



**DEPARTMENT OF THE NAVY**

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5750

Ser N4/0490

April 24, 2017

**CERTIFIED NO: 7016 0910 0001 0899 9082**

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U.S. Environmental Protection Agency  
Region IX  
75 Hawthorne Street  
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Mr. Steven Y.K. Chang, P.E., Chief  
State of Hawaii Department of Health  
Environmental Management Division  
Solid and Hazardous Waste Branch  
919 Ala Moana Boulevard, Room 210  
Honolulu, HI 96814

Dear Mr. Pallarino and Mr. Chang:

**SUBJECT: ADMINISTRATIVE ORDER ON CONSENT STATEMENT OF WORK  
SECTION 2.4 TIRM PROCEDURES DECISION DOCUMENT AND  
IMPLEMENTATION, RED HILL BULK FUEL STORAGE FACILITY, JOINT  
BASE PEARL HARBOR-HICKAM, OAHU, HAWAII**

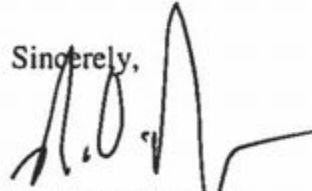
The Procedures Decision Document and Implementation for Red Hill pursuant to the Administrative Order on Consent ("AOC") Statement of Work ("SOW") Section 2.4, Decision Document/ Implementation, is enclosed.

The U.S. Department of the Navy ("Navy") and Defense Logistics Agency ("DLA") generated this Procedures Decision Document based on the concurrence with the U.S. Environmental Protection Agency ("EPA") and Hawaii Department of Health ("DOH") of objectives and requirements outlined in Section 2.3 having been met and the final decision meeting held on February 21, 2017. Once this submittal is approved by the EPA and DOH, the Navy and DLA shall implement the TIRM Procedures Decision Document and adhere to it unless it becomes modified under Section 3.5 and/or Section 3.7 of the AOC-SOW.

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Ser N4/0490  
April 24, 2017

Should you have any questions regarding this matter, please contact, Mr. Mark S. Manfredi, Red Hill Regional Program Director, at (808) 473-4148 or via e-mail at mark.manfredi@navy.mil.

Sincerely,

A handwritten signature in black ink, appearing to read 'R. D. Hayes, III', with a long horizontal stroke extending to the right.

R. D. HAYES, III  
Captain, CEC, U.S. Navy  
Regional Engineer  
By Direction of the  
Commander

Enclosure: 1. Red Hill Administrative Order on Consent Scope of Work Deliverable

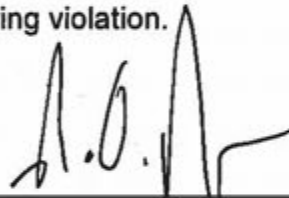
Red Hill Administrative Order on Consent Scope of Work Deliverable

SECTION 2.4: TANK INSPECTION, REPAIR, AND MAINTENANCE PROCEDURE  
DECISION DOCUMENT, dated 24 April 2017.

In accordance with the Red Hill Administrative Order on Consent, Paragraph 9,  
DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fines and imprisonment for knowing violation.

Signature: \_\_\_\_\_



CAPT R. D. Hayes III, CEC, USN  
Regional Engineer, Navy Region Hawaii

Date: \_\_\_\_\_

4/24/2017



**SITE SPECIFIC REPORT  
SSR-NAVFAC EXWC-CI-1745  
24 APRIL 2017**

**RED HILL FACILITY  
TANK INSPECTION, REPAIR, AND MAINTENANCE  
PROCEDURE DECISION DOCUMENT  
ADMINISTRATIVE ORDER ON CONSENT (AOC)  
STATEMENT OF WORK (SOW) SECTION 2.4**



Prepared by:  
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REPORT DOCUMENTATION PAGE			FORM APPROVED OMB NO. 0704-0188		
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1. REPORT DATE (DD-MM-YYYY) 24-04-2017		2. REPORT TYPE Site Specific Report		3. DATES COVERED (From – To) 2010-2017	
4. TITLE AND SUBTITLE RED HILL FACILITY TANK INSPECTION, REPAIR, AND MAINTENANCE PROCEDURE DECISION REPORT Administrative Order on Consent (AOC) STATEMENT OF WORK (SOW) SECTION 2.4			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Ms. Terri Regin, PE Mr. Frank Kern, PE Mr. James Gammon Mr. Lean-Miguel Sanpedro			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) NAVFAC EXWC 1000 23 <sup>RD</sup> AVE PORT HUENEME, CA			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) NAVFAC EXWC 1000 23RD AVE PORT HUENEME, CA			10. SPONSOR / MONITOR'S ACRONYM(S) NAVFAC EXWC		
			11. SPONSOR / MONITOR'S REPORT NUMBER(S) SSR-NAVFAC EXWC-CI-1745		
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This report, "Red Hill Facility Tank Inspection, Repair, and Maintenance Procedure Decision Document" summarizes the recommendations of the TIRM Report as required in the Red Hill AOC SOW Section 2.4. The "TIRM Procedure Decision Report" provides the final recommendations for Red Hill AOC SOW Section 2.4. The recommendations are based on a thorough review and understanding of the underlying cause and contributory factors of the Red Hill Tank 5 fuel release.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
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## EXECUTIVE SUMMARY

The Red Hill Administrative Order on Consent (AOC) and Statement of Work (SOW) are the result of discussions held between the Parties; Navy, Defense Logistics Agency (DLA), U.S. Environmental Protection Agency (EPA), and State of Hawaii Department of Health (DOH) following the Red Hill Tank 5 release. The order was approved by the stakeholders on 28 September 2015. The Red Hill AOC and SOW established a roadmap going forward to investigate and implement the best available practices. The roadmap consists of the following eight sections:

- Section 1 - Overall Project Management
- Section 2 - Tank Inspection, Repair and Maintenance
- Section 3 - Tank Upgrade Alternatives
- Section 4 - Release Detection/Tank Tightness Testing
- Section 5 - Corrosion and Metal Fatigue Practices
- Section 6 - Investigation and Remediation of Releases
- Section 7 - Groundwater Protection and Evaluation
- Section 8 - Risk/Vulnerability Assessment

The “Red Hill Facility Tank, Inspection, Repair and Maintenance (TIRM) Report” was published on 11 October 2016. The report was required by AOC SOW Section 2.2. The report followed the outline that was developed by the Navy and approved by EPA and Hawaii DOH on 23 March 2016. This report, “Red Hill Facility Tank Inspection, Repair, and Maintenance Procedure Decision Document” summarizes the recommendations of the TIRM Report and sets forth a schedule for implementation as required in the AOC SOW Section 2.4. Attachment A of this report is the errata to the TIRM report.

This “TIRM Procedure Decision Document” provides the final recommendations for Red Hill AOC SOW Section 2.4. The recommendations are based on a thorough review and understanding of the underlying cause and contributory factors of the Red Hill Tank 5 fuel release. Most of the TIRM recommendations are included in the two contracts awarded in August 2016 to Clean, Inspect, and Repair (CIR) Red Hill Tanks 4, 13, 14, 17, and 18. There are two recommendations that will be incorporated in the current contracts via a modification if required, and another recommendation that will be accomplished via a separate project. Additional TIRM recommendations will be deferred until the recommendations on Tank Upgrade Alternatives from Section 3 and Release Detection/Tank Tightness Testing technologies from Section 4 are developed and have been agreed upon by all Parties. The following are the recommendations that are stated in the TIRM Report, and the status of their implementation.



## TIRM IMPROVEMENTS – CURRENTLY BEING IMPLEMENTED

- **Tank Inspection Specification.**  
The specification codifies the inspection procedures, the use of high tech electronic inspection equipment used during the previous Red Hill tank inspections, requires destructive testing of coupons cut from each tank to determine the welding method most compatible with the steel, provides requirements for management and control of inspection data, and establishes the qualification requirements for inspection personnel.
- **Tank Repair Specification.**  
This specification sets the requirements for repair of existing welds and installation of patch plates to cover defects found in the steel plates. It provides the standards and minimum requirements for welding, weld inspection, and weld testing; the certification standards that welders, inspectors, and testers must meet to be qualified to do the work; and provides management and control of gas test holes drilled through the tank shell.
- **Construction Management.**  
Navy. The Contracting Officer, project manager, and design manager functions will be performed by personnel at Naval Facilities Engineering Command (NAVFAC) Engineering and Expeditionary Warfare Center (EXWC) in Port Hueneme, California. The Contracting Officer's representative, construction manager (includes quality assurance (QA) and environmental oversight), and safety officer functions will be performed on-site by NAVFAC HAWAII personnel at Pearl Harbor, Hawaii.  
  
Contractor. The project manager, quality control manager, and site safety and health officer functions will each be performed by a separate individual on-site at Pearl Harbor. Additionally, the quality control manager will report directly to a corporate officer, not to the project manager.
- **NAVFAC use of Standard design-build contract specific to Petroleum, Oils, and Lubricants (POL) work.**  
The two on-going contracts are design-build contracts. They standardize general requirements, specify adherence to the Navy Quality Control (QC) program, and require the Contractor's Quality Control Manager role to be independent.
- **Tank Re-filling and Return-To-Service Instruction.**

For each Red Hill tank, the tank owner, Fleet Logistics Center Pearl Harbor (FLCPH), will prepare a step-by-step procedure to insure that all tank repairs and maintenance are certified to be complete, and re-fill the tank with fuel to resume normal service.

- Tank Tightness Testing Frequency.  
The Navy has increased the frequency of Red Hill tank tightness testing from biennial to annual.

#### TIRM IMPROVEMENTS – PLANNING TO BE IMPLEMENTED

- Update to Tank Cleaning Specification.
- Spot Coat areas where the coating is currently disbonded, coat patch plates, spot or stripe coat selected areas.
- Install a slotted aluminum tube in each tank to house probes for the existing Automatic Tank Gauge (ATG) System.
- Develop as-built drawings of each tank.

#### TIRM IMPROVEMENTS – DEPENDENT ON OTHER AOC SOW SECTIONS

- Install a tell-tale leak detection/collection system in each tank.
- Coat entirety of tank.
- Investigate capabilities of Low Range Differential Pressure (LRDP) precision tightness apparatus.
- Reactivation of Existing LRDP precision tightness apparatus.

