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Section 1.0

CERTIFICATION

1.0 Certification

1.1 **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 gathered and evaluated the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to 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 fine and imprisonment for knowing violations.

Thomas Kitchen, P.E.
API - 653 Certification #1891

Section 2

INTRODUCTION

2.0 Introduction

2.1 Mid Atlantic Environmental, Inc. conducted an inspection on Tank #8 at the Red Hill Underground Storage Facility, Pearl Harbor, Hawaii. This inspection was conducted in accordance with the scope of work identified by Contract Number N00604-97-R-0013, PRL 96-21, titled "Emergency Repair for Red Hill Tanks."

2.2 Inspection Support

2.2.1 Access to the inside surface of the tank was provided through the use of the booms and power climber basket shown on NAVFAC Drawing Number 7927650.

2.2.2 Personnel support was provided by Dames and Moore. This support included:

2.2.2.1 Hole watch,

2.2.2.2 Boom operator,

2.2.2.3 An assistant, either in the basket or on the tank bottom.

2.3 Phase 1

2.3.1 The initial phase of the inspection was to inspect the interior of the tank to identify and make repair recommendations for any of the following defects:

2.3.1.1 Deterioration and damage to the coating on the interior of the tank shell plates and welds.

2.3.1.2 Pits on the interior of the tank shell plates and welds.

2.3.1.3 Holes through the tank shell plates and welds.

2.3.1.4 Non-visible holes and cracks in the tank shell plates and welds that are identifiable by the nondestructive test or the visible seepage of fuel and/or water back into the tank.

2.3.1.5 Suspect areas, such as blisters in the tank shell plates.

2.4 Phase 2

2.4.1 The second phase of the inspection was a test of the tank bottom after removal of the coating. The following tests were conducted:

2.4.1.1 Sample ultrasonic thickness (UT) measurements were taken on the bottom plates and the first ascending plates,

2.4.1.2 Vacuum box testing of all welds was conducted on the bottom plates and the first ascending plates,

2.4.1.3 Testing for the presence of chlorides, soluble ferrous and ferric salts, alkaline/acidic contaminants and flame sprayed aluminum was conducted on the tank bottom.

Section 3

REFERENCES

3.0 References

3.1 **American Petroleum Institute**:

3.1.1 API Standard 650, Welded Steel Tanks for Oil Storage.

3.1.2 API Recommended Practice 651, Cathotic Protection of Aboveground Petroleum Storage Tanks.

3.1.3 API Recommended Practice 652, Lining of Aboveground Petroleum Storage Tank Bottoms.

3.1.4 API Standard 653, Tank Inspection, Repair, Alteration, and Reconstruction.

3.2 **American Society of Mechanical Engineers Codes:**

3.2.1 ASME Boiler and Pressure Vessel Code; Section V, Non Destructive Examination.

3.2.2 ASME Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications.

3.3 **Code of Federal Regulations:**

3.3.1 29 CFR 1910, Permit-Required Confined Spaces for General Industry.

3.4 **National Association of Corrosion Engineers:**

3.4.1 NACE Recommended Practice, RP0184-91, Repair of Lining Systems.

3.4.2 NACE Recommended Practice, RP0193-93, External Cathotic Protection of On-Grade Metallic Storage Tank Bottoms.

3.4.3 NACE Recommended Practice, RP0288-94, Inspection of Linings on Steel and Concrete.

3.5 **National Fire Protection Association:**

3.5.1 NFPA-30, Flammable and Combustible Liquids Code.

Section 4

TANK DESCRIPTION

4.0 TANK DESCRIPTION

The tank is a vertical cylinder, 257 feet high and 100 feet in diameter with both upper and lower domes. Each dome is a 50 foot radius hemisphere. The tank is underground and encased in concrete. Tank shell, upper and lower domes are 1/4 inch carbon steel plate, except the 20 foot flat bottom which is 1/2 inch thick.

