Transmittal/Review/Approval

FILE NAME: JB Andrews Tank 10 Final Inspection Report

DATE: 08/09/2019

CONTRACT NO: W9128F-17-D-0021 / TO W9128F18F0327

TITLE Fill in Project Title/Location Here: SPCC Aboveground Storage Tank Inspections ADR, MRT, NGH, WST

FROM (CONTRACTOR): EEI

TO: USACE

SUBMITTAL NO.: 015

SPECIFICATION SECTION: N/A

Add Del

ENCL. NO.	NO. OF COPIES	DESCRIPTION	SOW PARAGRAPH	SCHEDULE ACTIVITY NO.	CQC CODE
1	1	JB Andrews Tank 10 Final Inspection Report	Attachment D	60	

DATE NEEDED BY:

TRANSMITTED FOR: ☑ APPROVAL ☐ CLARIFICATION ☐ SELECTION ☐ RECORD ☐ VARIANCE

"I hereby certify that the equipment, material, or article shown and marked in this submittal is that proposed to be incorporated with contract Number W9128F-17-D-0021, is in compliance with the contract documents"

CONTRACTOR'S REPRESENTATIVE NAME/TITLE: James Hall, Project Manager

SIGNATURE: James Hall

Received By (Print Name & Sign) /Date/Time:

FROM:

SIGNATURE:

DATE:

TO:

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☐ APPROVAL/ACCEPTANCE, subject to contract requirements

☐ APPROVAL/ACCEPTANCE, as noted, subject to contract requirements

☐ RETURN for correction and resubmission

☐ DISAPPROVAL

☐ REVIEWED AND PROCEED

☐ ____________________

REMARKS:

☐ copies of encls retained

SIGNATURE:

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FROM:

TO (CONTRACTOR) / ATTENTION:

DATE:

Enclosure(s) is (are):

☐ APPROVED/ACCEPTED, subject to contract requirements

☐ APPROVED/ACCEPTED, as noted, subject to contract requirements

☐ RETURNED for correction and resubmission

☐ DISAPPROVED

☐ NOT REVIEWED

☐ RECEIVED FOR RECORD

REMARKS:

File Name:

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SIGNATURE

BY DIRECTION OF THE CONTRACTING OFFICER

Copy to: Contract File (w/encls)
ConRep/ET (w/encls)
CME (w/encls)

Received By (Print Name & Sign) /Date/Time:

US Army Corps of Engineers
Omaha District
API 653 In-Service
Inspection Report

Joint Base Andrews, Maryland
Facility No. 3035
Tank No. 10

US Army Corps of Engineers Center of Expertise for Petroleum, Oils and Lubricants (USACE POL-MCX)
August 2019

Table of Contents

ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society of Non-Destructive Testing
ATG	Automatic Tank Gauge
BBL	Barrel
CFR	Code of Federal Regulations
CP	Cathodic Protection
DFT	Dry Film Thickness
HLA	High Level Alarm
HLCS	High Level Control Shutoff
HHLA	High-High Level Alarm
LLA	Low Level Alarm
LLLA	Low-Low Level Alarm
MFL	Magnetic Flux Leakage
MT	Magnetic Particle Testing
NACE	National Association of Corrosion Engineers
NDT	Non-Destructive Testing
NFPA	National Fire Protection Association
PSI	Pounds per Square Inch
PT	Penetrant Testing
P/V	Pressure/Vacuum
RP	Recommended Practice
PST	Product Saver Tank
RT	Radiography Testing
TML	Thickness Measurement Location
TRV	Thermal Relief Valve
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specifications
ULS	Ultra Low Sulfur
UT	Ultrasonic Testing
VT	Visual Testing

GENERAL SUMMARY

Enterprise Engineering Inc. (EEI) was retained by the United States Army Corps of Engineers (USACE), Omaha District, under Contract No. W9128F-17-D-0021 Delivery Order W9128F18F0327 to perform an in-service (IS) API 653 inspection of Tank 10 (Facility 3035) at Joint Base Andrews, Maryland.

The IS API 653 inspection was performed during April 29 to 30 2019 in accordance with the applicable portions of API Standard 653, UFC 3-460-01, UFC 3-460-03 and the Statement of Work (SOW).

Tank 10 is a field erected, vertical, aboveground storage tank. The tank was constructed in 1960. The nominal tank diameter is 42.5 feet and the shell height is 38 feet. The tank is of welded construction with butt-welded shell plates and lap-welded floor plates. The tank has a self-supported steel shed roof and an internal steel floating roof. The nominal shell capacity is 10,000 Bbls. The tank is currently in Jet Fuel A (F-24) service. The tank name plate indicates tank repairs were performed in 2004 by Totltest, Inc. to provide a second bottom.