#### CONSIDERED TIRM IMPROVEMENTS – NOT RECOMMENDED

- Remove all existing coating from the Lower Dome and Barrel and re-coat.
- Hydrotest the tank (fill it with water) to test for tightness.
- Remove channels covering the welded joints between shell plates in the Upper Dome.

This Report also includes inspection and repair schedules of all of the tanks for (1) current base-line schedule, (2) base-line schedule plus performing the recommendations that are planned to be implemented, (3) base-line schedule plus performing the Destructive Testing as required in the AOC SOW Section 5, and (4) combination of schedules (2) and (3) above.

Because the amount of work for each Section of the AOC SOW is different, each Section has its own timeline for completing its work. Also, there are some overlapping responsibilities between each Section. Consequently, some of the final decisions of the TIRM recommendations will be deferred until other Sections deliver final recommendations. The AOC SOW is an iterative process, which means that as work progresses, the findings from one Section may affect the recommendations of another Section.

As an aid to readers, a brief background on the Red Hill tank construction is included as Attachment B.

## ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AST	Aboveground Storage Tank
ATG	Automatic Tank Gauge
BAPT	Best Available Practicable Technology
BFET	Balanced Field Electromagnetic Testing
BPVC	Boiler and Pressure Vessel Code
CAD	Computer Aided Design
CIR	Clean, Inspect, and Repair
CM	Construction Manager
COR	Contracting Officer's Representative
CQC	Contractor Quality Control
CR	Continuing Resolution
DLA	Defense Logistics Agency
DOH	Department of Health
EPA	Environmental Protection Agency
ET	Engineer Technician
EXWC	Engineering and Expeditionary Warfare Center
FLC	Fleet Logistics Center
FLCPH	Fleet Logistics Center Pearl Harbor
JBPHH	Joint Base Pearl Harbor Hickam
LFET	Low-Frequency Electromagnetic Testing
LRDP	Low-Range Differential Pressure (leak detection)
MACC	Multiple Award Construction Contract
NAVFAC	Naval Facilities Engineering Command
NAVSUP	Naval Supply Systems Command
NDE	Non-Destructive Examination
NFAS	Naval Facilities Acquisition Supplement
NFESC	Naval Facilities Engineering Service Center
P-445	NAVFAC P-445 Construction Quality Management Program
PAUT	Phased Array Ultrasonic Testing
POL	Petroleum, Oils, and Lubricants
QA	Quality Assurance
QC	Quality Control
QCM	Quality Control Manager
RFP	Request for Proposal

SME	Subject Matter Expert
SOW	Statement of Work
Std	Standard
TIRM	Tank Inspection, Repair, and Maintenance
TUA	Tank Upgrade Alternatives
UFGS	Unified Facilities Guide Specification
UT	Ultrasonic Testing
VOC	Volatile Organic Compound

## TABLE OF CONTENTS

### **PART A – TIRM IMPROVEMENTS – CURRENTLY BEING IMPLEMENTED**

Chapter 1	Specification for Tank Inspection	1-1
Chapter 2	Specification for Tank Repair	2-1
Chapter 3	NAVFAC QA Design, Construction, and Project Management Roles Distributed Across Separate Individuals	3-1
Chapter 4	NAVFAC Locating Construction Management and QA Oversight at The Local Component	4-1
Chapter 5	NAVFAC Use of Standard Design-Build Contract Specific to POL Work	5-1
Chapter 6	New Filling and Return to Service Instruction	6-1
Chapter 7	Increase Frequency of Tightness Testing from Biennial to Annual	7-1

### **PART B – TIRM IMPROVEMENTS – PLANNING TO BE IMPLEMENTED**

Chapter 8	Update UFGS Section 33 65 00 Cleaning Petroleum Storage Tanks	8-1
Chapter 9	Spot Coat Areas Where the Coating is Currently Disbonded, Coat Patch Plates, Spot or Stripe Coat Selected Areas	9-1
Chapter 10	Provide ATG Slotted Tubes to Provide Compliance with DLA ATG Policy Letter	10-1
Chapter 11	Design to Document Tank Conditions	11-1

### **PART C – TIRM IMPROVEMENTS – DEPENDENT ON OTHER AOC SOW SECTIONS**

Chapter 12	Install Telltale Leak Detection/Collection System	12-1
Chapter 13	Coat Entirety of Tank	13-1
Chapter 14	Investigate Capabilities of LRDP Leak Detection System	14-1
Chapter 15	Reactivate Existing Mass-Based LRDP Precision Tightness Apparatus	15-1

### **PART D – CONSIDERED TIRM IMPROVEMENTS – NOT RECOMMENDED**

Chapter 16	Coat Lower Dome and Barrel to the Top of the Barrel Region	16-1
Chapter 17	Hydrotest Tank as a Means to Determine Tightness	17-1
Chapter 18	Remove Upper Dome Cover Channels	18-1

## **PART E – SCHEDULE FOR IMPLEMENTATION OF RECOMMENDATIONS**

Chapter 19 Schedule

19-1

## **LIST OF ATTACHMENTS**

- A Errata
- B Brief Background on Red Hill Tank Construction
- C Red Hill Tank CIR Schedule



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## **PART A – TIRM IMPROVEMENTS – CURRENTLY BEING IMPLEMENTED**

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## CHAPTER 1 - SPECIFICATION FOR TANK INSPECTION

(Attachment BD of the TIRM Report)

### 1-1 INTRODUCTION

As a means to improve the process which is used to inspect a Red Hill tank, the Navy has developed a Unified Facilities Guide Specification (UFGS) Section in accordance with MIL-STD-3007F. The specification formalizes criteria for a Red Hill tank inspection and memorializes process innovations. Implementation of the specification acts to help minimize the threat of release.

### 1-2 SPECIFIC BENEFITS

- a. Standardize a Red Hill tank inspection.  
Establishes the basis for future inspection methods, leverages lessons learned, and sets minimum performance standards.
- b. Reduce variability in inspection results.  
Optimizes inspection efforts towards producing both tank-specific actionable findings as well macro-level information.
- c. Provide the basis for substantive reports.  
Addresses lessons learned by removing imprecise terminology and avoiding contradictory findings.
- d. Establish qualification requirements for personnel.  
Minimize uncertainty by establishing performance qualification and certification requirements for inspection personnel.
- e. Quantify Non-Destructive Examination (NDE) reliability.  
This will primarily be accomplished by AOC SOW Section 5 Corrosion and Metal Fatigue Practices. Depending on the results of that Section, the TIRM may be changed. In any event, the inspection specification will qualify NDE technology and personnel.
- f. Provide for destructive testing in order to perform metallurgical, mechanical, and weldability testing; evaluate reliability of NDE backside corrosion data. Evaluating reliability of NDE results will primarily be accomplished by AOC SOW Section 5 Corrosion and Metal Fatigue Practices. The TIRM will focus on improving as-built dataset by establishing a metallurgical database for each tank.
- g. Require establishment of a professional data management system.  
Addresses lessons learned by requiring a professional database which will not only maintain data integrity but will bring uniformity in data collection across the tanks.

- h. Require management of gas test holes.  
Addresses the underlying cause of the Tank 5 release by requiring repair of every gas test hole, as well as incorporating the test hole locations into the inspection database.
- i. Inspection to take place before and during tank cleaning.  
Minimizes chances of damaging sound coating as the result of overpressurizing the coating surface during tank cleaning.
- j. Include detailed submittal requirements such as the certification of inspectors and NDE technicians.  
Formalizes the process for submitting proposed inspection personnel for Government quality assurance oversight.

### 1-3 TIRM REPORT REFERENCES

The following paragraphs in the TIRM Report discuss TIRM Report Attachment BD and its implementation.

- a. Paragraph 16-4.3 – Development of a Specification for Tank Inspections
- b. Paragraph 17-2 – Development of a New Specification for Tank Inspection
- c. Paragraph 21-2 – TIRM Improvements Being Implemented

### 1-4 CURRENT IMPLEMENTATIONS

1-4.1 As noted in TIRM Report Paragraph 20-2, the Navy will be performing another modified American Petroleum Institute (API) Standard (Std) 653 inspection of Tank 5. The contract for the reinspection was awarded in March 2017. Since the work is a reinspection and the tank is already out of service and clean, not all elements of TIRM Report Attachment BD are appropriate. However contract technical requirements fully deploy all improvements which resulted from lessons learned on Tank 5. In addition, contract requirements deploy numerous best practices from TIRM Report Attachment BD which will result in a reliable and high-quality inspection. Specific elements of TIRM Report Attachment BD included in the contract to reinspect Tank 5 are listed below.

- a. Professional design of the inspection means and methods is required.
- b. Management of gas test hole installation and repair (if they are necessary to safely perform work) is specified.
- c. Complementary screening methods capable of detecting and sizing surface, near-surface, product-side, and backside imperfections are required.
- d. Tailor corrosion rate calculations into tank regions and types of indications.

- e. Perform visual inspection of tank surfaces. See TIRM Report Attachment BD for more information.
  - f. Deploy Low-Frequency Electromagnetic Testing (LFET) to scan tank plates for imperfections. See TIRM Report Paragraph 4-2.1.1 for more information. Utilize Ultrasonic Testing (UT) to determine relevancy and size. See TIRM Report Paragraphs 4-2.1.3 and 4-2.1.4 for discussion of the various types of UT that are available to be used.
  - g. Deploy Balanced Field Electromagnetic Testing (BFET) to scan welds for imperfections. See TIRM Report Paragraph 4-2.1.2 for more information. Utilize UT to determine relevancy and size. See TIRM Report Paragraphs 4-2.1.4 for more information.
  - h. Deploy redundant methods of NDE. For example, backside corrosion imperfections found during LFET or BFET scanning will be proved up with Phased Array Ultrasonic Testing (PAUT). See TIRM Report Attachment BD for more information.
  - i. Produce a test plan and perform hydrostatic tests of tank nozzle piping.
  - j. Evaluate the reliability of nondestructive examination systems and operators which will be deployed in the tank plate and weld scanning. Demonstrate the capability of equipment and operators to detect flaws.
  - k. Examine specific tank joints with vacuum box testing.
  - l. Develop and deploy procedures for nondestructive test methods which are compliant with industry code American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) V.
  - m. Establish a database of inspection findings. Record associated geometric data. Manage the database in a secure, auditable, and organized manner. Provide safeguards to ensure data integrity. See TIRM Report Attachment BD for more information.
  - n. Examine the inaccessible nozzle piping with visual methods using high definition remote video units. See TIRM Report Attachment BD for more information.
- 1-4.2 As noted in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. The contracts were executed prior to full development of TIRM Report Attachment BD. However, the successful contractor's proposal included numerous improvements and betterments which exceeded contract requirements. Many of the improvements implement elements of TIRM Report Attachment BD. The improvements and betterments in the proposal, pursuant to Naval Facilities Acquisition Supplement (NFAS) 5252.236-9312 are part of the

contract. A summary of specific improvements to TIRM procedures which will be deployed in the ongoing inspection and repair contracts is listed below.

