN RED HILL

2-18.1 Provide the list of tank maintenance requirements from MO-230.

2-18.2 Provide the maintenance checklist for Tank 5 (From FLC).

Tank Preventative Maintenance Procedures	Periodicity
Product Sampling	After fill of tank
	Monthly
	As required by quality
Water draw from tanks	Weekly
Test High level Switch and interoperability with Skin Valve	Annual
Perform manual verification of AFHE against certified tape	Quarterly
Tank probe Calibration	Annual
	when out of tolerance (>/= 4/16")
Top gauge of tank after all product movements	As required by fuel movement
Visually inspect for signs of leakage at the lower tank gallery	Monthly/After UFM
Inventory trend analysis	Every 4 hours by operator

	Weekly by supervisor

2-18.3 Compare the two lists and provide documentation on any differences.

CHAPTER 3 – LESSONS LEARNED FROM TANK 5 AND RELATED MODIFICATIONS TO CURRENT PROCEDURES

3-1 INTRODUCTION

Provide a brief description of the content included in this section of the report. This section will address Lessons Learned from Tank 5 and Related Modifications to Current Procedures.

3-2 FEDERAL ACQUISITION REGULATIONS (FAR)

3-2.1 Contracts: The Government is required to abide by the Federal Acquisition Regulations (FAR).
Include in an Appendix I, the contract that was awarded for Tank 5.

3-2.2 From the contract information in Appendix D, the following is a list of the contracts for the five tanks in the order they were worked prior to Tank 5:

Tank No.	Contractor (Subcontractor)	Year	Contract Agent	Contract No.
15	Weston Solutions (Testex) – inspect	2006	AFCEE	FA8903-04-D-8681, Task Order 0176
	Thermal Engineering (Jurva Leak Testing)	2006	PACNAVFAC	
	Dunkin & Bush – clean and repair	2006	PACNAVFAC	N62742-03-C-1402
16	Weston Solutions (Testex) – inspect	2006	AFCEE	FA8903-04-D-8681, Task Order 0176
	Dunkin & Bush) – clean and repair	2006	PACNAVFAC	N62742-03-C-1402
6	Weston Solutions (Testex) – inspect	2006	AFCEE	FA8903-04-D-8681, Task Order 0176
	Dunkin & Bush – clean and repair	2007	PACNAVFAC	N62742-03-C-1402
2	Shaw (Testex/BIG, EEI, E&IHI, D&B)	2008	PACNAVFAC	
20	Shaw (TesTex/BIG, E&IHI, Dunkin & Bush)	2008/9	PACNAVFAC	
5	Willbros Government Services (TesTex/BIG)	2011/2	PACNAVFAC	N62583-09-D-0132, Task Order 0003

3-2.3 Observations for Tanks 15, 16, 6, 2, and 20:

a. Of the five tanks worked prior to Tank 5, only the first one, Tank15, had tank-specific plans and specifications prepared for cleaning and repair.
b. The plans and specifications for Tank 15 were detailed in describing the specific features of the tank and somewhat prescriptive in nature. For example, the maximum allowable temperature and pressure of the wash water for cleaning the coated tank shell were specified.
c. The first three tanks were inspected under a task order to an AFCEE POLMAC contractor, and cleaned and repaired under a PACNAVFAC open-bid contract.
d. Work under the two contracts overlapped since the open-bid contractor first cleaned the tank, then supported the POLMAC contractor's inspection work in the tank, and finally repaired the tank based on the findings of the inspection. This approach appeared to work well.
e. All five tanks were cleaned and repaired by the same contractor, Dunkin & Bush – three tanks as the prime contractor and two as a subcontractor.

3-2.4 Observations for Tank 5:

a. The work was bid using the RFP process. The RFP included a scope of work and a specification with limited information issued by EXWC to the six POLMAC contractors. The request for bids did not include drawings specific to Tank 5.
b. The prime contractor was responsible for tank cleaning, inspection, and repair.
c. Tank 5 was the first tank done by WGS.

3-2.5 Provide a general overview of the type of contract that was used for Tank 5. (Services vs Construction)

3-2.6 Provide a general overview of the process to award this type of delivery order.

3-2.7 Provide a general overview of the funding – minor construction, repair, maintenance.