Owner/Operator:	Fleet and Industrial Supply Center	
Location:	Pearl Harbor, HI	
Tank Number:	7	
Service:	Fuel Storage	
Capacity:	300,000 Bbl	
Diameter:	100 feet	
Shell Height:	155 feet	
Configuration:	Vertical	
Fill Height:	235 feet above flat bottom	
Foundation:	Concrete	
Construction:	Bottom:	Butt Welded
	Lower Dome:	Butt Welded
	Shell:	Butt Welded
	Upper Dome:	Butt Welded
Age:	56 years	
Specific Gravity:	1.00	
Seismic Zone:	Zone 1	
Construction Code:	Unknown	

Section 5

REPAIR HISTORY

Section 5

REPAIR HISTORY

RED HILL TANK NO. 7
PRODUCT: DFM

DATE	REMARKS
5/22/52	Cleaned tank. Labor Cost: $1898.30. Material: $398.60
10/11/63	Calibrated gauge.
4/64	Completed cleaning tank. Tank inspected. No corrosion. Good shape.
3/18/71	Emptied and cleaned for conversion.
4/20-5/3/71	Cleaned tank for Navy Distillate conversion. Installed flat steel bars around elevator shaft and catwalk inside of tank (256 hours). Labor cost: $1,024.
5/4/71	Topped off with Navy Distillate.
6/22/73	Emptied and cleaned for conversion.
6/23/73	Emptied and cleaned by Asteroid group for installation of gauging equipment.
7/13/73	Removed and installed new 6" valve on drain line.
9/11/73	Telemeter system installed. Converted to DFM.
11/14/73	Telltale #1 collector ring started to leak. Alarm sounded in sump pit. Transferred Navy Distillate to Tank 10.
11/26/73	Started to clean tank. Drain line plugged. Welded collector ring.
12/73	Tank cleaned to repair leak #1 telltale (collector ring). Found corroded jumper pipe in collector ring. Bad section of jumper pipe removed and new section welded in. Tank buttoned up on 5 December 1973.
7/74	Telemeter out.
5/22/78	Tank experienced significant telltale leakage during weekend of 20-21 May 1978 requiring immediate transfer of DFM inventory to other tankage.
6/9/78	Tank emptied and washed for contractors.
6/9/78	Completed fuel removal for turnover to contractor for MILCON P-060.
10/24/78	Contractor bagan work. Removed motorized valves and installed blanks.

DATE	REMARKS
2/15/80	Contractor notified ROICC that tank is ready to be returned to service.
2/11/80	Final inspection of tank was held on this date. As there were some discrepancies that needed to be corrected by the contractor, the tank was not accepted. The tank was accepted on 29 February 1980 and filled. This is the first tank to be completed under MILCON P-060.
2/20/80	Began refilling tank for leak test.

LEAK TEST DATA
(Note: Leak rate is based on data from telemetering)

DATE	FILL LEVEL	LEAK RATE (GAL/DAY)
2/20-7/20/80	Various 171-235	Bad data due to leaking skin valve.
7/21-25/80	235.0	609
7/26-31/80	214.8	334
8/1-7/80	209.9	208
8/9-9/10/80	207.0	12.7
9/10-10/4/80	207.0	12.0
10/22-11/12/80	206.9	2.6
11/13/80-1/8/81	206.9	3.1

8/7/80	Tank fill level dropped to 207.0 feet. Leak subsided. Tank maximum fill capacity temporarily reduced by 31.3 Mbbls. to 265.4 Mbbls.
1/8/81	Stopped leak test. Began use as receiving tank.
4/9/81	Tank was removed from service for leak repairs under MCON P-060.
5/3/81	Tank was returned to service for leak testing following completion of leak repairs.

Section 6

TESTING CONDUCTED

6.0 Testing Conducted

6.1 General: The internal inspection was conducted to gather the data necessary for the assessment of the interior of the tank. This data takes into account previous inspection information. An evaluation was conducted on the tank by means of visual inspection, NDE, including Ultrasonic, Dye Penetrant, and Vacuum Box testing. These results have been evaluated and are contained in the body of this report. Corrosion rates were established. A complete description of unusual conditions, as well as corrective action procedures is also included in the body of this report. All repair data is included in the body of this report.

6.2 Visual: To verify that the angle of vision and level of lighting were adequate for the visual inspection, a 1/32 inch wide black line on an 18% neutral grey background was used as a test guide.