- a. A robust plan to address access to the tank interior which distinguishes access limitations of various regions and provides means and methods tailored to each region. See TIRM Report Paragraph 21-3 for more information.
- b. A plan to optimize movement of personnel in the tunnels. See TIRM Report Paragraphs 2-9 for more information.
- c. Provisions to supply and maintain equipment to meet all temporary electrical, ventilation, and compressed air loads at the inspection workspaces. See TIRM Report Paragraphs 2-5, 2-7, and 2-12 for more information.
- d. Management of gas test hole installation and repair. See TIRM Report Attachment BD for more information.
- e. Deployment of LFET and BFET scanning for imperfections. See TIRM Report Paragraphs 4-2.1.1 and 4-2.1.2 for more information.
- f. For aggressive corrosion conditions, deployment of three dimensional capability using dual linear array ultrasonic equipment.
- g. Examine the inaccessible nozzle piping with visual methods using high definition remote video units. See TIRM Report Attachment BD for more information.
- h. Engineered test plan and performance of hydrostatic tests on tank nozzle piping. See TIRM Report Attachment BD for more information.
- i. Physical examination of the large bore nozzle with conventional visual and UT means. See TIRM Report Attachment BD for more information.
- j. Utilization of a specialty engineering subcontractor to produce the tank inspection design, perform API inspection, and oversee nondestructive examination results. See TIRM Report Paragraph 17-2.1 for more information.
- k. Onsite testing of NDE examiner skills to demonstrate competency prior to starting tank scan. See TIRM Report Paragraph 17-2.1 for more information.
- l. Random sample validation by the specialty engineering subcontractor of NDE results to ascertain whether the quality control program is functioning in an effective manner.
- m. Maintenance of a serialized database of findings. See TIRM Report Attachment BD for more information.
- n. Development of specific weld procedure specifications and procedure qualifications for the project, based on chemical analysis of the actual base metal. See TIRM Report Attachment BD for more information.

- o. Sequence tank inspection and validation of predicted repairs to occur during the design phase of the contract. See TIRM Report Paragraph 21-2 for more information.

#### 1-5 SCHEDULE

The draft tank inspection specification, TIRM Report Attachment BD, will be finalized to incorporate constructive comments to the Draft Specification received from stakeholders and external Subject Matter Experts (SME) prior to the issuance of the next CIR tank contract. See TIRM Report Paragraph 19-6.2 for more information. The next tank in the CIR cycle, as noted in TIRM Report Paragraph 19-6.2, will be either Tank 11 or Tank 3 depending on which of the tanks currently under contract is on track to be completed first. As of April 2017, the expected deployment date of the finalized tank inspection specification is 2019 for Tank 3.

#### 1-6 FUTURE IMPLEMENTATION

Prior to publication, edits on the draft specification will be finalized and the references will be updated to incorporate the latest revision. The specification will be published along with other specification sections to form a set of prescriptive specifications produced as part of the contract's Request for Proposal (RFP). The prescriptive specifications will become Part 5 of the next CIR contract document.



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## CHAPTER 2 - SPECIFICATION FOR TANK REPAIR

(Attachment BE of the TIRM Report)

### 2-1 INTRODUCTION

As a means to improve the process which is used to repair a Red Hill tank and to address lessons learned from Tank 5, the Navy has developed a UFGS Section in accordance with MIL-STD-3007F. The specification formalizes criteria for a Red Hill tank repair and memorializes process innovations. Implementation of the specification acts to help minimize the threat of release.

### 2-2 SPECIFIC BENEFITS

- a. Standardize many aspects of repair.  
This establishes the basis for future repair designs, leverages lessons learned, and sets minimum performance standards.
- b. Reduce variability in performance.  
Establishes a clearing house for minimum performance standards in areas of repair materials, design, welding, repair, and inspection of repairs.
- c. Provide the basis for record drawings documenting conditions to and changes made to a tank.
- d. Establish minimum qualification requirements for key personnel (welder, weld inspector, NDE technicians).  
Establishes minimum qualification and certification requirements for certain key roles such as welder, weld inspector, nondestructive examiner, tank engineer, and independent testing organization.
- e. Establish weld inspection and NDE frequency.  
Formalizes minimum performance requirements.
- f. Establish weld and NDE acceptance criteria.  
Puts into one place various acceptance criteria to provide clarity to contractors.
- g. State minimum repair design requirements.  
Sets performance requirements to elevate the standard of care.
- h. Establish repair requirements for gas test holes.  
Addresses the underlying cause of the Tank 5 release by requiring repair of every gas test hole, as well as incorporating the repair locations into the repair database.
- i. Require validation of repairs to occur during the design phase.  
Improves the TIRM process by requiring the repair design to be informed by the inspection results.

- j. Specify standards for materials used in repair.  
Sets minimum material requirements.
- k. Require in-progress review of repairs by API Std 653 inspector.  
Addresses a contributory cause of the Tank 5 release by requiring inspection of the repairs by the inspector of record.

## 2-3 TIRM REPORT REFERENCES

- a. Paragraph 16-4.4 – Development of a Specification for Tank Repairs
- b. Paragraph 17-3 – Development of a New Specification for Tank Repair
- c. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

## 2-4 CURRENT IMPLEMENTATION

As noted in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. The contracts were executed prior to full development of TIRM Report Attachment BE. However, the successful contractor's proposal included numerous improvements and betterments which exceeded contract requirements. Many of the improvements implement elements of TIRM Report Attachment BE. The improvements and betterments in the proposal, pursuant to NFAS 5252.236-9312, are part of the contract. A summary of specific improvements to TIRM procedures which will be deployed in the ongoing inspection and repair contracts is listed below.

- a. A robust plan to address access to the tank interior which distinguishes access limitations of various regions and provides means and methods tailored to each region. See TIRM Report Paragraph 21-3 for more information.
- b. A plan to optimize movement of personnel and materials in the tunnels. See TIRM Report Paragraph 2-9 for more information.
- c. Provisions to supply and maintain equipment to meet all temporary electrical, ventilation, and compressed air loads at the repair workspaces. See TIRM Report Paragraphs 2-5, 2-7, and 2-12 for more information.
- d. Management of gas test hole installation and repair. See TIRM Report Attachment BE for more information.
- e. Utilization of a specialty engineering subcontractor to produce the repair design, oversee nondestructive examination oversight, audit repairs, and produce as-built drawings. See TIRM Report Paragraph 17-2.1 for more information.

- f. Onsite testing of NDE examiner skills to demonstrate competency prior to performing examination of repairs. See TIRM Report Paragraph 17-2.1 for more information.
- g. Maintenance of a serialized database of repairs. See TIRM Report Attachment BE for more information.
- h. Utilization of a specialty engineering subcontractor to inspect repair welding with qualified personnel. See TIRM Report Attachment BE for more information.
- i. Perform an API Std 653 post-repair inspection. See TIRM Report Attachment BE for more information.

## 2-5 SCHEDULE FOR COMPLETION

The draft tank repair specification, TIRM Report Attachment BE, will be finalized to incorporate constructive comments to the Draft Specification received from stakeholders and external SMEs prior to the issuance of the next CIR tank contract. See TIRM Report Paragraph 19-6.2 for more information. The next tank in the CIR cycle, as noted in TIRM Report Paragraph 19-6.2, will be either Tank 11 or Tank 3 depending on which of the tanks currently under contract is on track to be completed first. As of April 2017, the expected deployment date of the finalized tank inspection specification is 2019 in Tank 3.

## 2-6 FUTURE IMPLEMENTATION

Prior to publication, edits on the draft specification will be finalized and the references will be updated to incorporate the latest revision. The specification will be published along with other specification sections to form a set of prescriptive specifications produced as part of the contract's RFP. The prescriptive specifications will become Part 5 of the next CIR contract document.

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## **CHAPTER 3 - NAVFAC QA DESIGN, CONSTRUCTION, AND PROJECT MANAGEMENT ROLES DISTRIBUTED ACROSS SEPARATE INDIVIDUALS**

### **3-1 INTRODUCTION**

During Tank 5 inspection and repair, NAVFAC concentrated contract project management, construction management, and design management QA roles in an individual who was responsible for multiple projects simultaneously. As a means to improve the process which is used to inspect and repair a Red Hill tank and to address lessons learned from Tank 5, the Navy has changed the distribution of the roles and responsibilities for QA. Implementation of this new distribution acts to increase oversight and reduce the threat of release.

### **3-2 SPECIFIC BENEFITS**

- a. The separation and distribution of project roles amongst different individuals spreads work load more evenly and allows more QA to take place.
- b. Vesting project, design, and construction management in different individuals leverages the expertise of various NAVFAC communities. This approach recognizes capabilities in the organization and more appropriately aligns job function with skill set.
- c. NAVFAC is a global military Command with a headquarters element and Component Commands that work together as one team. The change in NAVFAC distribution of roles and responsibilities implements the Command concept of operations to provide critical services and support to the Fleet and Combatant commanders.

### **3-3 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discuss the distribution of project roles and its implementation.

- a. Paragraph 11-3 – Solution or Improvement [as a lesson learned]
- b. Paragraph 15-2 – Observations and Shortcomings
- c. Paragraph 15-3 – Solution or Improvement
- d. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

### **3-4 CURRENT IMPLEMENTATION**

As noted in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. Changes to the Navy distribution of roles and responsibilities have already taken place and are in full effect for these contracts. The Contracting Officer Representative (COR) oversight and the Construction Manager (CM) and Engineer Technician (ET) roles are different individuals. The project management role is a different individual forward deployed on-island. Navy management of the design, a different individual, will be performed by NAVFAC both in Port Hueneme, California and on-island.

