

Engineering Report

Red Hill Tank #10

prepared for

**Naval Supply Center
Pearl Harbor, Hawaii**

**PRL 96-21
Emergency Repairs for Red Hill Tanks**

Contract No N00604-97-R-0013

Prepared by:

**Mid Atlantic Environmental, Inc.
5252 Challedon Drive
Virginia Beach, VA 23462**

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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 Kitchener
No. 17240
THOMAS G. KITCHENER, P.E.
API - 653 Certification # 1891

Section 2

INTRODUCTION

2.0 Introduction

2.1 Mid Atlantic Environmental, Inc. conducted an inspection on Tank #16 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, Cathodic 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 Cathodic 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:	16	
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

RED HILL TANK NO. 10
PRODUCT: DFM

<u>DATE</u>	<u>REMARKS</u>
10/2/63	Put in floats and welding brackets to secure 3/4" pipe from telltale #4 to catwalk entrance. Telltales plugged following inspection after cleaning.
10/3/63	Completed piping on telltale #4 in tank. Ready for testing.
10/7/63	Made air test of 2-1/2 psi on telltale #4.
10/11/63	Calibrated gauge.
4/21/64	Repaired broken tape.
3/3/67	Replaced 6" standard 150 lbs. steel valve (new). Old valve frozen and valve stem bent. Labor Cost: \$22. Material: \$185
3/3-21/67	Fished float from tank bottom and installed new float. Labor Cost: \$174. Material: \$65
3/67	Installed turn buckles at top of guide wires for float.
3/3/67	Removed all gear from tank and took to maintenance shop for cleaning.
3/6/67	Machined new manhole cover for tank.
3/9/67	Checked and found counterweight required an additional 1-1/2 lbs. Machined additional weight to be installed.
3/10/67	While attempting to install additional weight to counterweight, upon removing cover, chain cable jumped, causing counterweight to drop to bottom of tank and breaking cable. Tank gear was set up immediately to start washing down catwalk and elevator shaft.
3/15/67	Tested elevator with 920 lbs. Washed side wall of tank using elevator.
3/17/67	Washed, checked and inspected tank bottom. No signs of any new dents or splits. Machined cracked 52 lbs. counterweight.
3/20/67	Cleared and tested plugged collector ring.
3/21/67	Wire brushed bad pits on tank bottom and painted same with tarset. Hung back counterweight and checked operation of float.
3/10/72	Emptied and cleaned for conversion.

RED HILL TANK NO. 10
PRODUCT: DFM

<u>DATE</u>	<u>REMARKS</u>
3/22-4/10/72	Cleaned tank (252 hours). Labor Cost: \$1,174.32. Converted from NSFO to Navy Distillate.
6/29/72	Topped off with Navy Distillate.
1/73	Started to empty tank. Suspected leak. No sign of oil from telltale.
8/22/73	Emptied tank into mainline. Started cleaning.
9/1/73	Emptied and cleaned for conversion. Telemeter system installed. Converted to DFM.
9/4/73	Installed 6" valve on drain line.
11/14/73	Started receiving Navy Distillate from Tank 7 due to leak.
4/20/76	Telltale #1 started to leak--60 drops per minute.
4/23/76	Started to drain pits into Tank 13.
5/5/76	Emptied and cleaned tank for repairs.
5/28/76	Leak found on collector ring.
5/4/76	Tank removed from service due to leakage.
9/21/76	PWC working in tank. Tank emptied and washed down for contractors.
12/15/77	PWC Pearl commenced repairs to tank.
10/25/78	Contractor began work. Removed motorized valves and installed blanks.
4/9/80	Contractor notified ROICC that tank ready to be returned to service.
4/11/80	Began refilling tank for leak test.

RED HILL TANK NO. 10
PRODUCT: DFM

DATE REMARKS

LEAK TEST DATA

(Note that leak rate is based on data from telemetering.)