6.3 Surface contamination of the tank bottom: After the tank bottom was brush blasted testing was performed for the presence of chlorides, soluble ferrous and ferrous salts, alkaline/acid contaminates per NACE Bulletin No.24118 using a KATA SCAT Kit (Surface Contamination Analysis Test Kit). The bottom was tested for the presence of flame sprayed aluminum using a caustic soda method.

Section 7
TESTING RESULTS

7.0 TESTING RESULTS

7.1 **Results of Internal Visual Inspection:**

7.1.1 A total of twenty two (22) defects were identified on the interior of the tank. These repairs are identified and described in section 9 of this report.

7.2 **Results of Bottom Inspection:**

7.2.1 The original bottom thickness was determined to be 0.500 inches and the first ascending plate to be 0.250 inches. The ultrasonic thickness measurements taken determined that backside corrosion in this area is not a problem. Pitting is not a problem since the remaining metal thickness is well within the 0.10 inches of metal required by API Standard 653 by the next inspection. Also the coating to be applied to the tank bottom should prevent any increase in pit depth. Although pitting is not a problem with regard to structural integrity, it did present a problem regarding the coating to be applied. Pictures of this pitting are included with this report. The surface contamination test results yielded 0% ferrous salts, 32 ppm Nacl and a ph level of 7. These results are within the limits set forth in the KTA SCAN Kit tecnical data and the NACE tecnical committee report on Surface Preparation of Contaminated Steel Surfaces. The Caustic Soda test of the tank bottom indicated that all Flame Sprayed Aluminum had been removed. By visual inspection, scattered pitting was observed on the tank bottom and first ascending plates. The deeper pits were measured and recorded on the Bottom Layout With Pit Indications drawing.

7.3 **Engineering Calculations:**

7.4 **KTA SCAT Kit Calculation Sheet:**

Calculation	Determination 1
Reading from Titratch Strip	0.005 ppm
(A) x milliliters of water	0.05 micrograms Cl
Calculate the area swabbed ($cm^2 = in^2 \times 2.54^2$)	103 cm^2
(microgram Cl) / (area swabbed)	0.0005 micrograms/cm^2 Cl
((micrograms) / (cm^2)) x 10	0.005 milligrams/cm^2 Cl

4 inch x 4 inch area tested
10 ml solution used

Results:	**Fe test = 0**	**Satisfactory**
	ph = 6	**Satisfactory**
	Quantum unit test = 1.2	**Satisfactory**
	% NaCl less than 0.005%	**Satisfactory**
	ppm less than 32	**Satisfactory**

7.3 Engineering Calculations (cont'd):

7.4.2 Minimum Thickness for Tank Bottom and Remaining Life:

$$MRT_1 = T_o - GC_a - StP_a - UP_m - (StP_r + UP_r + GC_r)O_{r1}$$

$$MRT_2 = T_o - GC_a - StP_m - UP_a - (StP_r + UP_r + GC_r)O_{r2}$$

$$O_{r1} = \frac{T_o - GC_a - StP_a - UP_m - MRT_1}{(StP_r + UP_r + GC_r)}$$

$$O_{r2} = \frac{T_o - GC_a - StP_m - UP_a - MRT_2}{(StP_r + UP_r + GC_r)}$$

Where:

MRT_1 or MRT_2	=	Minimum remaining thickness at the end of the in-service period of operation, in inches. MRT_1 represents minimum remaining thickness due to average internal pitting and maximum external pitting. MRT_2 represents minimum remaining thickness due to maximum internal pitting and average external pitting.
T_o	=	Original plate thickness, in inches.
StP_a	=	Average depth of internal pitting, in inches, measured from the original thickness.
StP_m	=	Maximum depth of internal pitting remaining in bottom plates after repairs are completed, in inches, measured from the original thickness.
UP_a	=	Average depth of underside pitting, in inches.
UP_m	=	Maximum depth of underside pitting, in inches.
StP_r	=	Maximum internal pitting rate in inches per year; $StP_r = 0$ if tank bottom is internally lined.
UP_r	=	Maximum underside pitting rate, in inches per year; $UP_r = 0$ if tank bottom is cathodically protected.
O_{r1} or O_{r2}	=	Anticipated in-service period of operation (normally 10 years).
GC_a	=	Average depth of generally corroded area, in inches.
GC_r	=	Maximum rate of corrosion, in inches per year.