3-2.8 Provide the background of the development of the Statement of Work.

a. Describe the difference between performance and prescriptive specifications.
b. The FAR requires the DoD to use performance specifications.

3-2.9 Lesson learned: The contract must be more specific to explain expectations. As a lesson learned, the Navy/DLA is changing their process to require drawings and procedures. More on this topic will be explained in Section 4 – Quality Control and Assurance of TIRM and Section 5 – Options for improving current TIRM.

3-3 Contractor Quality Control

3-3.1 Human Factor

Provide a summary of how the Contractor's Quality Control system was not effective since the Project Manager was also the Quality Control Manager. Provide a narrative on the lack of specifications and drawings.

3-4 Government Quality Assurance

3-4.1 Provide a narrative of why there was limited Government Quality Assurance provided during the execution of this contract. Include confined space requirements. Discuss the lack of a good Quality Assurance Surveillance plan. Since there was a lack of specifications and drawings, the Government QA engineer had no basis to determine if the work was per the contract or not.

3-5 Release was not attributable to corrosion related defects

3-5.1 Inspection methods were sound. Provide narrative that the API 653 inspection was sound, used the right equipment and personnel.

3-5.2 Poor Quality Repair. Provide narrative that the Contractor was not working from drawings or repair procedures. The welds were not good and the hole was not plugged.

3-6 Discuss repairs of the previous 6 tanks.

3-6.1 Provide documents and other information

Provide a narrative stating why there was a failure in Tank 5, but not the other tanks. Provide documentation that the inspection was the same. Provide documentation of what was repaired in the other tanks. Provide information concerning the other prime contractor's quality control procedures.

3-7 Incident Reporting and Process

3-7.1 Provide the Government's process for reporting and responding to errors and omissions in the design and warranty issues during construction. (FAR clauses).

3-8 Tank Filling Procedures

3-8.1 Provide the Government's process that was used to fill Tank 5.

3-8.2 Provide discussion about the new filling instruction. Include it as an Appendix J.

3-9 Tank Cleaning and Initial Inspection

3-9.1 Pressure Washing

a. The Government specification does not specify the maximum allowable pressure and temperature for pressure washing.
b. Reference 1, Section 4.5.1.2. "A high pressure spray wash of the tank interior and internal components shall be conducted." The pressure for cleaning Tank 5 is not specified.
c. Reference 1, Appendix D, SOP #5 Water Blasting. Specification lists the following categories of water blasting:

Category	Pressure (psi)	Purpose
Low pressure	<3500	Remove material not bonded to surface
Standard pressure	3500-20,000	Remove rust, scale, or epoxy coating
Ultra high pressure	> 20,000	Cutting and stripping operations

The pressure for cleaning Tank 5 is not specified.

d. Reference 2, Section1.0. "Willbros cleaned the tank by high pressure washing all internal surfaces." The actual pressure used for cleaning Tank 5 is not specified.
e. Reference 2, Section 6.1, Summary of Indications and Flaws. "The coating has disbonded, flaked, or deteriorated over 80% of all internal surface areas."

NOTE: In none of the previous five tanks was the coating in the Upper Dome and Barrel so badly deteriorated. The condition of the coating in the Lower Dome was consistent with the previous tanks.

3-9.2 Lessons learned for Tank Cleaning

a. Government specifications shall specify the maximum allowable pressure and temperature for washing the tank with pressure sprayers (water blasters).
b. Government shall review the contractor's Work Plan to insure that the maximum allowable pressure and temperature are specified.
c. Government personnel shall oversee xx percent of the contractor's tank cleaning operation, i.e., on the work platform or in the man-basket with the tank cleaning personnel to insure that the maximum allowable pressure and temperature of the wash spray (water blast) is not exceeded; and to insure that back-seepage, dis-bonded coating, and blisters in the coating are carefully checked and marked for further inspection.

3-10 Tank Ventilation

This section will provide lessons learned on providing ventilation during Tank 5 and all previous Red Hill Tank projects.