<u>DATE</u>	<u>FILL LEVEL</u>	<u>LEAK RATE (GAL/DAY)</u>
4/11-7/22/80	Various 188-235	Bad data due to leaking skin valves
7/22-8/21/80	235.0	13.3
9/10-10/4/80	235.0	12.8
10/4-11/12/80	235.0	2.4
11/12/80-1/9/81	235.0	4.7
1/9-10/81	242.1	1206
1/10-12/81	195.4	NIL
1/12-15/81	235.1	NIL
1/15-19/81	236.1	NIL
1/19-22/81	237.1	NIL
1/22-26/81	238.0	NIL
1/26-29/81	238.0	NIL
1/29-30/81	240.0	693
1/30-2/10/81	239.0	15.0

1/9/81 Fill level raised from 235.0 ft. to 242.1 ft. to test upper dome. Severe leak somewhere between 235.0 ft. and 242.1 ft. Fuel ran out of concrete near first platform on stairway to top of dome.

1/29/81 Leak located between 239 ft. and 240 ft. level.

10/9/81 Completed draining DFM from tank.

10/14/81 Flushed with JP-5 and drained.

10/19/81 Started refilling tank with JP-5.

4/1/83 Tank is still being tested for leaks. If necessary, the contractor will return in August or September 1983 for a final rework.

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 contaminants 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 seventy one (71) 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. 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 technical data and the NACE technical 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. Pictures of typical pitting on the first ascending plate are included in Section 11 of this report.

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 ($\text{cm}^2 = \text{in}^2 \times 2.54^2$)	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 = 7	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:

$$\begin{aligned}
 MRT_1 \text{ or } MRT_2 &= 0.1 \text{ inches} \\
 T_o &= 0.5 \text{ inches} \\
 StP_a &= 0.05 \text{ inches} \\
 StP_m &= 0.125 \text{ inches} \\
 UP_a &= 0.01 \text{ inches} \\
 UP_m &= 0.01 \text{ inches} \\
 StP_r &= 0.0022 \text{ inches/year} \\
 UP_r &= 0.0002 \text{ inches/year} \\
 GC_a &= 0.02 \text{ inches} \\
 GC_r &= 0.0004 \text{ inches/year}
 \end{aligned}$$

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

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

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

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

Therefore, the remaining bottom life is:

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

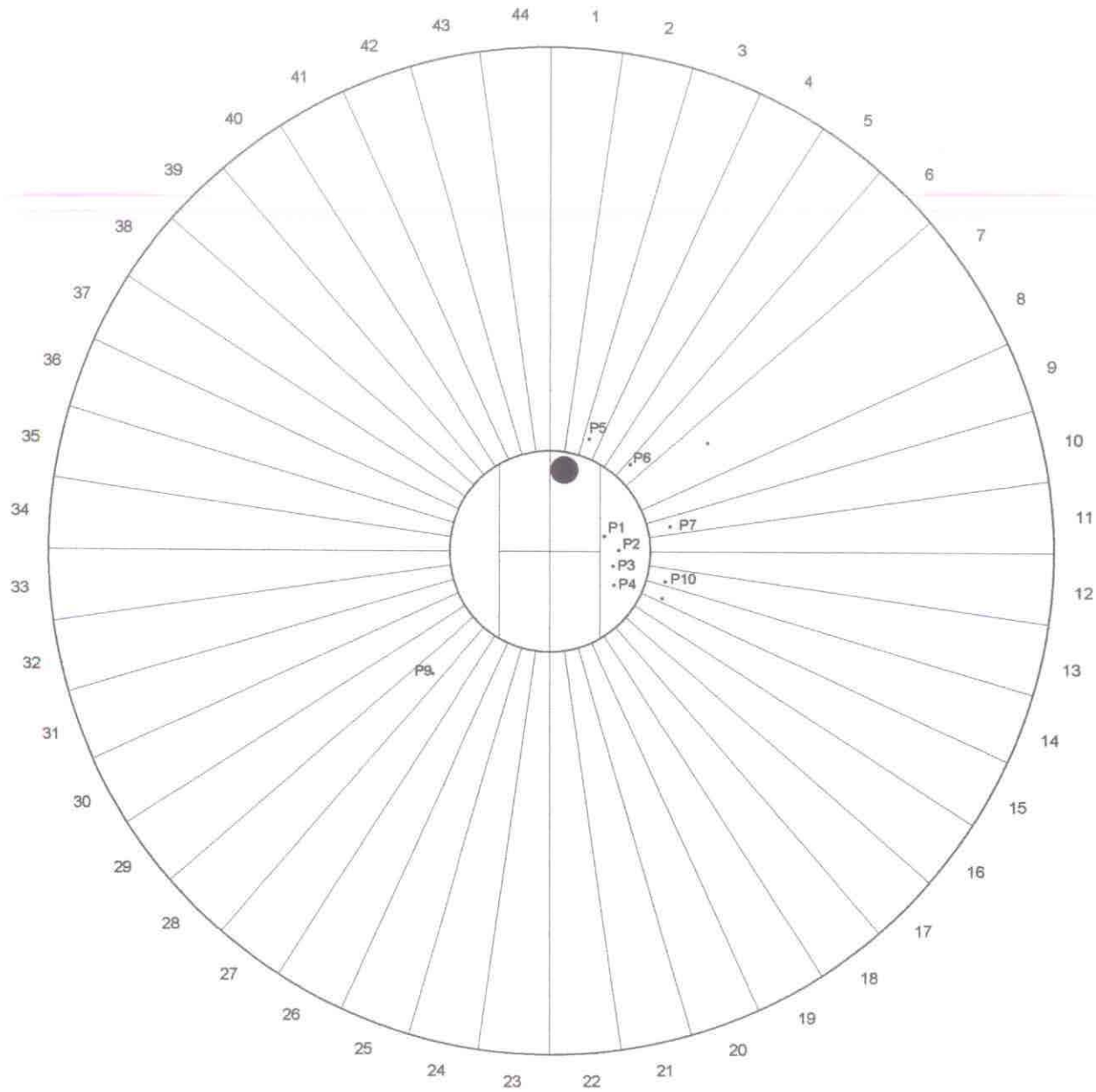
NOTE: The engineering data used to calculate in-service period of operation (O_r) assumes the tank remains in the same service and all corrosion rates remain constant.