7.4 Engineering Calculations (cont'd):

7.4.2 Minimum Thickness for Tank Bottom and Remaining Life (cont'd):

PRESENT CONDITION:

MRT_1 or MRT_2 = 0.1 *inches*
T_o = 0.5 *inches*
StP_a = 0.05 *inches*
StP_m = 0.125 *inches*
UP_a = 0.01 *inches*
UP_m = 0.01 *inches*
StP_r = 0.0022 *inches/year*
UP_r = 0.0002 *inches/year*
GC_a = 0.02 *inches*
GC_r = 0.0004 *inches/year*

$$O_{r1} = \frac{T_o - GC_a - StP_a - UP_m - MRT_1}{(StP_r + UP_r + GC_r)}$$

$$O_{r1} = \frac{0.5 - 0.02 - 0.05 - 0.01 - 0.1}{(0.0022 + 0.0002 + 0.0004)} > 20 \text{ years}$$

$$O_{r2} = \frac{T_o - GC_a - StP_m - UP_a - MRT_2}{(StP_r + UP_r + GC_r)}$$

$$O_{r2} = \frac{0.5 - 0.02 - 0.125 - 0.01 - 0.1}{(0.0022 + 0.0002 + 0.0004)} > 20 \text{ years}$$

Therefore, the remaining bottom life is:

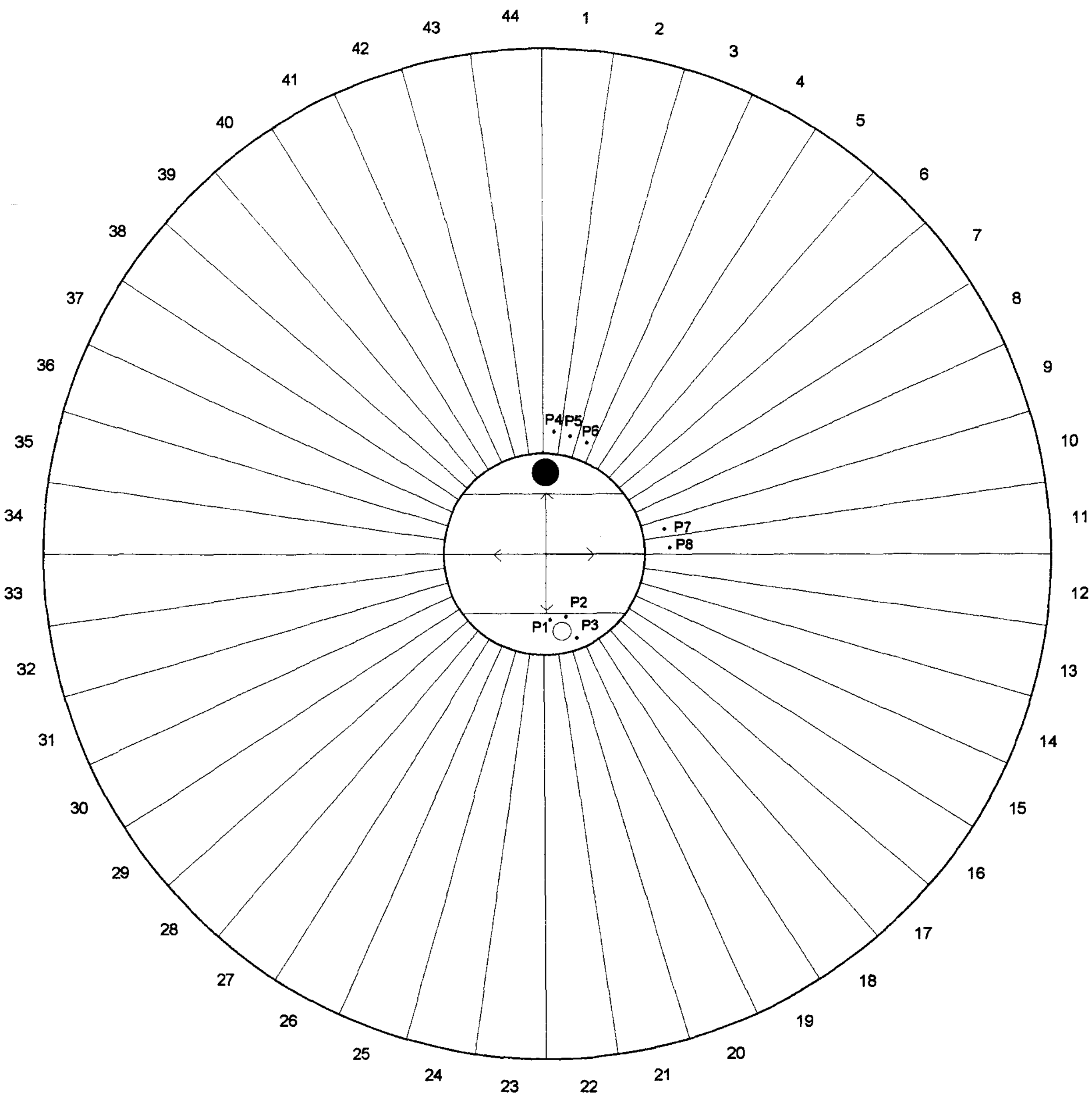
$$O_r > 20 \text{ years}$$

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

7.5 Engineering Drawings

7.5.1 Bottom Layout With Pit Indications
7.5.2 Bottom Layout & Thickness Measurements

Remarks/Legend:



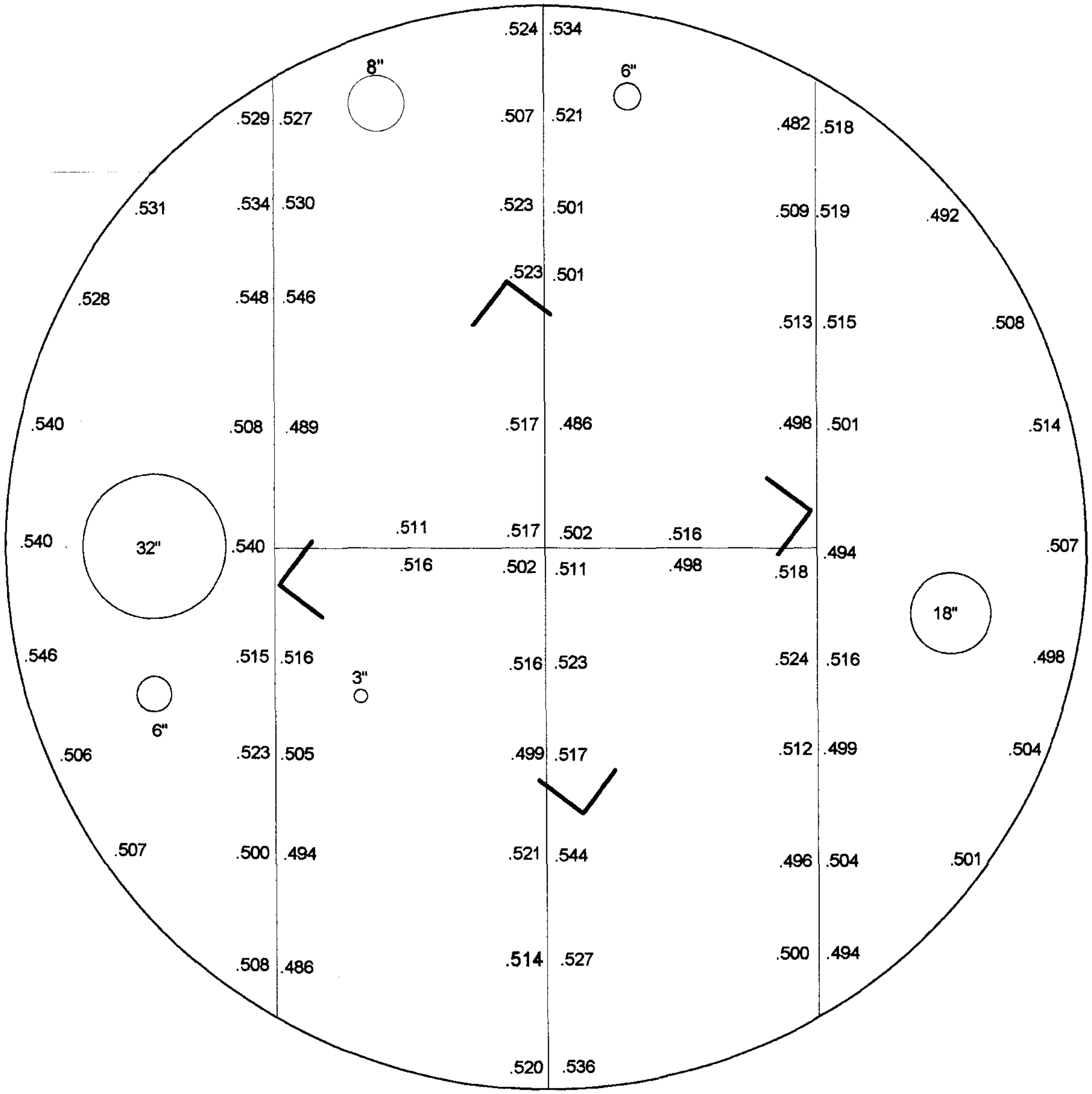
Pit Depth in inches:

P1 = 0.120
P2 = 0.160
P3 = 0.120
P4 = 0.119
P5 = 0.075
P6 = 0.071
P7 = 0.090
P8 = 0.125

Company:		
Naval Supply Center, Pearl Harbor, HI		
Drawn By:		
Mid Atlantic Environmental, Inc.		
Date:	Rev. No.:	Scale:
08/02/98	N/A	1/200 feet

Drawing Title:
Bottom Layout with Pit Indications

Tank Description:
Tank #7



Remarks/Legend:

Company: Naval Supply Center, Pearl Harbor, HI

Drawn By: Mid Atlantic Environmental, Inc.

Date:	Rev. No.:	Scale:
07/31/98	N/A	1/40 feet

Drawing Title:

Bottom Layout & Thickness Measurements

Tank Description:

Tank #7

7.6 Engineering Data (cont'd)

7.6.2 Field Test Report:

Quality Control
Field Test Report

Vacuum Leak Tests

Project Name: Red Hill Emergency Repairs
Project Number: Tank #8

Test Report Number: 1

Service: Fuel Storage

Material: Carbon Steel **Thickness:** 0.50 inch (flat bottom plates) **Diameter:** 100 ft
0.25 inch (first ascending plates)

Location: Honolulu, HI

New Construction: _____ **Repair:** x **ASME Code:** ________

Service Boundary Description: Tank Bottom & First Ascending Plates

Test Type: Hydrostatic _____ Pneumatic _____ Vacuum x

Test Date: 7/26 to 7/31/98

Ambient Temp: 77 degrees Fahrenheit **Test Pressure:** 5 psi minimum **Design Pressure:** _________

Test Media: Soapy Water **Temperature:** 77 degrees Fahrenheit **Holding Time:** 30 seconds

Test Acceptable: x **Unacceptable:** _____

Authorized Code Inspectors: Tom Kitchen **Date:** 7/31/98

Boundaries of Test:

ID Number	Results	Notes
Bottom Butt Welds	No Leaks Detected	
36", 10" & 6" nozzle to repad	No Leaks Detected	
Repads & patches on floor	No Leaks Detected	
Ring at bottom of first course	No Leaks Detected	
Ring at top of first course	No Leaks Detected	
Angle legs to bottom	No Leaks Detected	
Radial welds, first course	No Leaks Detected	