This inspection has determined that no mandatory repairs are required.

INSPECTION DATE

API In-Service (External) Inspection Date: 29 to 30 April 2019

Equipment Used:

Manufacturer: Olympus
Model Number: 38DL Plus
Calibration Method: 2-point calibration using a single material standard

Manufacturer: Positector Dry Film Thickness (DFT) Gauge
Model Number: 6000
Calibration Method: Calibration to know thickness standard

Inspector(s):
James E. Hall, P.E.
Matthew C. McGowan
Sierra C. Kuun

STATE REGULATIONS

State Regulation for API In-Service Tank Inspections	N/A
State Regulation for API Out-of-Service Tank Inspections	N/A

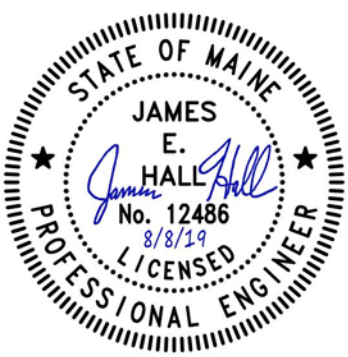
Maryland does not regulate inspection of aboveground storage tanks.

PREVIOUS INSPECTION DATES

API Out-of-Service (Internal) Inspection Date:	June 2014 (including floor scan)
API In-Service (External) Inspection Date:	2004

RECOMMENDED FUTURE INSPECTION DATES (CALCULATIONS SHALL BE PROVIDED)

API Out-of-Service (Internal) Inspection Date:	June 2034 (Taken from 2014 Inspection Report)
API In-Service (External) Inspection Date:	April 2024 (5 Years)



James E. Hall, P.E.
Project Manager
Enterprise Engineering Inc.
API 653 Certified Inspector No. 46418

GENERAL TANK INFORMATION

<table>
<tr><th>ITEM</th><th colspan="3">DESCRIPTION</th></tr>
<tr><td>Owner</td><td colspan="3">U.S. Air Force</td></tr>
<tr><td>Location</td><td colspan="3">Joint Base Andrews</td></tr>
<tr><td>Facility Number</td><td colspan="3">3035</td></tr>
<tr><td>Tank Number</td><td colspan="3">10</td></tr>
<tr><td>State / Country</td><td colspan="3">Maryland / United States</td></tr>
<tr><td>City</td><td colspan="3">Camp Springs</td></tr>
<tr><td>Inspection Date</td><td colspan="3">29 to 30 April 2019</td></tr>
<tr><td>Tank Manufacturer</td><td colspan="3">Unknown</td></tr>
<tr><td>Design Standard</td><td colspan="3">API Standard 12C</td></tr>
<tr><td>Date of Construction</td><td colspan="3">1960</td></tr>
<tr><td>Tank Contents</td><td colspan="3">Jet A (F-24)</td></tr>
<tr><td>Tank Serial Number</td><td colspan="3">None present</td></tr>
<tr><td>Tank Diameter</td><td colspan="3">42’-6”</td></tr>
<tr><td>Shell Height</td><td colspan="3">38’-10”</td></tr>
<tr><td>Product Height</td><td colspan="3">35’-11”</td></tr>
<tr><td>Tank Capacity</td><td colspan="3">10,000 BBLS (Nominal) / 9,788 BBLS (Gross)</td></tr>
<tr><td>Foundation</td><td colspan="3">Concrete Ringwall</td></tr>
<tr><td rowspan="4">Construction</td><td>Bottom</td><td colspan="2">Lap welded</td></tr>
<tr><td>Shell</td><td colspan="2">Butt-welded / 6 courses</td></tr>
<tr><td>Floating Roof</td><td colspan="2">Lap welded</td></tr>
<tr><td>Fixed Roof</td><td colspan="2">Steel shed roof</td></tr>
<tr><td rowspan="4">Material</td><td>Bottom</td><td colspan="2">Steel / Unknown grade</td></tr>
<tr><td>Shell</td><td colspan="2">Steel / Unknown grade</td></tr>
<tr><td>Floating Roof</td><td colspan="2">Steel / Unknown grade</td></tr>
<tr><td>Fixed Roof</td><td colspan="2">Steel / Unknown grade</td></tr>
<tr><td>Cathodic Protection</td><td colspan="3">Impressed</td></tr>
<tr><td>Interior Coating System</td><td colspan="3">Floor: Thin-film epoxy
Shell: Thin-film epoxy
Roof: Thin-film epoxy</td></tr>
<tr><td>Exterior Coating System</td><td colspan="3">Shell: Thin-film epoxy
Roof: Thin-film epoxy</td></tr>
<tr><td>Level Gauging</td><td colspan="3">Varec tape gauge system
ENRAF ATG system</td></tr>
<tr><td>Overfill Protection</td><td colspan="3">High level shut off valve on Fill piping</td></tr>
<tr><td>Piping</td><td>Receipt</td><td>6-inch</td><td>Carbon steel</td></tr>
<tr><td></td><td>Issue</td><td>10-inch</td><td>Carbon steel</td></tr>
<tr><td></td><td>Low Suction</td><td>4-inch</td><td>Carbon steel</td></tr>
<tr><td></td><td>Water Draw-Off</td><td>Two 2-inch drain in shell</td><td>Carbon steel</td></tr>
<tr><td>Level Alarms</td><td colspan="3">Scully high-high, high, low and low-low level alarms; ENRAF ATG alarms</td></tr>
<tr><td>Type of Internal Floating Roof</td><td colspan="3">Lap welded</td></tr>
</table>