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 = 0.08
- P2 = 0.09
- P3 = 0.10
- P4 = 0.07
- P5 = 0.07
- P6 = 0.06
- P7 = 0.09
- P8 = 0.11
- P9 = 0.12
- P10 = 0.11

Company:

Naval Supply Center, Pearl Harbor, HI

Drawn By:

Mid Atlantic Environmental, Inc.

Date:

06/16/98

Rev. No.:

N/A

Scale:

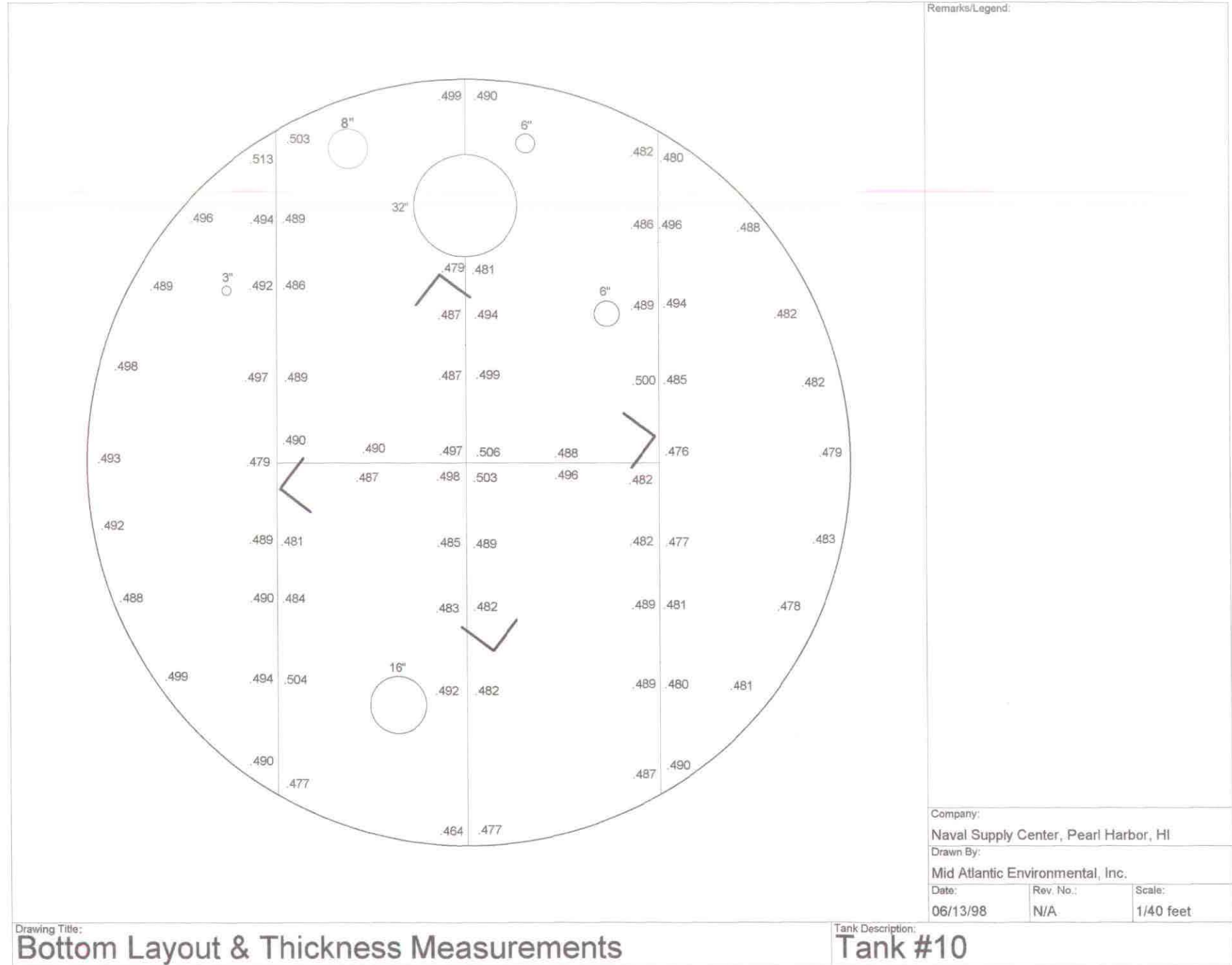
1/200 feet

Drawing Title:

Bottom Layout with Pit Indications

Tank Description:

Tank #10



Remarks/Legend:

Company:
 Naval Supply Center, Pearl Harbor, HI
 Drawn By:
 Mid Atlantic Environmental, Inc.
 Date: 06/13/98 Rev. No.: N/A Scale: 1/40 feet

Drawing Title:
Bottom Layout & Thickness Measurements

Tank Description:
Tank #10

7.6 Engineering Data:

7.6.1 Thickness Measurements for the First Ascending Plates

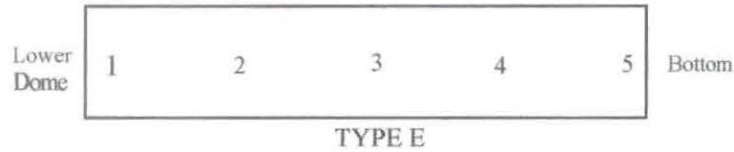