Section 8

REPAIR SPECIFICATIONS

8.0 REPAIR SPECIFICATIONS

8.1 Typical Repair Procedures:

REPAIR TYPE #	TYPE OF DAMAGE	REPAIR PROCEDURE (SEE NOTE 4)	APPROX. SIZE
1	RUSTED AREA, PITTING	REMOVE RUST AND ADJACENT COATING. MEASURE & RECORD DEPTH OF PITS. CLEAN TO BARE METAL, RECOAT.	0.25 SQ. M.
2	DEEP GOUGE IN LINER PLATE	MEASURE & RECORD DEPTH OF GOUGE. CHECK WITH UT FLAW DETECTOR FOR CRACKS. RESURFACE WITH WELD, GRIND SMOOTH, RECOAT.	0.1 SQ. M.
3	LEAK - POROUS/DEFECTIVE WELD	CLEAN SURFACE, VACUUM TEST FOR LEAK, WELD PATCH PLATE OVE R LEAK, CLEAN TO BARE METAL, RETEST WITH VACUUM BOX, RECOAT	0.1 SQ. M.
4	LEAK - DOUBLER PLATE	CLEAN SURFACE, VACUUM TEST FOR LEAK REMOVE DOUBLER PLATE, CLEAN SURFACE AND GRIND, WELD PATCH PLATE OVER LEAK, CLEAN TO BARE METAL, RETEST WITH VACUUM BOX, RECOAT.	0.25 SQ. M.
5	LEAK - BLISTER/RUST THROUGH FROM BACK SIDE	REMOVE RUST AND ADJACENT COATING, MEASURE & RECORD THICKNESS. WELD PATCH PLATE OVER LEAK. CLEAN TO BARE METAL. RETEST WITH VACUUM BOX, RECOAT	0.2 SQ. M.
6	LEAK - HOLE	CLEAN SURFACE, VACUUM TEST FOR LEAK. WELD PATCH PLATE OVER LEAK. CLEAN TO BARE METAL, INCLUDING WELD. RETEST WITH VACUUM BOX, RECOAT	0.1 SQ. M.
7	BLISTER/DENT	REMOVE COATING TO BARE METAL. MEASURE & RECORD THICKNESS, RECOAT.	0.1 SQ. M.
8	COATING FAILURE	REMOVE COATING TO BARE METAL, RECOAT.	1.0 SQ. M.
9	BUTT WELD FAILURE BETWEEN LINER PLATES	DRILL HOLES IN LINER PLATE AT BOTH SIDES OF THE DAMAGE. PURGE WITH NITROGEN DURING HOTWORK. REMOVE WELD, REWELD, INSTALL THREADED PLUGS IN HOLES AND SEALWELD. CLEAN TO BARE METAL, INCLUDING WELD. RETEST WITH VACUUM BOX, RECOAT.	300mm
10	FILLET-WELD FAILURE BETWEEN BACKER STRIPS IN UPPER DOME AND LINER PLATES	REMOVE DEFECTIVE WELD AND REWELD. CLEAN TO BARE META, INCLUDING WELD. RETEST WITH VACUUM BOX, RECOAT.	300 mm
11	FILLET-WELD FAILURE BETWEEN 3.5 MM STEEL COVER PLATE AND LINER PLATES IN UPPER DOME	DRILL HOLES IN STEEL COVERS AND PURGE WITH NITROGEN DURING HOT WORK. REMOVE DEFECTIVE WELD AND REWELD. INSTALL THREADED PLUGS IN HOLES AND SEALWELD. CLEAN TO BARE METAL, INCLUDING WELD, RETEST WITH VACUUM BOX, RECOAT	300 mm

GENERAL NOTES:

1. PATCH PLATES FOR UPPER DOME, DOME EXTENSION, BARREL OF TANK AND LOWER DOME TO BE 6mm THICK. PATCH PLATES FOR BOTTOM PLATE TO BE 11mm THICK.
2. ALL WELDS TO BE CONTINUOUS.
3. SANDBLAST PATCH PLATES BEFORE WELDING IN PLACE AND BREAK EXPOSED EDGE BY GRINDING CHAMFER OF 1.5 mm MINIMUM.
4. THE REPAIR PROCEDURE IS THE SAME, REGARDLESS OF THE LOCATION OF THE DAMAGE IN THE UPPER DOME, TANK BARREL, OR LOWER DOME.