### 3-5 FUTURE IMPLEMENTATION

Continuous process evaluation will be performed to identify improvements. Should additional resources be required, the Navy has means to elevate the level of effort. Should substantive process improvements be identified, the Navy will implement them in the next CIR tank contract. See TIRM Report Paragraph 19-6.2 for more information. The next tank in the CIR cycle, as noted in TIRM Report Paragraph 19-6.2, will be either Tank 11 or Tank 3 depending on which of the tanks currently under contract is on track to be completed first.

## **CHAPTER 4 - NAVFAC LOCATING CONSTRUCTION MANAGEMENT AND QA OVERSIGHT AT THE LOCAL COMPONENT**

### **4-1 INTRODUCTION**

During Tank 5 inspection and repair, NAVFAC performed construction management with an individual who was based in California. As a means to improve the process which is used to inspect and repair a Red Hill tank and to address lessons learned from Tank 5, the Navy has placed the construction management role on-island. Implementation of this change acts to increase construction oversight and reduce the threat of release.

### **4-2 SPECIFIC BENEFITS**

- a. The construction management role, which is specific and well defined in the NAVFAC engineering community, is located on-island at the NAVFAC office onboard Joint Base Pearl Harbor Hickam (JBPHH). This allows timely response to project challenges and allows more QA to take place.
- b. Core competencies of a CM have unique qualities in the NAVFAC business model. Attaching an individual possessing these competencies targets corporate efficiencies, avoids lapses in QA oversight, and addresses the lessons learned on Tank 5.
- c. Pursuant to NAVFAC business management process, a construction manager will be designated for each contract.
- d. The COR, designated for each contract, is located on-island at the NAVFAC office onboard JBPHH.
- e. The ET role, which is specific and well defined in the NAVFAC engineering community, is located on-island at the NAVFAC office onboard JBPHH. This allows timely response to project challenges and allows more QA to take place.
- f. Collectively the CM, COR, and ET will provide primary Navy QA oversight of construction. Since individuals performing these roles are located on-island, the level and efficiency of quality and safety oversight – location-dependent activities – is substantially elevated above prior efforts.

### **4-3 TIRM REPORT REFERENCES**



The following paragraphs in the TIRM Report discuss local construction and QA management and its implementation.

- a. Paragraph 15-2 – Observations and Shortcomings
- b. Paragraph 15-3 – Solution or Improvement
- c. Paragraph 16-4 – Government Quality Assurance
- d. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

#### 4-4 CURRENT IMPLEMENTATION

As noted in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. Changes to Navy construction management and QA oversight have already taken place and are in full effect for these contracts.

#### 4-5 FUTURE IMPLEMENTATION

Continuous process evaluation will be performed to identify improvements. Should additional resources be required, the Navy has means to elevate the level of effort. Should substantive process improvements be identified, the Navy will implement them in the next CIR tank contract. See TIRM Report Paragraph 19-6.2 for more information. The next tank in the CIR cycle, as noted in TIRM Report Paragraph 19-6.2, will be either Tank 11 or Tank 3 depending on which of the tanks currently under contract is on track to be completed first.

## **CHAPTER 5 - NAVFAC USE OF STANDARD DESIGN-BUILD CONTRACT SPECIFIC TO POL WORK**

### **5-1 INTRODUCTION**

As a means to improve the process which is used to inspect and repair a Red Hill tank, the Navy awarded a specialty construction contract for POL fuel systems. The contract formalizes the NAVFAC design-build model and deploys specialty engineering and construction expertise. The contract model includes parts which utilize the MasterFormat™ 2010 structure, as published by the Construction Specifications Institute. Part 2 is Division 01 general requirements and incorporates NAVFAC-tailored UFGS Sections to specify requirements for products, material, and workmanship. Included in the Part 2 are the UFGS Sections that define the requirements for contractor quality control, safety, and schedule. Implementation of the NAVFAC specialty contract acts to minimize the threat of release.

### **5-2 SPECIFIC BENEFITS**

- a. The contract's Part 2 includes UFGS Section 01 45 00.05 20, which is the NAVFAC implementation of Contractor Quality Control (CQC), pursuant to NAVFAC P-445 Construction Management Program (P-445).
- b. Adherence to P-445 will require the Quality Control Manager (QCM) role to be independent of production, safety, and project management.
- c. The contract's Part 2 is a standard execution model across the NAVFAC design-build enterprise. Use of Division 01 specifications will leverage NAVFAC COR, CM, and ET competencies which are trained in their use.

### **5-3 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discuss the use of the specialty design-build contract, its implementation, and how P-445 is part of it.

- a. Paragraph 16-2 – POL Multiple Award Construction Contract (MACC) Contract Information
- b. Paragraph 6-6 – Quality Assurance and Quality Control Program for Repair Verification
- c. Paragraph 9-5 – Additional Changes to be Implemented
- d. Paragraph 11-2.2 – Manual P-445 [tenets of the NAVFAC Manual]
- e. Paragraph 16-1 – Introduction [quality control improvements]

- f. Paragraph 16-5 – Contractor Quality Control Plan
- g. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

#### 5-4 CURRENT IMPLEMENTATION

As stated in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. Changes to Navy contract model and incorporation of Division 01 specifications have already taken place and are in full effect for these contracts. The Division 01 specifications include UFGS Section 01 45 00.05 20 Design and Construction Quality Control, which requires adherence to P-445. This improvement addresses lessons learned and contributory causes of the Tank 5 release.

#### 5-5 FUTURE IMPLEMENTATION

Continuous process evaluation will be performed to identify improvements. The next tank in the CIR cycle, as noted in TIRM Report Paragraph 19-6.2, will be either Tank 11 or Tank 3 depending on which of the tanks currently under contract is on track to be completed first. During development of the contract, improvements will be incorporated into the Division 01 specification sections as they are tailored specifically to the project.

## CHAPTER 6 - NEW FILLING AND RETURN TO SERVICE INSTRUCTION

(Attachment AZ of the TIRM Report)

### 6-1 INTRODUCTION

This Chapter discusses the benefits of the new instruction, provides references to the TIRM Report, and how this recommendation will be used in the current and future CIR projects.

### 6-2 SPECIFIC BENEFITS

- a. Standardize the filling and return to service process for a storage tank.  
The instruction provides specific direction on the paperwork and approval process required to issue fuel to a tank that has been out of service, for any reason, including after it has been removed from service for cleaning, inspection, or repair.
- b. Mandates receipt of suitability for service statement prior to refilling.  
The instruction requires a statement signed by an appropriately certified tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service.
- c. Documents that all repairs have been completed; compares with inspection report to ensure all repairs have been completed prior to refilling.  
The instruction requires a list of repairs that were identified during the inspection, including completed repairs, and repairs that are still pending (which can be completed once the tank is returned to service).
- d. Receipt of final inspection report prior to refilling.  
The final inspection report is to be compliant with the applicable code (i.e., API Std 653) including all required calculations and analysis.
- e. Receipt of proper turnover documentation from NAVFAC prior to refilling.  
A statement signed by an agent of NAVFAC (i.e., Project Manager), and the repair contractor, that custody of the tank is returned to the activity and that items in paragraph b, c, and d above have been provided to the Naval Supply Systems Command (NAVSUP) Fleet Logistics Center (FLC).
- f. Prior to return to service, development of a specific procedure for filling the tank being returned to service.  
A tank-specific Operations Order is prepared in accordance with local tank filling standard operating procedures. The specific procedure includes: (1)

tank filling procedures, (2) physical inspection, gauging, and trend analysis, and (3) emergency drain-down plan.

- g. Approval of a tank specific operations order by the Fleet Logistics Center Pearl Harbor (FLCPH) Commanding Officer prior to refilling the tank. Upon receipt of the tank-specific operations order, and the signed turn-over documentation from NAVFAC, the NAVSUP FLC Commanding Officer will provide approval to execute the operations order and return the tank to service.

### 6-3 TIRM REPORT REFERENCES

The following paragraphs in the TIRM Report discuss this Instruction and its implementation.

- a. Paragraph 9-4 – Filling Procedures
- b. Paragraph 9-5.a – Additional Changes to be Implemented
- c. Chapter 12 – Lesson #3 Refilling Procedure
- d. Paragraph 13-3.a – Solution or Improvement
- e. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

### 6-4 CURRENT IMPLEMENTATION

The following is an excerpt from Part 3 of the current CIR contracts:

**Fuel Tank Return to Service Requirements**

Prepare return to service documentation for each tank. Refer to NAVFAC Red Zone (NRZ) Checklist for POL Storage Tank and NAVSUPGLINST 10345.1. Provide adequate schedule time to comply with NRZ requirements in [UFGS] Section 01 32 17.05 20 and [UFGS] Section 01 45 00.05 20.

Submit in accordance with [UFGS] Section 01 33 00.05 20. At minimum provide the following.

- a. Inspection report
- b. Suitability for Service Statement
- c. List of repairs identified during the inspection
- d. List of repairs recommended prior to the next external or internal inspection
- e. List of pending repairs annotated with due dates
- f. Third-party calibration (strapping) charts
- g. Signed statement which declares: 1) Custody of the tank is returned to the Activity 2). Items a through f above have been provided to the Contracting Officer.

### 6-5 FUTURE IMPLEMENTATION

The same statement will be included in Part 3 of future CIR contracts. It will be reviewed and modified, if necessary.

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## **CHAPTER 7 - INCREASE FREQUENCY OF TIGHTNESS TESTING FROM BIENNIAL TO ANNUAL**

### **7-1 INTRODUCTION**

This Chapter addresses the advantages of increasing the frequency of tank tightness testing, provides references to the TIRM Report, and how this recommendation will be used in the current and future CIR projects.

### **7-2 SPECIFIC BENEFITS**

The Navy and DLA have been compliant with regulatory requirements for tank tightness testing. As a best management practice, the Navy and DLA have decided to halve the test interval and conduct the tests annually. This new practice is compliant with new regulatory requirements for tightness testing which will come into effect in 2018. Refer to the Red Hill AOC SOW Section 4 Report for further details.