Plate Number	Thickness Measurements (in inches)					Plate Type
	Point Numbers					
	1	2	3	4	5	
1	0.278	0.269	0.24	0.25	0.25	E
2	0.272	0.256	0.264	0.263	0.245	E
3	0.279	0.273	0.246	0.244	0.271	E
4	0.266	0.269	0.272	0.246	0.247	E
5	0.275	0.267	0.265	0.246	0.238	E
6	0.267	0.27	0.275	0.247	0.24	E
7	0.281	0.277	0.271	0.247	0.264	E
8	0.271	0.274	0.274	0.251	0.242	E
9	0.26	0.268	0.258	0.251	0.247	E
10	0.26	0.262	0.259	0.24	0.251	E
11	0.256	0.255	0.261	0.247	0.243	E
12	0.263	0.261	0.266	0.238	0.243	E
13	0.259	0.263	0.264	0.241	0.245	E
14	0.273	0.274	0.272	0.267	0.253	E
15	0.262	0.271	0.251	0.251	0.247	E
16	0.286	0.271	0.275	0.256	0.246	E
17	0.27	0.256	0.261	0.24	0.251	E
18	0.272	0.28	0.271	0.247	0.246	E
19	0.263	0.268	0.266	0.256	0.253	E
20	0.265	0.264	0.252	0.253	0.265	E
21	0.284	0.288	0.274	0.262	0.273	E
22	0.271	0.256	0.262	0.261	0.256	E