A. GENERAL PROJECT INFORMATION

1. API 653 Inspection

EEI performed an IS API 653 inspection on Tank 10 (Facility 3035) 29 to 30 April 2019. Results of this inspection identified required repairs to comply with API 650, API 653, UFC 3-460-01, UFC 3-460-03, AW 78-24-27 and industry standards and recommended repairs as part of regular maintenance.

2. Site Information

Joint Base Andrews is located in Maryland. The base is home to Air Force District of Washington's 11th Wing -- the base's host wing -- with several partner units on base including Air Mobility Command's 89th Airlift Wing, Air Force Reserve Command's 459th Air Refueling Wing, D.C. Air National Guard's 113th Wing, the Naval Air Facility, and Army and Marine Corps detachments.

B. TANK INSPECTION COMMENTS

1. Tank Construction

Tank 10 (Facility 3035) is a field erected, vertical, aboveground storage tank. The tank was constructed in 1960. The nominal tank diameter is 42 feet 6 inches and the shell height is 38 feet 10 inches. The tank is of welded construction with butt-welded shell and lap welded floor plates. The tank has a self-supported steel shed roof and an internal steel floating roof. The nominal shell capacity is 10,000 Bbls. The design liquid level is 35-feet 11-inches. The tank is currently in Jet A service.

2. Tank Evaluation Items

Refer to Appendix A for a discussion of the tank evaluation items. The information has been provided in a tabular format for reference.

C. FINDINGS AND RECOMMENDATIONS

The following subsections outline the tank repairs/upgrades. Repairs and upgrades shall be completed in accordance with API requirements and best engineering practice.

1. MANDATORY REPAIRS per API 653, UFC 3-460-01, or AW 78-24-27 Standards

Mandatory repairs represent items that require immediate attention, in order to prevent imminent risk to system operators, equipment integrity, or the adjacent environment. The tank should remain out of service until these repairs are completed.

No mandatory repairs were identified.

2. REQUIRED REPAIRS to Fully Comply with API 653, UFC 3-460-01, or AW 78-24-27 Standards

Short-term Repairs that directly relate to the long-term preservation of the asset. Short-term repairs represent items that should be addressed in a timely manner in order to prevent future potential risks to system operators, equipment integrity, or the adjacent environment. These items may be required by Federal, State and Local Codes or by Military Criteria.

a. Tank Handrail

OBSERVATION: A section of platform handrail at the top of the spiral stairs has been removed and sections of Unistrut are bolted in its place.

REFERENCE: OSHA 29 CFR 1910

RECOMMENDATION: Remove sections of Unistrut and provide top and mid rails to match existing handrail.

b. Tank Labelling

OBSERVATION: The tank product stenciling is failing.

REFERENCE: AW 78-24-27 Sheet D.13, Detail 3

RECOMMENDATION: Remove failed stenciling and provide stenciling in accordance with MIL-STD 161G.

c. Manway Covers

OBSERVATION: The tank manway covers are not equipped with davits.

REFERENCE: AW 78-24-27 Sheet D.10, Detail 3

RECOMMENDATION: Remove manway hinges and provide davits in accordance with AW 78-24-27.

3. RECOMMENDED REPAIRS as Part of Regular Maintenance Long-Term Repairs

Long-term Repairs that directly relate to repair/upgrade of an asset to bring it up to the current standard from the standard at time of construction. Long-term Repairs represent items that should be addressed in a timely manner in order to prevent future potential risks to system operators, equipment integrity, or the adjacent environment.

a. Exterior Coating Failure

OBSERVATION: Coating failure and corrosion was observed on the tank valves, flanges, stair platform framing and appurtenances.