### **7-3 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discuss this Instruction and its implementation.

- a. Paragraph 20-6 – Increase Frequency of Tank Tightness Testing
- b. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

### **7-4 CURRENT IMPLEMENTATION**

Implementation of additional tightness testing has been implemented by the Navy and DLA. The testing program remains compliant with current regulatory requirements as well as requirements to become effective in 2018.

### **7-5 FUTURE IMPLEMENTATION**

Capabilities of technologies for use in future tightness testing are being investigated in AOC SOW Section 4 Release Detection/Tank Tightness Testing. Future implementation for annual tightness testing is dependent on the outcome of the decision made in that Section.



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## **PART B – TIRM IMPROVEMENTS – PLANNING TO BE IMPLEMENTED**

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## **CHAPTER 8 - UPDATE UFGS SECTION 33 65 00 CLEANING PETROLEUM STORAGE TANKS**

### **8-1 INTRODUCTION**

This Chapter discusses the benefits of updating the specification, provides references to the TIRM Report, and how this recommendation will be used in the current and future CIR projects.

### **8-2 SPECIFIC BENEFITS**

- a. Avoids damage to coating during cleaning and to account for pressure and temperature of power wash.  
A prescriptive specification to indicate the pressure requirements for the water used during cleaning a tank will provide assurance that the existing coating will not be stripped during the cleaning operations.
- b. Requires contractor to provide test patch of the power wash technique.  
The specification will require the contractor to perform quality control on a test patch to ensure that the pressure washing will not cause well-adhered coating to disband from the tank shell.

### **8-3 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discusses the Tank Cleaning specification.

- a. Chapter 14 - Lesson #5 – Cleaning and Initial Inspection
- b. Paragraph 21-2, Table 2-1 – TIRM Improvements Being Implemented

### **8-4 CURRENT IMPLEMENTATION**

Since this Tank Cleaning UFGS Section has not yet been updated, this recommendation is considered not currently implemented. However, the improvements can be realized in current contracts should additional cleaning work be required. If the updated specification is not available when the change to a current CIR contract is made, the requirements themselves will be added into the verbiage of the modification.

- a. Red Hill Tanks 14 and 17 were previously cleaned by Willbros. The cleanliness of the tank and the condition of the coating has not yet been

determined. If further cleaning is determined to be required, improvements to avoid damage to the coating, to account for pressure and temperature of power wash, and for the Contractor to provide test patch of the power wash technique will be incorporated.

- b. The following is an excerpt from UFGS Section 33 65 00 of the current CIR contracts. This paragraph does not specifically state the water pressure to be used, but it does state to not clean the steel to bare metal. The specification does not require test plates prior to cleaning for quality control testing.

### 3.5 TANK CLEANING

For the interior of the tanks, the upper dome, barrel and extension rings, lower dome, catwalk, tower, stairs, shell projections, structural supports, piping, tubes, sample lines, manways, product openings, and other interior accessory equipment, shall be cleaned not to bare metal but only to the sound surface of the lining or coating, free of rust, dirt, disbanded coating, scale, loose materials, fuel, oil, grease, sludge, carbon, and other deleterious materials. Clean surfaces as-required to perform inspection per API Std 653, RFP Part 3 requirements, [UFGS] Section 09 97 13.27, and [UFGS] Section 09 97 13.15. Do not damage sound existing lining material unless required to comply with API Std 653, RFP Part 3 requirements, [UFGS] Section 09 97 13.27, and [UFGS] Section 09 97 13.15. Remove unsound or loose lining or coating and clean the surfaces exposed thereby to bare metal or concrete as applicable.

## 8-5 FUTURE IMPLEMENTATION

UFGS Section 33 65 00 will be included in future CIR contracts. If the updated version of this specification is not available during the development of the RFP for the next CIR contracts, a paragraph in Part 3 of the RFP will be included. The paragraph will include verbiage to avoid damage to coating during cleaning, to account for pressure and temperature of power wash, and for the Contractor to provide test patch of the power wash technique.

## 8-6 SCHEDULE

The schedule to update UFGS Section 33 65 00, and several others, is currently dependent on the Continuing Resolution (CR). The Government is currently being funded by a CR, passed in December 2016, through April 28, 2017. The schedule for updating the specifications is approximately one (1), which will start when the Government's appropriation bills are passed by Congress.

## **CHAPTER 9 - SPOT COAT AREAS WHERE THE COATING IS CURRENTLY DISBONDED, COAT PATCH PLATES, SPOT OR STRIPE COAT SELECTED AREAS**

### **9-1 INTRODUCTION**

This Chapter discusses the benefits of spot coating selected areas of the tank, provides references to the TIRM Report, what is currently being coated and how this recommendation will be incorporated in the current and future CIR projects.

### **9-2 SPECIFIC BENEFITS**

- a. Areas more susceptible to internal corrosion are coated with a barrier system.
- b. The coating system is thick and flexible so it can bridge small discontinuities in metal surfaces.
- c. Minimizes chance of bimetallic corrosion between new and old steel and in heat affected zone of fillet welds.

### **9-3 TIRM REPORT REFERENCES**

- a. Paragraph 17-2.2.5(c) – Coating
- b. Paragraph 17-6.2 – Background [regarding Navy coating system]
- c. Paragraph 21-2, Table 21-1 – TIRM Improvements Being Implemented

### **9-4 WHERE AND TYPE OF COATING CURRENTLY BEING USED**

As stated in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. Contract requirements include the tank interior coating specification UFGS Section 09 97 13.15 Low Volatile Organic Compound (VOC) Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks. This specification is a modern, flexible, thick-film solution which has been successfully deployed across the world in Navy storage tanks. The coating is to be applied in the lower dome only.

### **9-5 INCORPORATION OF RECOMMENDATION IN FUTURE CONTRACTS**

The next tank in the CIR cycle, as noted in TIRM Report Paragraph 19-6.2 of the TIRM Report, will be either Tank 11 or Tank 3 depending on which of the tanks currently under contract is on track to be completed first. During development of

the next contract, UFGS Section 09 97 13.15 will be incorporated into the engineering system requirements, on the lower dome and also spot coat the areas where the coating has disbonded, coat the patch plates, and spot or stripe coat selected areas.

## **CHAPTER 10 - PROVIDE ATG SLOTTED TUBES TO PROVIDE COMPLIANCE WITH DLA ATG POLICY LETTER**

### **10-1 INTRODUCTION**

This Chapter discusses the benefit of slotting the ATG stilling well tubes, provides references to the TIRM Report, how it is being addressed in the current CIR contracts, and how it will be incorporated in future CIR contracts.

### **10-2 SPECIFIC BENEFIT**

Replace current unslotted carbon steel ATG stilling wells with slotted aluminum ATG Stilling Wells.

The slots are necessary to prevent stratification of the fuel in wells versus in the tank. The slotting of the stilling well will provide more accurate ATG data. The DLA ATG Policy letter, TIRM Report Attachment BG, requires slotted aluminum stilling wells. However stilling wells made from aluminum are not required in the Red Hill tanks. The DLA ATG Policy was developed primarily for aboveground storage tanks (AST) where the stilling well is supported on the roof, and not fixed on the tank bottom. Therefore, for ASTs, the stilling wells need to be of a lighter weight than carbon steel in order to not require additional support to the roof for this additional weight. Since the carbon steel stilling wells in the Red Hill tanks are supported on the center tower, they do not need to be replaced with aluminum, but should be slotted if they are not already.

### **10-3 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discuss this policy and its implementation:

- a. Paragraph 17-12 – Stilling Wells
- b. Paragraph 21-3, Table 21-2 – Options for Improving the TIRM

### **10-4 INSPECTION REQUIREMENTS OF THE STILLING WELLS IN THE CURRENT CIR CONTRACTS**

The DLA ATG policy letter is incorporated into the current CIR contracts in Part 6 of the RFP document. Inspection results of the stilling well are required per the Full Inspection Report Format that is also included in Part 6 of the RFP. As



stated in the Full Inspection Report Format, slotting of the stilling wells, if they are not already slotted, will be considered a “Non-Mandatory Recommended Repair.”

#### 10-5 FUTURE IMPLEMENTATION OF RECOMMENDATION IN FUTURE CIR CONTRACTS

The current CIR contracts will determine if the ATG stilling well is currently slotted or not. If it is not slotted, a repair to slot the ATG stilling well will be included as a task in Part 3 of the future RFPs.

## CHAPTER 11 - DESIGN TO DOCUMENT TANK CONDITIONS

### 11-1 INTRODUCTION

Each Red Hill tank has unique conditions and historical repairs, many of which are sparsely documented. This Chapter addresses the recommendation to develop and produce electronic designs which document known conditions of each operational Red Hill tank. Tanks 1 and 19 will not be included in this effort because they are not being operated. The intent of this recommendation is to memorialize, in Computer Aided Design (CAD) drawings:

- a. The original construction and design variations which are known to exist between tanks.
- b. The known changes that have been made to the tanks since original construction.

### 11-2 SPECIFIC BENEFITS

- a. The drawings will be used as the concept design for future inspection and repair projects.
- b. The designs will complement the new inspection and repair specifications discussed in Chapters 1 and 2 of this TIRM Procedure Decision Document.
- c. Provide living as-built documentation for any future changes, updates, and improvements to the tanks.
- d. Reduce the variability between engineering firms and increase the quality of Red Hill tank inspection and repair.

### 11-3 TIRM REPORT REFERENCES

The following paragraph in the TIRM Report discusses the development of tank condition design documents.

- a. Paragraph 17-10 – Design to Document Tank Conditions
- b. Paragraph 21-3, Table 21-2 – Optional TIRM Improvements

### 11-4 CURRENT METHOD OF DOCUMENTING TANK CONDITIONS

As noted in TIRM Report Paragraph 20-3, in August 2016 the Navy awarded modified API Std 653 inspection and repair contracts for Tanks 14, 17, 18, 4, and 13. The contracts were executed prior to full development of the TIRM Report

recommendations. However, the Navy will receive detailed inspection data and repair information on these tanks, as well as detailed inspection information from Tank 5. This information will be used to inform the designs to document tank conditions for these six tanks.

#### 11-5 FUTURE IMPLEMENTATION OF DEVELOPING TANK DESIGN DOCUMENTS

The Navy plans to implement the work in phases in order to synchronize the priority of designs to meet the schedule of tank CIR as stated in this TIRM Procedure Decision Document Chapter 19. The phasing will provide for designs to be complete prior to the respective tank CIR evolution.