Plate Number	Thickness Measurements (in inches)					Plate Type
	Point Numbers					
	1	2	3	4	5	
23	0.283	0.269	0.256	0.255	0.252	E
24	0.256	0.266	0.262	0.236	0.251	E
25	0.284	0.267	0.246	0.261	0.259	E
26	0.283	0.281	0.265	0.248	0.243	E
27	0.266	0.273	0.274	0.251	0.249	E
28	0.285	0.283	0.274	0.243	0.241	E
29	0.26	0.267	0.269	0.246	0.241	E
30	0.271	0.273	0.258	0.251	0.254	E
31	0.262	0.266	0.251	0.254	0.256	E
32	0.266	0.269	0.264	0.249	0.241	E
33	0.271	0.269	0.265	0.247	0.251	E
34	0.261	0.256	0.259	0.239	0.237	E
35	0.267	0.261	0.254	0.247	0.246	E
36	0.261	0.265	0.271	0.242	0.248	E
37	0.275	0.269	0.267	0.258	0.252	E
38	0.269	0.263	0.255	0.235	0.258	E
39	0.268	0.274	0.271	0.253	0.256	E
40	0.287	0.284	0.281	0.256	0.252	E
41	0.277	0.284	0.291	0.256	0.248	E
42	0.274	0.267	0.256	0.251	0.245	E
43	0.269	0.271	0.269	0.255	0.248	E
44	0.281	0.271	0.286	0.245	0.246	E

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 #10

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: ASME Code:

Service Boundary Description: Tank Bottom & First Ascending Plates

Test Type: Hydrostatic Pneumatic Vacuum

Test Date: 5/28 to 6/2/98

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: Unacceptable:

Authorized Code Inspectors: Tom Kitchen Date: 3/16/98

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	

ENGINEERING REPORT

PITTING AT BOTTOM OF TANK

RED HILL TANK #10

PRL 96-21

EMERGENCY REPAIRS FOR RED HILL TANKS

Prepared for:

DEPARTMENT OF THE NAVY
FLEET AND INDUSTRIAL SUPPLY CENTER
PEARL HARBOR, HAWAII

Prepared by: Tom Kitchen

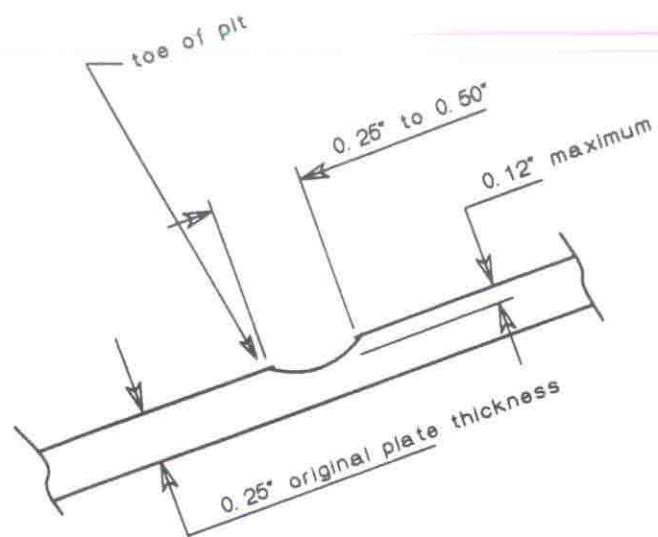
MID ATLANTIC ENVIRONMENTAL, Inc.
5252 Challedon Dr. Suite A
Virginia Beach, VA 23462