SECTION 4 - QUALITY CONTROL AND ASSURANCE OF TIRM

4-1 INTRODUCTION

Provide a brief description of the content included in this section of the report. This section will address Quality Control and Assurance of TIRM

4-1.1 Provide the definition of Quality Control

4-1.2 Provide the definition of Quality Assurance

4-2 New POL MACC Contract information

4-2.1 Provide the description of the new POL MACC contract

4-3 Existing Specifications

4-3.1 Reference Whole Building Design Guide that has UFCs and UFGSs

https://www.wbdg.org/

4-3.2 Reference the web site that has the standard designs (AST, Cut and Cover, etc.)

http://apps.hnc.usace.army.mil/stddgn/Library.aspx

4-4 Government Quality Assurance

4-4.1 Submittal Reviews

4-4.2 On-site inspections

a. Government personnel requirements

(1) Safety regulations

(2) Education & experience & certifications

b. Third party requirements

(1) Safety Regulations

(2) Education & experience & certifications

4-4.3 Development of a Specification for Tank Inspections (Include draft as an Appendix K.)

The Tank Inspection Performance specifications will include detailed submittal requirements such as the certification of the inspectors and NDE technicians. Part 3 of the specification provides requirements for “Workmanship”. This Part can include more “requirements” than can be prescriptive in nature. (ie: Provide test equipment that has a POD of xx and that is verifiable in accordance with API xxx).

4-4.4 Development of a Specification for Tank Repairs (Include draft as an Appendix L.)

The Tank Repair Performance specifications will include detailed submittal requirements such as the certification of the welders, NDE technicians and materials. Part 3 of the specification provides requirements for “Workmanship”. This Part can include more “requirements” than can be prescriptive in nature. (ie: Plug test hole prior to welding on patch plate by …).

4-5 Contractor Quality Control Plan

4-5.1 Describe the UFGS for Contractor Quality Control. Provide how the roles and responsibilities are addressed for the site manager and the Quality Control manager.

4-5.2 Describe the UFGS for Submittals and how Quality Control is managed thru the submittal process. Also, describe the submittal section in each individual technical specification section.

4-5.3 Describe the UFGS for Contractor Safety, and that the SSHO cannot be dual-hatted unless specifically stated in the contract.

4-6 Government Quality Assurance Surveillance Plan (QASP)

4-6.1 Describe the requirements of the plan per the BMS documents.

4-6.2 Describe the requirements of performing and documenting the efforts of the Quality Assurance.

4-6.3 Describe the roles and responsibilities between NAVFAC EXWC and NAVFAC HI. Discuss the Project Manager, Construction Manager, Design Manager, Engineer

Tech, etc. qualifications. List all of the training each one requires to perform their role generically and technically.

4-7 Third Party Quality Assurance

4-7.1 Describe the features of third part quality assurance (API 653, NACE, ASNT, QP5 etc. certifications.

4-7.2 Discuss the pros and cons (cost, additional time, better inspection & product)

4-7.3 Discuss that the contract has to have this additional inspections included so that the ktr doesn't claim Government caused delays. (Add to new specs).

4-8 QA/QC History for the previous tanks at Red Hill

4-8.1 Provide any lessons learned from the past

4-8.2 Provide any knowledge transfer between the Contracting Officers, the internal peer review system.

4-8.3 Provide a narrative of the history of the Clean, Inspect, Repair SOW template. (Note that it is not used in anymore due to the new 6-part format, but it will be cannibalized in developing the new specifications and the "General Requirements" part).

SECTION 5 - OPTIONS FOR IMPROVING THE TIRM PROCEDURES

5-1 INTRODUCTION

Provide a brief description of the content included in this section of the report. This section will address options for improving the TIRM Procedures

5-2 DEVELOPMENT OF A NEW SPECIFICATION FOR TANK INSPECTION

5-2.1 Provide what will be in this specification

a. Provide QC criteria for the inspection design & personnel [see above]
b. Performance requirements for establishing corrosion rate [see below]
c. Performance requirements for determining TIRM
d. Provide requirements to repair tank after destructive testing
e. Provide submittal requirements
f. Provide material criteria
g. Tank cleaning and initial inspection.
   (1) Careful observation of the tank shell during the tank cleaning process is the first step in inspecting the tank shell for corrosion and leaks. Things to look for:
   - Backseepage of fuel. Before or after the initial washing, backseepage may show up as a discolored stain on the coating or on bare steel if the coating is gone; or as drops of liquid running down the tank shell. Mark the source of the stain or running liquid for further inspection.
   - Dis-bonded coating (all layers of coating separated as a single sheet from the steel surface to which they were applied). Carefully remove the coating and check the steel underneath for corrosion. Mark suspect areas for further inspection.
   - Blisters in the coating.
   - Small hard tightly adhering blisters about the diameter of a pencil eraser in the polyurethane coating are not a problem as long as the top coating remains unbroken. Usually the blister is due to separation between the top coat and the prime coat. Removal of the top coat usually reveals the underlying prime coat (yellow) still adhered to the tank shell.