#### 11-6 SCHEDULE FOR DEVELOPMENT OF TANK DESIGN DOCUMENTS

Implementation of this plan will involve development of an independent project which will be initiated in FY17. Depending on the funding, project development is expected to take place in the second and third quarter of FY17. Contract award is planned for the first quarter of FY18. Since the project will be independent and phased as detailed above, there will be no impact to the overall TIRM schedule.

## **PART C – TIRM IMPROVEMENTS – DEPENDENT ON OTHER AOC SOW SECTIONS**

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## CHAPTER 12 - INSTALL TELLTALE LEAK DETECTION/COLLECTION SYSTEM

### 12-1 INTRODUCTION

This Chapter addresses the advantages of installing a telltale leak detection and collection system on the Red Hill storage tanks.

### 12-2 TELLTALE SYSTEM OVERVIEW

- a. The TIRM Report Paragraph 17-7.2.a describes the telltale system for Red Hill tanks as follows:

The tell-tale leak detection system provides a real-time, analog tool for identifying potential releases, collects product trapped in the reinforced concrete shell to steel liner interstice, and provide[s] a pathway to relieve product from the interstice.

- b. The TIRM Report Paragraph 1-3.1.2 describes how the telltale system was used during the original construction phase.
- c. The TIRM Report Paragraph 17-7 provides background on the history of the system, its advantages and disadvantages, and improvements which were made over the years to the design.
- d. TIRM Report Attachment BF contains detailed background information about the telltales and includes a 1972 Navy memorandum which makes the case for the system to be kept functional.

### 12-3 IMPLEMENTATION OF THE TELLTALE SYSTEM

During the development of the TIRM Report, it was decided to defer the recommendation of reinstalling the telltale leak detection and collection system to AOC SOW Section 3 Tank Upgrade Alternatives (TUA) and AOC SOW Section 4 Release Detection/Tank Tightness Testing. Depending on the outcome of decisions made in those Sections, future TIRM work performed may include implementation of the telltale systems.

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## **CHAPTER 13 - COAT ENTIRETY OF TANK**

### **13-1 INTRODUCTION**

This Chapter addresses the alternative to coat the entire inner surface of the Red Hill storage tanks.

### **13-2 COATING OVERVIEW**

The TIRM Report Paragraph 17-6 describes the history of the internal coating system for Red Hill tanks which includes a 50-year-old thin-film system composed of polyurethane over epoxy. This system was not the typical Navy specification at the time which was similar to UFGS Section 09 97.13.17 Three Coat Epoxy Interior Coating of Welded Steel Petroleum Fuel Tanks.

A different specification was designed by the Navy circa 2010 for a polysulfide epoxy coating with low VOCs. This system offers multiple advantages, including durability for 50 years, high abrasion resistance, lower porosity, easier quality control during application, and compliance with many environmental regulations. TIRM Report Paragraph 17-6 contains details about UFGS Section 09 97 13.15 Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks.

### **13-3 DECISION TO COAT THE ENTIRETY OF A RED HILL TANK**

The decision to coat the entirety of a Red Hill tank will be discussed in AOC SOW Section 3 Tank Upgrade Alternatives. Depending on the outcome of decisions made in that Section, future TIRM work may include coating of the entirety of a tank.



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## CHAPTER 14 - INVESTIGATE CAPABILITIES OF LOW RANGE DIFFERENTIAL PRESSURE LEAK DETECTION SYSTEM

### 14-1 INTRODUCTION

This Chapter addresses the advantages of investigating the capabilities of a LRDP leak-detection system for Red Hill tanks.

### 14-2 LRDP OVERVIEW

The TIRM Report Paragraph 20-7 describes the LRDP leak-detection system, which was developed for the Red Hill tanks by the Naval Facilities Engineering Services Center (NFESC) and Vista Research, Inc. in 1999. The LRDP system was installed in Tanks 9 and 16 and underwent third-party evaluation. However since this time the system has not been used. TIRM Report Paragraph 20-7.a states:

The Navy/DLA is currently planning to reactivate the LRDP in Tank 9 and evaluate its capabilities and compare it to the current Mass Technology system that is used for the annual tank tightness test requirement.

Further details are available in the Red Hill SOW Section 4.3 Report, "Red Hill Facility Current Fuel Release Monitoring Systems Report, Appendix F, "Market Survey of Leak Detection System for the Red Hill Fuel Storage Facility, Fleet Industrial Supply Center, Pearl Harbor," written by Michael Baker Jr., Inc. Specifically, Sections 3.1.3, 5.2, 6, and 7 (particularly Table 7-1, Item 2) of the report contain relevant information about LRDP.

The above report states that the advantages of the LRDP system include high leak-rate sensitivity (0.59 gal/hr), high instrument reliability, and excellent third-party certification (i.e., compliance with performance standards set by regulatory agencies like the EPA).

It would be beneficial to perform additional testing to analyze the benefits of real-time monitoring, the possibility of dynamic analysis, and direct communication with the FLCPH control operator.

### 14-3 LRDP SYSTEM INVESTIGATION

During the development of the TIRM Report, it was decided to investigate the capabilities of the LRDP system in AOC SOW Section 4 Release Detection/Tank Tightness Testing. Depending on the outcome of decisions made in that Section, future TIRM work may include investigation of the capabilities of the LRDP system.

## **CHAPTER 15 - REACTIVATE EXISTING MASS-BASED LOW RANGE DIFFERENTIAL PRESSURE PRECISION TIGHTNESS APPARATUS**

### **15-1 INTRODUCTION**

This Chapter addresses the advantages of reactivating the existing mass-based LRDP precision tightness apparatus on the Red Hill tanks.

### **15-2 LRDP OVERVIEW**

Chapter 14 of this TIRM Procedure Decision Document contains a brief overview of LRDP. TIRM Report Paragraph 20-7 describes the system and some of its capabilities at Red Hill.

The Red Hill SOW Section 4.3 Report, “Red Hill Facility Current Fuel Release Monitoring Systems Report, Appendix F includes Appendix A titled “Addendum to the Evaluation of the LRDP-24 and the LRDP-24-n on Bulk Field-Constructed Tanks: Final Report” by Ken Wilcox Associates, Inc. This report evaluates the LRDP-24 and LRDP-24-n systems for leak detection on Red Hill Tank 9. It assesses whether the system can be used for any Red Hill storage tank because of the hemispherical top and bottom geometry, and concludes that no scaling has been found. In other words, the system is compatible with the Red Hill tanks. Therefore, the system can be reactivated. Reactivating the LRDP system will provide enhanced tightness-testing capabilities for Tank 9.

### **15-3 LRDP SYSTEM REACTIVATION**

It has been decided the recommendation to reactivate the LRDP system will be discussed in AOC SOW Section 4 Release Detection/Tank Tightness Testing. Depending on the outcome of decisions made in that Section, future TIRM work may include reactivation of the LRDP system.

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## **PART D – CONSIDERED TIRM IMPROVEMENTS – NOT RECOMMENDED**

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## **CHAPTER 16 - COAT LOWER DOME AND BARREL TO THE TOP OF THE BARREL REGION**

### **16-1 INTRODUCTION**

This Chapter provides the TIRM Report reference and a discussion on why this improvement is not recommended.

### **16-2 TIRM REPORT REFERENCES**

The following paragraph in the TIRM Report discusses the option to coat the lower dome and barrel to the top of the barrel region.

- a. Paragraph 21-3, Table 21-2 – Optional TIRM Improvements

### **16-3 DISCUSSION ON WHY THIS IMPROVEMENT IS NOT RECOMMENDED**

UFGS Section 09 97 13.15 Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks contains rigorous requirements for surface preparation, environmental control, and material application. Consideration of the option to coat the lower dome and barrel to the top of the barrel region involves the following:

- a. Each Red Hill tank lower dome is already programmed for application of a new coating system during the CIR cycle.
- b. The Navy intends to spot and stripe coat selected areas of the tank as a TIRM improvement.
- c. At Red Hill, performing work to meet the specification for the entirety of the barrel region is a massive undertaking that will substantially extend the current TIRM schedule.
- d. The barrel region is, during ordinary operations, immersed in non-corrosive product.
- e. The AOC SOW Section 3 Tank Upgrade Alternatives is considering an alternative to recoat the entire tank using this coating system. Depending on the outcome of the decision made in Section 3, future TIRM work may include implementation of coating the entire tank.

For these reasons, applying coating to just the entire barrel region is not recommended.



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## **CHAPTER 17 - HYDROTEST TANK AS A MEANS TO DETERMINE TIGHTNESS**

### **17-1 INTRODUCTION**

This Chapter provides the TIRM Report reference and a discussion on why this improvement is not recommended.

### **17-2 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discuss the option to hydrotest the tank as a means to determine tightness.

- a. Paragraph 17-8 – Tank Hydrotesting With Water
- b. Paragraph 21-3, Table 21-2 – Optional TIRM Improvements

### **17-3 DISCUSSION ON WHY THIS IMPROVEMENT IS NOT RECOMMENDED**

Hydrotesting an aboveground storage tank is sometimes performed under the auspices of API Std 653 in order to strength test a tank after major repairs. Due to the unique construction of a Red Hill tank, the shell does not have the same stresses as an ordinary aboveground storage tank. For this reason, hydrotesting a Red Hill tank has greatly diminished utility.

Hydrotesting the Red Hill tanks as a means to determine tightness was performed during the original wartime construction project. During this era, the tank was gradually filled with water and high pressure air was pumped through the then existing telltale system piping to identify leaks by observing bubbles in the water. Today, the lack of an installed telltale system and environmental regulations make this method unfeasible.

For reasons stated above and upon consideration of disadvantages given in TIRM Report Paragraph 17-8.4, hydrotesting to determine tightness is not recommended.

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## **CHAPTER 18 - REMOVE UPPER DOME COVER CHANNELS**

### **18-1 INTRODUCTION**

This Chapter provides the TIRM Report reference and a discussion on why this improvement is not recommended.

### **18-2 TIRM REPORT REFERENCES**

The following paragraphs in the TIRM Report discuss the option to remove the upper dome channels in order to fill tanks to the designed heights and recover lost capacity.