June 3, 1998

Tank 10 Bottom Pitting

- 1.0 Mid Atlantic Environmental conducted an inspection of the bottom of Red Hill Tank #10. Part of this inspection was to determine the amount of pitting and make repair recommendations.
- 2.0 Ultrasonic thickness measurements of the bottom and first ascending plates confirmed that the original plate metal thickness was $\frac{1}{2}$ inch on the tank bottom and $\frac{1}{4}$ inch on the ascending plates. The most severe pitting was found on the ascending plates. Pits found in the ascending plate area over 0.15 inches would result in a remaining plate thickness of less than 0.10 inches; (API's requirement of minimum metal thickness for tank bottoms is 0.10 inches.)
- 3.0 Only pits over 0.06 inches deep were identified. Twenty pitted areas were identified and measured in the first ascending plates of the lower dome. The deepest pit recorded on the ascending plates was 0.12 inches. The metal thickness at the identified pits is greater than 0.10 and the scheduled repair by providing a welded patch plate over the pit is not applicable and no repair is necessary to maintain the integrity of the tank. (The method of repair specified by contract is provided on sheet M-9 of NAVFAC DWG. NO. 7927658, REPAIR TYPE 1.)
- 4.0 Pitting at the bottom of tank #16 was similar to #10 and did not require the scheduled repairs. However the sharp edges at the toe of pit caused problems with the coating application. To correct this problem on tank #10 Mid Atlantic Environmental advises smoothing the sharp edge mechanically or by applying primer coat with a stiff brush as proscribed by NAVFAC SPECIFICATION N62472-96-C-1356, Section 09970, 3.9.5, Application of Polyurethane Coating System, which states, "For blasted areas which are pitted, work the wash primer into the crevices, and pits with a stiff brush (100 mm brush cut 25mm long, for example)"
- 5.0 A drawing showing the contour of the pits and pictures taken at the bottom are attached to this report.
- 6.0 Mid Atlantic identified 20 pits in the first ascending plates, which measured over 0.06 inches deep. There were an estimated 100 that measured less than 0.06 inches deep. Mid Atlantic does not consider this to be excessive or abnormal for steel, which has been in service for nearly 60 years.