- Soft blisters the size of a fingerprint or larger with liquid behind them should be lanced to determine if the liquid is fuel or water. In either case the blistered coating should be removed and the spot marked for further inspection. Water behind a blister could indicate a hole through the tank shell plate.

(2) Washing the coated tank shell.

- Pressure washing (vs water blasting). CAUTION: Washing with a high pressure spray that is too high will cause a tightly adhered coating to disbond from the steel tank shell so that it must be removed and replaced with new coating.
- To prevent unnecessary coating damage while cleaning the tank, the original specifications for the repair of Red Hill Tank 15 under contract N62742-03-C-1402 (or tanks cleaned and repaired in the years 1994-1998) specified the maximum allowable pressure and temperature for pressure washing.

g. Tank Ventilation
h. List is to be expanded.

5-2.2 Provide Corrosion Detection Discussion

5-2.2.1 Provide narrative on API's method of determining corrosion rates.

5-2.2.2 Provide narrative on method to obtain a high confidence in locating pits and corrosion using the testing methods that is available.

5-2.2.3 Provide narrative on determining metallurgical information on the existing plates and any new patch plates.

5-2.2.4 Provide narrative in the potential of corrosion when dissimilar metals are welded together (ie: new plate to old plate).

5-2.2.5 Provide narrative in the potential of performing destructive testing during the inspection. Include the issue of welding (which is considered construction) during an "inspection" process. Also the issue of old/new plate corrosion.

5-3 Development of a new specification for Tank Repair

5-3.1 Provide what will be in this specification

a. Design requirements - Require design of repairs prior to mobilization by an API 653 certified engineer / P.E. experienced in repair of the Red Hill Tanks
b. Certifications – API 653, NACE, ASNT, etc. as required by the task.
c. Welding – refer to the UFGS for welding of the pipelines, but we need to include requirements for welding tanks. We can specify welding rods, etc.
d. Materials – MTR & material verification.
e. Coatings – refer to UFGS for tank coatings.
f. Gas Freeing procedure and repair methods

5-4 Comparison of equipment used over the years for personnel access to the tank shell in the Upper Dome, Barrel, and Lower Dome.

5-4.1 1940-1943 Original tank construction.

a. Circular metal framed wooden platform around entire tank perimeter. Platform was raised and lowered by hand operated winches (see photos no. 15560 and 15721). Also used steel and wood plank scaffolding welded to tank shell (photo not yet available).
b. Water staging was used during the final leak test/leak repair work in each tank. The water level in a tank was gradually increased as air was pumped behind the shell plates via the tell-tale pipes under low pressure. Leaks through the shell plates and welds showed up as bubbles in the tank. Welders working in small boats applied patches and repaired welds to stop the leaks. [photo]

5-4.2 1960-1962 Clean, repair, modify, and coat Tanks 17-20. Little is yet known about the scaffolding used except for the attached drawing, Y&D Drawing No. 761336. More research needed.

5-4.3 1970 Clean, repair, and modify Tanks 5, 6, and 12. Nothing is yet known for certain about the scaffolding used. It is known that the project included a water pumping system for filling a tank from the Navy well at Red Hill, but it was rumored that Oahu suffered a severe drought in 1970 which precluded using 12,000,000 gallons to fill a tank in order to use water staging.

5-4.4 1978-1985 Clean, repair, modify, and coat Tanks 1-16. The work was executed under FY-78 MILCON Project No. P-060. The prime contractor was Hawaiian Dredging and Construction. For the initial major repairs two separate scaffold systems were installed in each tank. For the follow-on re-entry into a tank for leak search and repair, a different scaffold system was used. All scaffold systems are driven by compressed air powered motors.

a. Major repair work.