- a. Paragraph 17-11 – Remove Upper Dome Cover Channels
- b. Paragraph 21-3, Table 21-2 – Optional TIRM Improvements

### **18-3 DISCUSSION ON WHY THIS IMPROVEMENT IS NOT RECOMMENDED**

The current operational procedure does not fill the tank into the upper dome. The fillet welds on the cover channels in the upper dome are being examined with BFET and visual means, and repaired during current TIRM procedures. Removing the cover channels, examining upper dome butt welds, and performing repairs is a massive undertaking that will substantially extend the TIRM schedule. For these reasons, removing the cover channels in order to fill tanks to the designed heights is not recommended. Should the Navy decide to increase fill heights, the decision to remove the cover channels or continue to repair them will be revisited.

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## **PART E – SCHEDULE FOR IMPLEMENTATION OF RECOMMENDATIONS**

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## CHAPTER 19 - SCHEDULE

### 19-1 INTRODUCTION

This Chapter sets forth the schedule for TIRM at Red Hill.

### 19-2 SCHEDULE IN THE TIRM REPORT

The TIRM schedule was included in the TIRM Report as Attachment BM. Since this schedule was published, the overall schedule has changed due to the acquisition process for the re-inspection of Tank 5.

### 19-3 CHANGE OF SCHEDULE DUE TO IMPLEMENTATIONS OF IMPROVEMENTS LISTED IN PART A OF THIS REPORT.

The improvements listed in Part A of this report are included in the schedule provided in Attachment C.

### 19-4 CHANGE OF SCHEDULE DUE TO IMPLEMENTATION OF IMPROVEMENTS LISTED IN PART B OF THIS REPORT.

- a. There are two TIRM improvements that are recommended in the TIRM Report which can affect the overall schedule. These are (1) spot coat areas where the coating is currently disbonded, coat patch plates, spot or stripe coat selected areas, and (2) provide ATG slotted tubes to provide compliance with DLA ATG Policy Letter.
- b. The coating of the bottom dome is currently scheduled for:
  - (1) Blast & first coat = 25 days
  - (2) Apply top coat = 15 days
  - (3) This equates to a total of 40 workdays. (56 calendar days)

Therefore, without any additional knowledge of how many patch plates, areas of disbondment, and the linear feet of stripe coating that will be required, the revised schedule as shown in Table 19-1 will extend the schedule for a total of 56 calendar days. This work cannot be performed at the same time as coating of the tank bottom dome since it is not safe for people and equipment to work above other people at the same time.

- c. The second TIRM Improvement, slotting of the stilling well, is currently planned to be executed at the same time as the installation of the patch



plates since this work will be on the tower, not the tank shell. Different means of access will enable this work to not influence the overall schedule.

- d. The third recommended TIRM improvement, "Design to Document Tank Conditions" can be executed concurrently and as part of the TIRM process. This will be a separate project from the TIRM contracts during its initial development. Drawings for each tank will be initially developed using known data, but will be modified during each tank inspection, and then modified again after each tank repair. This project will be initiated in FY18, unless funding becomes available earlier.

#### 19-5 DEPENDENCIES BETWEEN IMPLEMENTATION OF TIRM RECOMMENDATIONS AND OTHER AOC SECTIONS.

- a. Red Hill AOC SOW Section 5 Corrosion and Metal Fatigue Practices.  
The destructive testing in Tank 17 will take approximately the following number of days:
  - (1) Taking of samples = 10 days. Additional days are included for any delays due to discussions during the process.
  - (2) Installation of patch plates = 5 days
  - (3) Non-destructive Examination of the patch plate welds. = 1 day.
  - (4) This equates to a total of 16 work days (22 calendar days)

This work will be the first task that the Contractor performs after the design of this task, and before any required repairs resulting from the inspection. Due to the number of people who will be involved in this task, no other work will be allowed to be on-going in the tank. The effect to the overall schedule for the destructive testing is shown in Table 19-2 below.

- b. Red Hill AOC SOW Section 4 Release Detection/Tank Tightness Testing.  
The effect to the overall schedule due to the installation of electronic leak detection system will be dependent on the type of leak detection system that is selected to be installed in the tanks. One system can be installed quickly and possibly with the tank in service and another system will take several days to install when the tank is out of service. In addition to the installation, time will be required to test and validate the installed system.

The mechanical leak detection system (telltals) and its installation will also be evaluated during the AOC SOW Section 4 Release Detection/Tank Tightness Testing. It is anticipated that this system will take several weeks to install while the tanks are out of service.

The final report for AOC SOW Section 4 will address how each system will affect the overall schedule for the inspection and repair of the tanks.

c. Red Hill AOC SOW Section 3 Tank Upgrade Alternatives.

The effect to the overall schedule due to the Tank Upgrade Alternatives and Best Available Practicable Technology (BAPT) selected will be addressed in the AOC SOW Section 3 Tank Upgrade Alternatives report.

## 19-6 COMPARISON OF SCHEDULES

Table 19-3 provides a comparison between the baseline schedule and the implementation of the TIRM improvements stated in paragraph 19-4 and the destructive testing stated in paragraph 19-5.a above.

**Table 19-1: Comparison between Baseline and Implementation of Recommendation Schedules**

The following compares the baseline schedule to the schedule for implementing the two recommendations to the TIRM process:

**Baseline Schedule**

Tank #	Duration	Start	Finish
Tank 5	495 days	8/1/2016	6/22/2018
Tank 14	550 days	5/12/2016	6/20/2018
Tank 17	605 days	5/12/2016	9/5/2018
Tank 18	960 days	5/12/2016	1/15/2020
Tank 13	620 days	5/12/2016	9/26/2018
Tank 4	952 days	5/12/2016	1/3/2020
Tank 11	640 days	2/14/2019	7/28/2021
Tank 12	640 days	2/14/2019	7/28/2021
Tank 3	640 days	2/4/2019	7/16/2021
Tank 8	640 days	8/27/2020	2/8/2023
Tank 9	640 days	8/27/2020	2/8/2023
Tank 7	640 days	3/10/2022	8/21/2024
Tank 10	640 days	3/10/2022	8/21/2024
Tank 15	640 days	3/10/2022	8/21/2024
Tank 16	1040 days	3/10/2022	3/4/2026
Tank 6	640 days	9/21/2023	3/4/2026
Tank 2	640 days	9/21/2023	3/4/2026
Tank 20	640 days	4/3/2025	9/15/2027

**Additional Time for Coating patch plates, etc (40 days)**

Tank #	Duration	Start	Finish	Delta from baseline
Tank 5	495 days	8/1/2016	6/22/2018	0
Tank 14	550 days	5/12/2016	6/20/2018	0
Tank 17	605 days	5/12/2016	9/5/2018	0
Tank 18	960 days	5/12/2016	1/15/2020	0
Tank 13	620 days	5/12/2016	9/26/2018	0
Tank 4	952 days	5/12/2016	1/3/2020	0
Tank 11	680 days	2/14/2019	9/22/2021	56
Tank 12	680 days	2/14/2019	9/22/2021	56
Tank 3	680 days	2/4/2019	9/10/2021	56
Tank 8	680 days	10/22/2020	5/31/2023	112
Tank 9	680 days	10/22/2020	5/31/2023	112
Tank 7	680 days	6/30/2022	2/5/2025	168
Tank 10	680 days	6/30/2022	2/5/2025	168
Tank 15	680 days	6/30/2022	2/5/2025	168
Tank 16	1120 days	6/30/2022	10/14/2026	224
Tank 6	680 days	3/7/2024	10/14/2026	224
Tank 2	680 days	3/7/2024	10/14/2026	224
Tank 20	680 days	11/13/2025	6/21/2028	280

**Table 19-2: Comparison of Baseline and Destructive Testing Schedules**

The following compares the baseline schedule to the schedule for removing and replacing the plates for the Red Hill AOC SOW Section 5 Corrosion and Metal Fatigue Practices:

**Baseline Schedule**

Tank #	Duration	Start	Finish
Tank 5	495 days	8/1/2016	6/22/2018
Tank 14	550 days	5/12/2016	6/20/2018
Tank 17	605 days	5/12/2016	9/5/2018
Tank 18	960 days	5/12/2016	1/15/2020
Tank 13	620 days	5/12/2016	9/26/2018
Tank 4	952 days	5/12/2016	1/3/2020
Tank 11	640 days	2/14/2019	7/28/2021
Tank 12	640 days	2/14/2019	7/28/2021
Tank 3	640 days	2/4/2019	7/16/2021
Tank 8	640 days	8/27/2020	2/8/2023
Tank 9	640 days	8/27/2020	2/8/2023
Tank 7	640 days	3/10/2022	8/21/2024
Tank 10	640 days	3/10/2022	8/21/2024
Tank 15	640 days	3/10/2022	8/21/2024
Tank 16	1040 days	3/10/2022	3/4/2026
Tank 6	640 days	9/21/2023	3/4/2026
Tank 2	640 days	9/21/2023	3/4/2026
Tank 20	640 days	4/3/2025	9/15/2027

**Additional Time for Section 5 coupons (16 days), Tank 17**

Tank #	Duration	Start	Finish	Delta from baseline
Tank 5	495 days	8/1/2016	6/22/2018	0
Tank 14	550 days	5/12/2016	6/20/2018	0
Tank 17	621 days	5/12/2016	9/27/2018	22
Tank 18	960 days	5/12/2016	1/15/2020	0
Tank 13	620 days	5/12/2016	9/26/2018	0
Tank 4	952 days	5/12/2016	1/3/2020	0
Tank 11	640 days	2/14/2019	7/28/2021	0
Tank 12	640 days	2/14/2019	7/28/2021	0
Tank 3	640 days	2/4/2019	7/16/2021	0
Tank 8	640 days	8/27/2020	2/8/2023	0
Tank 9	640 days	8/27/2020	2/8/2023	0
Tank 7	640 days	3/10/2022	8/21/2024	0
Tank 10	640 days	3/10/2022	8/21/2024	0
Tank 15	640 days	3/10/2022	8/21/2024	0
Tank 16	1040 days	3/10/2022	3/4/2026	0
Tank 6	640 days	9/21/2023	3/4/2026	0
Tank 2	640 days	9/21/2023	3/4/2026	0
Tank 20	640 days	4/3/2025	9/15/2027	0