REFERENCE: UFC 3-460-03 ¶8-3.1

RECOMMENDATION: Provide surface preparation and recoat.

b. Coating failure on Piping

OBSERVATION: Coating failure and corrosion was observed on the fill and issue piping and pipe supports within the containment dike.

REFERENCE: UFC 3-460-03 ¶8-3.1

RECOMMENDATION: Provide surface preparation and recoat. Approximately 200 LF of 10-inch piping, 175 LF of 6-inch piping, and 24 pipe supports.

c. Organic growth

OBSERVATION: Organic growth was observed on the exterior shell and exterior piping.

REFERENCE: UFC 3-460-03 ¶8-3.1

RECOMMENDATION: Pressure wash the tank shell and piping.

d. Secondary Containment Sealant

OBSERVATION: The tank is located within a concrete containment area. Locations of unsealed cracks were observed at isolated locations.

REFERENCE: UFC 3-460-03, ¶8-10.2

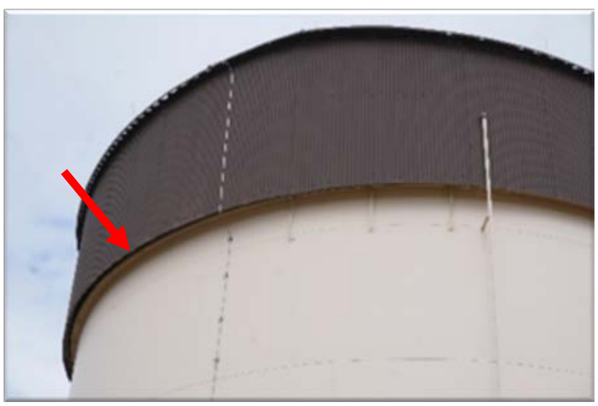
RECOMMENDATION: Repair cracks by routing and providing jet fuel resistant sealant. Approximately 50 LF of cracks.

e. Roof Perimeter Screens

OBSERVATION: Several locations of the roof perimeter bird screens are missing.

REFERENCE: Usual and customary engineering practices.

RECOMMENDATION: Provide additional sections of screen. Approximately 30 LF of screen.

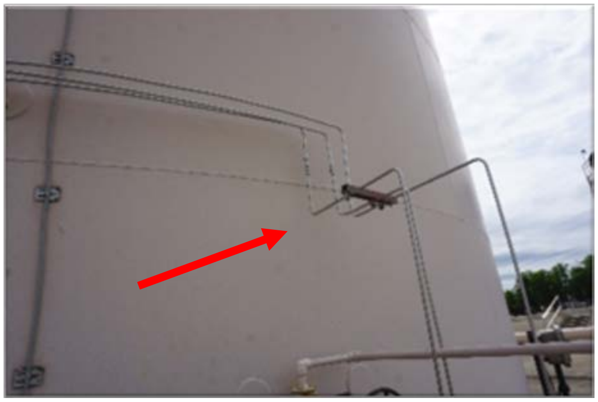


f. **High-level control valve tubing supports**

OBSERVATION: The high-level control valve tubing is not properly supported above the valve.

REFERENCE: Usual and customary engineering practices.

RECOMMENDATION: Provide an additional support for the tubing.

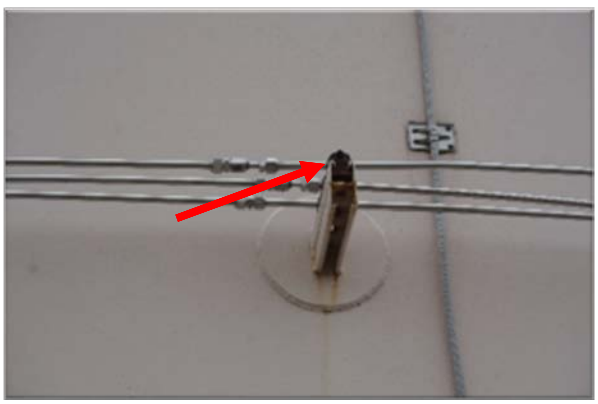



g. **Corrosion at high-level valve tubing supports**

OBSERVATION: Corrosion was observed at the carbon steel HLCV tubing supports.

REFERENCE: AW 78-24-27 Sheet D.10, Detail 5 and usual and customary engineering practices.

RECOMMENDATION: Replace carbon steel tubing clamps with stainless steel cushioned clamps. Approximately 30 clamps.