(1) Upper Dome. First, structural members were added to the top of the center tower to strengthen and stiffen it. (The added structural members were never removed. Next, two guy wires on each tower leg, one each at the Upper Spring Line and Lower Spring Line (eight wires total) connecting the tower leg to points opposite on the tank shell were removed. Then two box-shaped steel rings were installed horizontally around the outside of the center tower, one near the top of the tower and another on the tower 10'-15' above the catwalk. Next a truss matching the curvature of the Upper Dome was attached to the two rings on the tower. The truss rotated on the ring 360 degrees around the tower. Three man-baskets capable of moving independently up and down the topside of the truss were installed. This was the dome truss rotating scaffold and it provided access to all points on the Upper Dome.

(2) Barrel and upper (steep) section of Lower Dome. Just above the spring line near the bottom of the Lower Dome, a trolley rail was installed around the perimeter of the tank. The trolley rail supported two hanging scaffold platforms (think window washing scaffolds on high rise buildings) to provide access to the Barrel and Lower Dome.

b. Follow-on tank re-entry for leak search and repair. (Add drawing)

(1) Upper Dome, Barrel, and upper (steep) section of Lower Dome. Two telescoping box booms are attached to opposite legs of the center tower. The attachment/pivot point on the tower leg for the inner end of the boom is approximately 3-feet above the catwalk level. The outer end of the boom is raised and lowered by a cable that runs over a sheave attached to the same tower leg near the top of the tower. A cable hangs from the outer end of the boom on which an industrial man-basket climbs up and down to access the tank shell. From the pivot point each boom rotates horizontally 180-degrees to cover half of the tank Barrel and vertically 90-degrees to cover half of the Upper Dome. The boom and man-basket are moved by air-driven motors and winches. The man-basket is able to access most, but not all areas of the tank shell.

c. Dome truss and trolley rail with hanging platforms vs. telescoping box booms with man-baskets

(1) Dome truss and trolley with hanging platforms – pros

- Five work platforms can support five teams working simultaneously.
- Separate scaffold systems support simultaneous work in Upper Dome and Barrel/Lower Dome.
- Dome truss scaffold provides rapid access to all points on Upper Dome.
- Hanging work platforms travel rapidly on trolley rail to expedite plate scanning in horizontal direction.
- Hanging work platforms are 14' long.
- 14'-long work platform with rapid horizontal travel enables scan of an entire 20' long x 5' high plate in Barrel section at once.
- Provides two work platforms each in Upper Dome and Barrel to support large shell plate repairs.

(2) Dome truss and trolley with hanging platforms – cons

- Requires a longer time to install and remove from tank (estimate 2-3 weeks each) due to relatively heavier weight and more parts to assemble.

(3) Two telescoping box booms each with a man-basket – pros

- Requires a shorter time to install and remove from tank(estimate 3-5 days each) due to relatively lighter weight and fewer parts to assemble.

(4) Two telescoping box booms each with a man-basket – cons

- Maximum of two work platforms.
- Limited boom lift capacity which must be strictly adhered to.
- Low boom lift capacity limits size of man-basket, number of personnel, and amount of portable equipment in basket. Man-basket approximately 8-feet by 3-feet.
- 8-foot long man-basket requires more vertical "drops" to cover tank shell.
- Vertical "drops" and horizontal travel are overly time consuming – scanning stops, boom telescopes in, man-basket travels vertically and/or horizontally, boom telescopes back out to tank shell, scanning starts again.

- Cannot scan complete 20' long x 5" high shell plate in one drop. Scan limited to 8-foot length of man-basket.
- Limited access to Courses E and F in Upper Dome.
- Limited access to shell plates in Barrel directly beneath catwalk.

5-5 Other methods of access for Inspection and Repair

5-5.1 Scaffolding

Provide a narrative of scaffolding.

5-5.1.1 Pros for Scaffolding

a. Can have multiple people working concurrently throughout the tank.
b. May get better inspections since they will be able to inspect one plate at a time.
c. May get better QC/QA since they will be able to inspect the work when it is being done.

5-5.1.2 Cons for Scaffolding

a. Time for assembly/disassembly (est 3 months each)
b. Availability of that much scaffolding for three tanks.
c. Availability of personnel to erect the scaffolding (25 or so for each tank)
d. Design of scaffolding – will it need to be connected to the tank or concrete behind the tank? Will this affect the inspection and repair of the tank?
e. Availability of qualified inspectors to warrant the cost & time (will it take just as long to inspect with the scaffolding than with just the baskets due to limited number of inspectors)
f. Availability of qualified welders to warrant the cost & time (will it take just as long to inspect with the scaffolding than with just the baskets due to limited number of welders)
g. Safety

5-5.2 Any other methods?