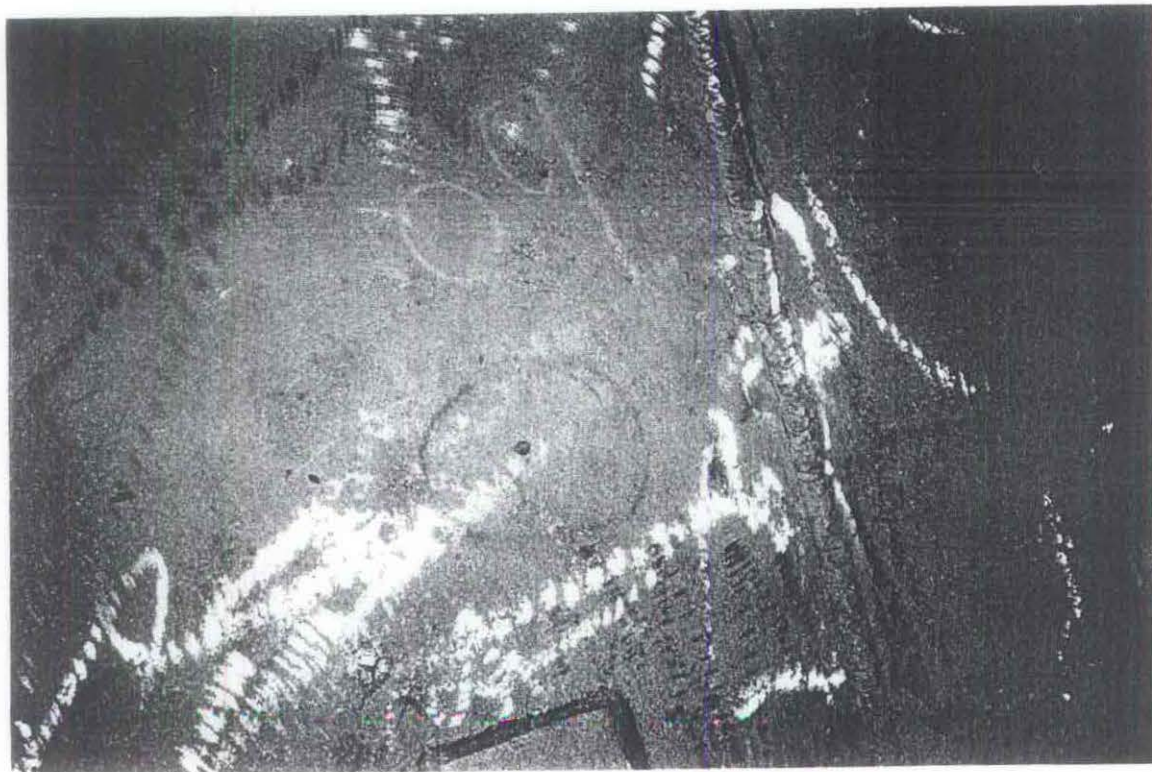
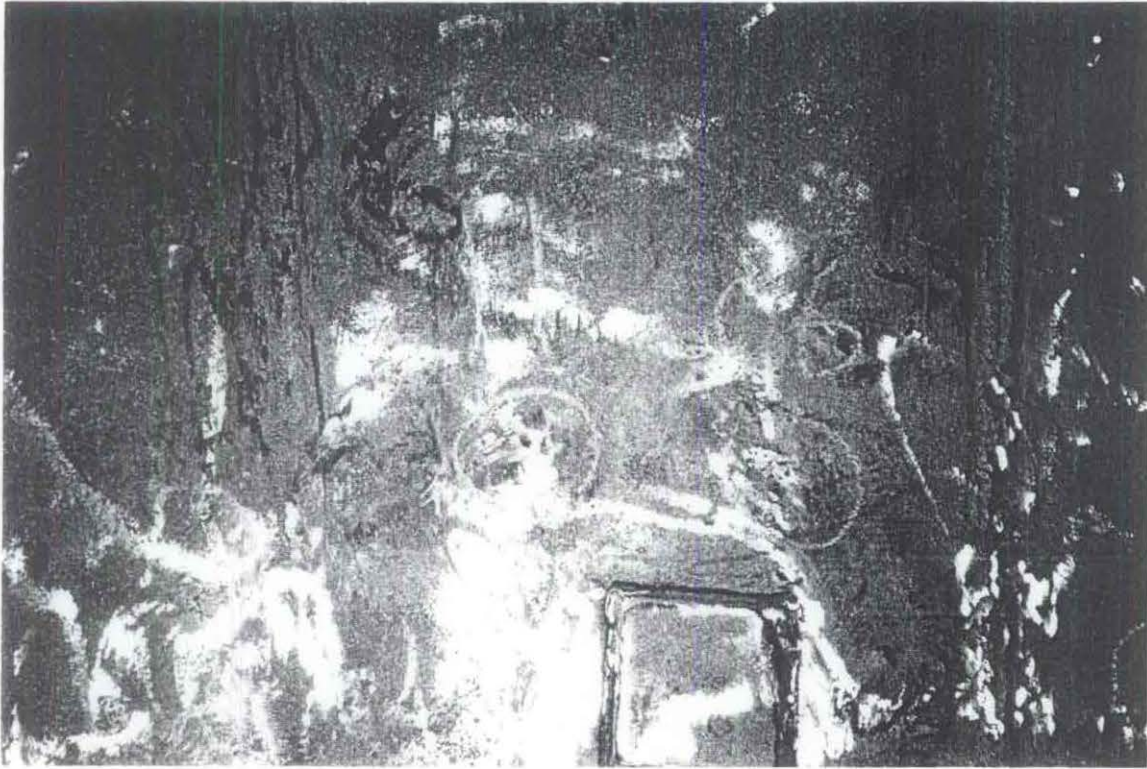
Twenty pits were identified and measured on the first ascending plates in the area to be coated at the bottom of tank #10. The deepest pit measured 0.12 inches. A sketch showing the dimensions of a typical pit is shown below.



SECTION VIEW AT TYPICAL PIT

MID ATLANTIC ENVIRONMENTAL	
EMERGENCY REPAIRS FOR RED HILL TANKS	
Tank #10	
Pitting Detail	File:10pit
Tank bottom	
NOT TO SCALE	
Drawn By: T. Kitchen	Date: 6/3/98

PICTURES SHOWING PITTING ON FIRST ASCENDING PLATES



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 OVER 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.