**Table 19-3: Comparison between Baseline and Implementation of Recommendation and Destructive Testing Schedules**

The following table compares the baseline schedule to the schedule for implementing the two recommendations to the TIRM process and removing and replacing the plates for the Red Hill AOC SOW Section 5 Corrosion and Metal Fatigue Practices:

**Baseline Schedule**

Tank #	Duration	Start	Finish
Tank 5	495 days	8/1/2016	6/22/2018
Tank 14	550 days	5/12/2016	6/20/2018
Tank 17	605 days	5/12/2016	9/5/2018
Tank 18	960 days	5/12/2016	1/15/2020
Tank 13	620 days	5/12/2016	9/26/2018
Tank 4	952 days	5/12/2016	1/3/2020
Tank 11	640 days	2/14/2019	7/28/2021
Tank 12	640 days	2/14/2019	7/28/2021
Tank 3	640 days	2/4/2019	7/16/2021
Tank 8	640 days	8/27/2020	2/8/2023
Tank 9	640 days	8/27/2020	2/8/2023
Tank 7	640 days	3/10/2022	8/21/2024
Tank 10	640 days	3/10/2022	8/21/2024
Tank 15	640 days	3/10/2022	8/21/2024
Tank 16	1040 days	3/10/2022	3/4/2026
Tank 6	640 days	9/21/2023	3/4/2026
Tank 2	640 days	9/21/2023	3/4/2026
Tank 20	640 days	4/3/2025	9/15/2027

**Schedule for Recommendations + Section 5 coupons**

Tank #	Duration	Start	Finish	Delta from baseline
Tank 5	495 days	8/1/2016	6/22/2018	0
Tank 14	550 days	5/12/2016	6/20/2018	0
Tank 17	621 days	5/12/2016	9/27/2018	22
Tank 18	960 days	5/12/2016	1/15/2020	0
Tank 13	620 days	5/12/2016	9/26/2018	0
Tank 4	952 days	5/12/2016	1/3/2020	0
Tank 11	680 days	2/14/2019	9/22/2021	56
Tank 12	680 days	2/14/2019	9/22/2021	56
Tank 3	680 days	2/4/2019	9/10/2021	56
Tank 8	680 days	10/22/2020	5/31/2023	112
Tank 9	680 days	10/22/2020	5/31/2023	112
Tank 7	680 days	6/30/2022	2/5/2025	168
Tank 10	680 days	6/30/2022	2/5/2025	168
Tank 15	680 days	6/30/2022	2/5/2025	168
Tank 16	1120 days	6/30/2022	10/14/2026	224
Tank 6	680 days	3/7/2024	10/14/2026	224
Tank 2	680 days	3/7/2024	10/14/2026	224
Tank 20	680 days	11/13/2025	6/21/2028	280

## **ATTACHMENTS**

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## ATTACHMENT A

### ERRATA

#### RED HILL FACILITY TANK INSPECTION, REPAIR, AND MAINTENANCE REPORT (TIRM) ADMINISTRATIVE ORDER ON CONSENT (AOC) STATEMENT OF WORK (SOW)

ERRATA NO: 1  
REFERENCE Section 2.2 TIRM Report  
DATE: 24 April 2017

The Navy notes the following error in the Red Hill AOC SOW TIRM Report dated 11 Oct 2016.

Change 5-6.1, second paragraph, to read as follows:

WGS drilled gas test holes in the tank shell to sample for hydrocarbon vapors due to fuel which may have been in the tank shell to concrete interstice. The installation of the holes is industry practice per API RP ~~2510~~ 2207. The WGS inspection report stated “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.”

ERRATA NO: 2  
REFERENCE Section 2.2 TIRM Report  
DATE: 24 April 2017

The Navy notes the following change in the Red Hill AOC SOW TIRM Report dated 11 Oct 2016.

Change paragraph 6-2(b) to read as follows:

The Tank 5 warranty work took place in three phases. The first phase was forensic in nature with the objective to investigate and determine the underlying cause of the release. This investigation found the release was due to defects in workmanship by



Willbros. After 17 unrepaired gas test holes through the tank shell were found, the underlying cause of the release was clear and the forensic phase ended. Additional information on the forensic phase is contained in Chapter 9.

## ATTACHMENT B

### BRIEF BACKGROUND ON RED HILL TANK CONSTRUCTION

The Red Hill bulk storage facility was constructed circa 1940 – 1943 under the direction of Admiral Ben Moreell, the Chief of the Bureau of Yards and Docks and the Chief of Civil Engineers of the Navy. Twenty mined tanks, all connected by access tunnels, were constructed within a mountain ridge specifically chosen for its basalt geology in the Koolau Range.

Each tank is composed of three primary areas: a hemispherical upper dome, a cylindrical barrel, and a hemispherical lower dome. Each tank is approximately 250-feet high and is 100-feet in diameter. The interior surfaces of a tank are lined with ¼-inch thick welded steel plates except for a portion at the bottom of each tank which is lined with ½-inch thick steel plates. The steel liner is known as the tank shell. Each tank shell was constructed enclosed within a thick layer of reinforced concrete.

In the construction sequence of a Red Hill tank, a vertical shaft was mined down the centerline of the tank. Then the upper dome region was excavated and constructed. The welded steel dome liner was installed, and reinforced concrete was placed to surround the steel. The thickness of this concrete varies from 2-feet at the top to 8-feet at the base of the upper dome.

After construction of the upper dome, miners excavated basalt for the barrel and lower dome regions. Once excavation was complete, workers erected a steel tower which extends from the tank bottom to the upper dome. Much of the tank construction activity was supported by the center tower. The towers are still used today to support most tank inspection repair and maintenance activities.

Surfaces of the basalt excavation were covered with a layer of gunite to form the barrel. Once workers had placed reinforcement and welded the shell plates, concrete was placed around the steel. The concrete surrounding the barrel region ranged in thickness from 2.5-feet at the top to 4-feet at the bottom. Once the concrete had cured, it was pre-stressed by pumping grout to a specific pressure into the joint between the concrete and the gunite.

A massive plug of reinforced concrete, in some places 18-feet thick, was placed beneath the lower dome and to brace the center tower. Figure B-1 depicts a typical cross-section construction of a Red Hill tank.

More information on Red Hill tank construction is available at the Wikipedia® page: [https://en.wikipedia.org/wiki/Red\\_Hill\\_Underground\\_Fuel\\_Storage\\_Facility](https://en.wikipedia.org/wiki/Red_Hill_Underground_Fuel_Storage_Facility)

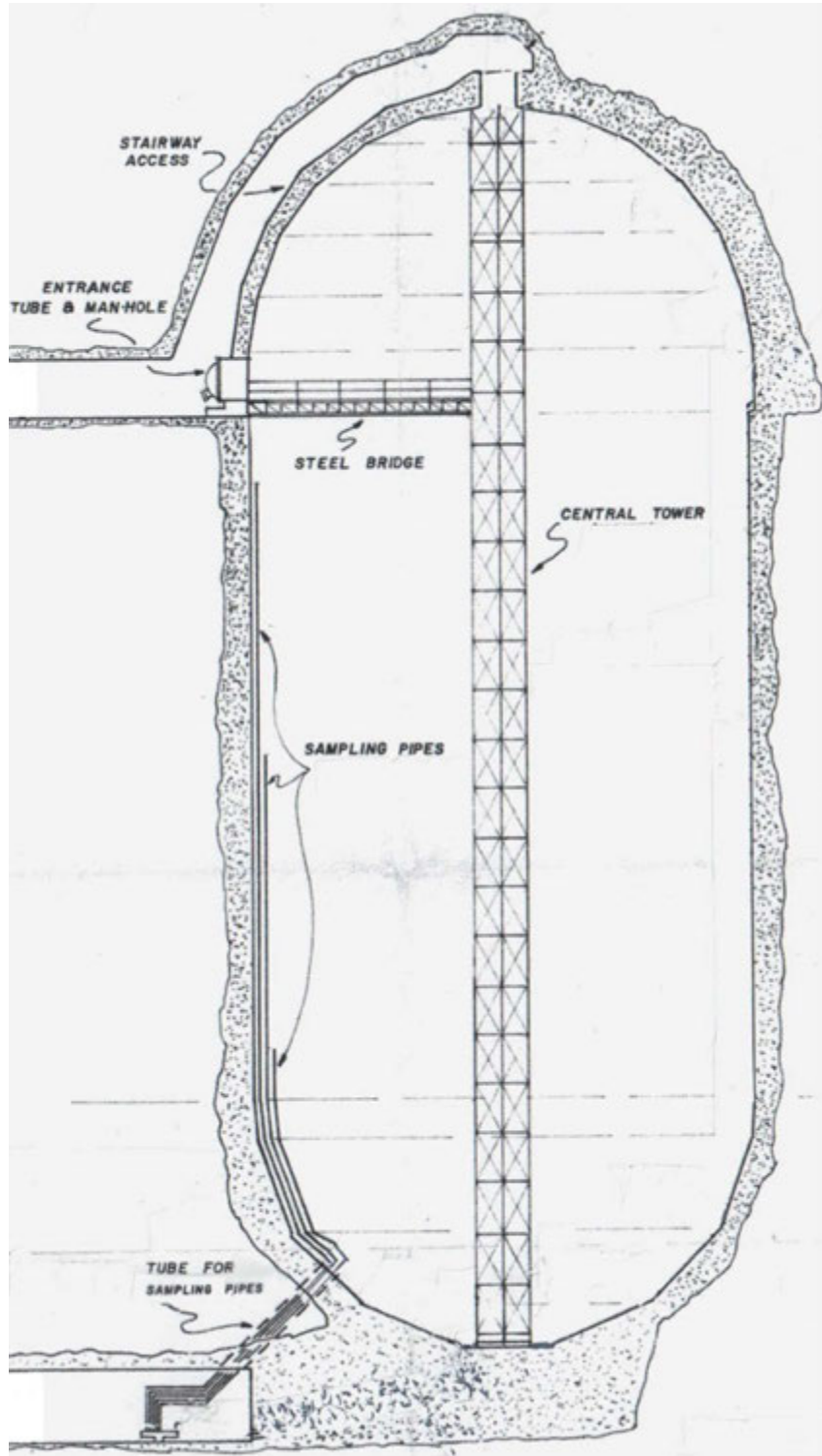


Figure B-1 Typical Tank Construction