5-6 Coatings

5-6.1 Coating History

5-6.1.1 1962 – Tanks 17-20. The entire tank shell was coated with a thin film polyurethane coating system formulated by Naval Research Laboratory.

From the Reference 3 coating inspection in Tank 17 (then in place for 50 years) in October 2012:

> "The overall coating is in fair condition. The coating has small areas that have disbonded, flaked, or deteriorated over the majority of the internal surfaces. The Lower Dome and floor are in poor condition."

From the Reference 4 coating inspection in Tank 20 (then in place for 48 years) in October 2008:

> "The area referenced as the Lower Dome has approximately 40% coating failure with exposure of the tank steel liner. The area known as the tank Barrel section was noted to have smaller areas of coating failure. The tank Upper Dome was noted to have the best areas of coating with only minimal failure."

5-6.1.2 1982 – Tanks 1-16. The entire tank shell was coated with a thin film polyurethane coating system re-formulated by Naval Research Laboratory. Differences from the 1962 formulation include an acid wash primer applied to the steel after sandblasting to remove any rust remaining in the pores of the steel, and the application of flame sprayed aluminum to the circular flat bottom and a few feet up the first sloping plates prior to applying the polyurethane coating system. It was thought that the polyurethane would adhere better to the more porous aluminum. Upon inspection in later years, it was found that over time the aluminum sacrificed itself to the steel, forming aluminum oxide. With no aluminum to adhere to, the polyurethane coating disbonded from the tank bottom.

5-6.1.3 1994 to present – Tanks 2, 4, 5, 6, 7, 8, 10, 14, 15, 16, 17, and 20 have been cleaned, inspected, and repaired. In each tank the coating covering the flame sprayed aluminum on the tank bottom was removed along with any remaining aluminum, and the area was recoated. In some cases the entire Lower Dome was sandblasted to bare metal and recoated. Records research to determine the replacement coatings that were applied is yet to be done. The 1982-vintage polyurethane coating in the Barrel and Upper Dome is generally in good condition and remains in place in most, if not all, tanks. Starting in 1998, the sandblasted steel was checked for soluble salts (chlorides, sulfates, and nitrates) prior to recoating and cleaned as required.

5-6.2 LOW VOC POLYSULFIDE INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS (UFGS SECTION 09 97 13.15)

5-6.2.1 Background

The polyurethane over epoxy coating system that was developed by the Navy Research Laboratory was applied to these tanks over 50 years ago, and the coating is still in good (not great) condition. The problem with this coating system is that it was very expensive and took skill and experience to apply. Due to this issue, this system was not used frequently within the DoD, but instead a standard 3-coat epoxy was the normal specification (UFGS 09 97.13.17).

Knowing that the 3-coat epoxy system was only lasting maybe 20 years, the Navy recently developed and published a new specification. This new coating specification is for a Low VOC Polysulfide Epoxy Coating system. This system is expected to exceed 50 years without any failure.

5-6.2.2 Performance

The Low VOC Polysulfide Epoxy Coating System cost approximately 30% more than the 3-coat epoxy system, but it will last 2-3 times as long. The dry film thickness is 24 to 30 mils. The new system has the following advantages:

a. Adhesion is around 2x greater (+2000 psi vs 800 to 1000 psi) helps reduce impact of under film corrosion
b. Better chemical / fuel resistance - novolac epoxy vs standard epoxy
c. Greater impact resistance
d. Greater abrasion resistance which will better resist erosion due to fuel movement and any debris that may get through
e. Greater elongation (50% vs 10%) which will make it more adaptable to temperature extremes, hold on to edges, corners, weld seams
f. Greater flexibility which will help it retain shape over longer periods of time
g. Higher solids (100% vs 60%) so number of gallons used to achieve the DFT is less and thinning or pulling at edges and corners is eliminated.
h. Higher contact angle (slicker) approaching "teflon" which will allow it to shed water more easily, important to keeping water off the bottom which can lead to corrosion of tank bottoms and easier to clean and inspect tanks holding heavier fuels
i. Lower porosity thereby reducing effects of moisture on steel substrates (corrosion of tank bottoms)

j. The DFT is about twice that of the old system on top of all the improved qualities.
k. A previous generation system was applied to a steel tank in 1998 and inspected in 2008. No signs of any type of deterioration were evident. There were no striations at fuel inlet or outlet, no checking (minor cracks), no apparent loss in gloss, no edge cracks or corrosion marks of any type.

5-6.2.3 Quality Control

a. QA / QC updates in the new UFGS have been added to the two coat spec that makes it more robust in the coating application and contractor oversight.

b. Holiday testing - check for pinholes in the coating - is done after the first coat of the coating is applied. If any holidays are found they are fixed and retested. The second coat is then applied providing greater insurance of an intact and continuous system. The 3-coat system is checked after fully applied and holidays fixed. This should not be a problem but it is not a truly continuous film.

c. While the system requires heated hoses during application, other environmental conditions are similar but the system is more tolerant of hotter substrate temperatures offering a greater range of application conditions and potential reduction in required environmental controls.

5-6.2.4 Environmental Regulations

a. Many States are now requiring coating systems to have Low VOC's.

b. The Low VOC (0%) Modified Epoxy Polysulfide meets the States' environmental regulations.

c. The three coat Epoxy System does NOT meet the States' environmental regulations.

5-6.2.5 Long Term Repair

a. The system is easily repaired as it easily adheres to itself.

b. This is useful when tanks are modified and coating is damaged.

c. The 3 coat epoxy system embrittles with time as it continues to cross link with time (slowly) and requires greater care to repair.

d. The new system is not expected to embrittle since full cure is set and completed during application.

5-7 Tank Commissioning

The goal in refilling a Red Hill tank for leak testing is to minimize the expansion or shrinkage of the fuel volume due to changes in fuel temperature so that the actual amount of leakage, if any, can be accurately measured. Fuel expansion due to temperature increase can mask a loss of fuel from the tank. Fuel shrinkage due to temperature decrease can give a false impression that the tank is leaking when it is not. Historically, the temperature of thermally stable fuel in long term storage at Red Hill is 80-degrees F plus or minus 1-degree. The key to a successful leak test is to minimize the time for the fuel to reach thermal equilibrium with the tank shell by:

- Controlling tank ventilation to bring the temperature of the tank shell as close as possible to 80-degrees F, and
- Refilling the tank from a **single full** Red Hill tank with thermally stable fuel that has been in long term storage.

5-7.1 Tank Out-of-Service

When a Red Hill tank is taken out-of-service for cleaning and repair, on average it remains empty for one year. For most of the out-of-service time, the tank is constantly ventilated with forced air ducted in from outside Red Hill. In the month preceding refill of the tank, ventilation is essential to set the new coating as it cures. During this time with no added heat in the tank from hot work or lights, the temperature of the steel tank shell can be expected to assume the average temperature of the ventilation air. The temperature of the secondary reinforced concrete shell behind the inner steel shell is less likely to be effected by the ventilation air.

5-7.2 Prepare tank for refilling

Provide a description on how to prepare the tank for refilling

5-7.3 Refill the tank for leak test. Transfer the test fuel from a single full Red Hill tank with thermally stable fuel that has been in long term storage.

Provide a description on how to fill the tank and hold points.

5-7.4 Monitor the skin valves for leakage. At each “hold” point in the tank filling process do the following:

Provide a description on how to monitor the skin valves.

5-7.5 Monitor the casing pipes for the sample lines and the slop line (if slip-lined) for leakage.

Provide a description on how to monitor the casing pipes.

5-7.6 Monitor the tank level.

Provide a description on how to monitor the tank level.

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SECTION 6 - SCHEDULE/FREQUENCY OF MODIFIED AMERICAN PETROLEUM INSTITUTE ("API") 653 TANK INSPECTIONS, REPAIRS, AND MAINTENANCE

6-1 INTRODUCTION

Provide a brief description of the content included in this section of the report. This section will address the schedule/frequency of modified American Petroleum Institute ("API") 653 tank inspections, repairs, and maintenance.

6-2 API 653 Inspections

This section will address the frequency requirements as stated in API 653.

6-3 API RP 580 Risk-Based Inspection, Downstream Segment

6-2.1 This section will discuss the API RP 580 and its philosophy on the determination of the frequency of inspection based on Probability of Failure and Consequence of Failure.

6-3.2 This section will discuss the Navy/DLA's analysis of the process as defined in the API RP 580. The Navy/DLA has different Consequences of Failure than that stated in API RP 580, therefore analysis section needs to be revised to be more in-line with the requirements of the Navy/DLA.

a. Mission Requirements – Need to fuel the forces that protect the USA.

b. Self-Insured – Taxpayers money pay for the Inspections, Repair, and Maintenance of the tanks.

c. Public – Public opinion counts

d. FAR Requirements – Time it takes to repair the tank is longer than industry.

6-4 Constraints for scheduling the Clean, Inspect, and Repair of the tanks

6-4.1 Operations

This section will describe that the tanks contain different fuels and that only one tank for each fuel can be out of service at a time.

6-4.2 Physical Limitations

This section will describe the limitations of entering and working on the tanks

a. Roads to the tunnel & the effect to the local population in transporting the equipment, materials, and personnel

b. Brief description of the access to the tank and the tunnel.

c. Manway on top of tank is the only access into the tank.

d. Power – the Navy can provide some power, but not enough for major construction work. The Navy is currently upgrading the power source so that three tanks can be cleaned, inspected, and repaired concurrently.

e. Qualified Personnel – There are only so many API 653 inspectors and certified welders available that will want to work day in and day out in the tank, and still maintain their ability to provide the required high level of performance.

f. Security Access – All personnel, from the Project Manager to the scaffolding laborer, are required to obtain a security access. This takes approximately three months to obtain and the person must have a completely clean record. Therefore, if an inspector decides he would rather work on another project, it will take at least three months to hire a new inspector.

6-5 Acquisition Timeline

This section will address the activities that take place from the time to start working on a tank project to the time the Contractor mobilizes to the site. A Gantt Chart may be included.

a. Develop RFP, GCE

b. Obtain Work Classification Statement

c. Obtain funding

d. Send out the RFP

e. Contractors' develop technical & cost proposal

f. Government reviews proposals & prepare technical evaluation

g. Negotiations

i. Develop contract

j. Award

k. Bonds

l. Develop Plans & Specs

m. Review/Approval of Plans & Specs

o. Submittal development & approvals

p. Order materials/equipment/etc.

q. Obtain Security Assess

r. Set up job site/laydown area/power/water

s. Decommission Tank

t. Mobilize

6-6 Determination of order of tanks

This section will provide a narrative on the decision of the order to clean, inspect, and repair the tanks.

6-7 Previous History

This section will provide background information on the timelines that it has taken to perform the previous contracts. Provide APPENDIX M listing previous contracts.

SECTION 7 - ACTIONS THAT CAN BE TAKEN THROUGHOUT THE FACILITY, AS SOON AS PRACTICABLE, TO REDUCE RISK OF RELEASE THAT CAN BE IMPLEMENTED INDEPENDENT OF TANK UPGRADES

7-1 INTRODUCTION

Provide a brief description of the content included in this section of the report. This section will address the actions that can be taken throughout the facility, as soon as practicable, to reduce risk of release that can be implemented independent of tank upgrades.

7-2 Continue repairing tank 5. After the repair, place it back into service per the NAVSUP instruction, and improved procedures.

Provide additional detail information – what we are currently doing, timeline, etc.

7-3 Continue with performing the Clean, Inspect, and Repair of the tanks in the order proposed in Section 6 above.

Provide additional detail information – what we are currently doing, timeline, etc.

7-4 Adapt the proposed new Quality Control and Quality Assurance processes

Provide additional detail information – what we are currently doing, timeline, etc.

7-5 Install new Fire Suppression System with oil tight doors

Provide additional detail information – what we are currently doing, timeline, etc.

7-6 Increase frequency of testing of the tanks via the Leak Detection System.

Provide additional detail information – what we are currently doing, timeline, etc.

7-7 Investigate updating and/or validating the existing Leak Detection Systems

Provide additional detail information – what we are currently doing, timeline, etc.

7-8 Incorporate findings developed by the Corrosion and Metal Fatigue Practices

Provide additional detail information – what we are currently doing, timeline, etc.

7-9 Update the Power Capability in the tunnel.

Provide additional detail information – what we are currently doing, timeline, etc.