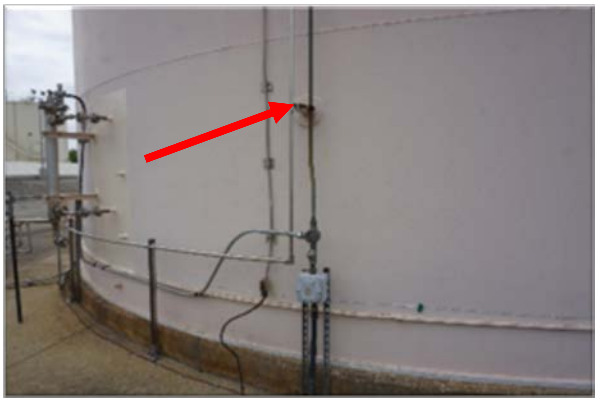



h. Corrosion at electrical conduit supports

OBSERVATION: Corrosion was observed at the carbon steel electrical conduit supports.

REFERENCE: AW 78-24-27 Sheet D.10, Detail 5 and usual and customary engineering practices

RECOMMENDATION: Replace carbon steel tubing clamps with stainless steel cushioned clamps. Approximately 10 clamps.




i. Receipt pressure relief loop

OBSERVATION: The pressure relief loop at the receipt valve contains carbon steel relief valve, piping, and flanges, which have coating failure and corrosion.

REFERENCE: AW 78-24-27 Detail 4 on Sheet D.10.

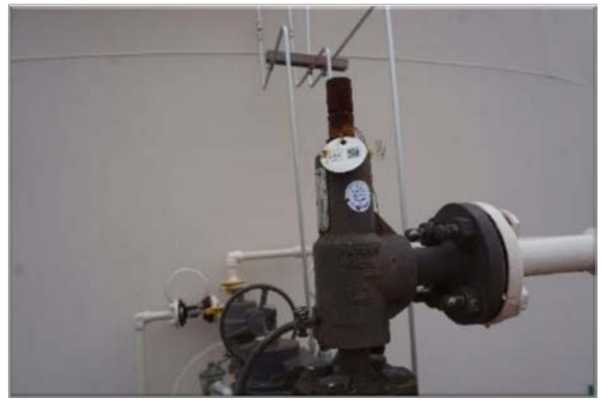
RECOMMENDATION: Replace relief valve, piping, and flanges with a stainless-steel relief valve, piping, and flanges.


j. Issue pressure relief loop

OBSERVATION: The pressure relief loop at the issue valve contains carbon steel piping and flanges, which have coating failure and corrosion.

REFERENCE: AW 78-24-27 Detail 4 on Sheet D.10.

RECOMMENDATION: Replace piping and flanges with stainless-steel.



k. Tank ground wire

OBSERVATION: One tank ground wire below the tank stairs has detached from the original floor extension.

REFERENCE: AW 78-24-27 Sheet ED.02

RECOMMENDATION: Reattach ground wire.

l. Testing

OBSERVATION: The tank is equipped with an ENRAF ATG system, high level control valve, and an independent level alarm system.

REFERENCE: UFC 3-460-03 Appendix C

RECOMMENDATION: Test ATG system, level alarm switches, and overfill prevention devices as part of the on-going maintenance program.

APPENDIX A: ENGINEERING CALCULATIONS AND DRAWINGS

NDE DATA
ENGINEERING CALCULATIONS
TANK DRAWING
OSHA ACCESS STRUCTURE REPORT

Tank No.: 10
Location: Joint Base Andrews
EEI Project No.: 9364
Performed By: JEH, MCM, SCK
Date: 29-30 April 2019

Form 07 Shell: Exterior UT & Coating

Shell Course No.	Reading No.	UT Reading (Inches)	Coating Thickness at Same Location (Mils)
1	1	0.241	22.10
	2	0.243	20.90
	3	0.245	28.90
	4	0.242	24.10
	5	0.241	32.90
	6	0.240	32.00
	Average	0.242	26.82
2	1	0.236	18.10
	2	0.238	21.90
	3	0.241	20.50
	4	0.241	24.10
	5	0.239	19.30
	6	0.235	17.60
	Average	0.238	20.25
3	1	0.234	19.50
	2	0.254	19.90
	3	0.254	18.50
	4	0.252	20.70
	5	0.246	26.60
	6	0.246	21.70
	Average	0.248	21.15
4	1	0.243	20.60
	2	0.247	21.00
	3	0.247	18.20
	4	0.251	15.80
	5	0.246	18.20
	6	0.238	26.20
	Average	0.245	20.00

Tank No.: 10
Location: Joint Base Andrews
EEI Project No.: 9364
Performed By: JEH, MCM, SCK
Date: 29-30 April 2019

Form 07 Shell: Exterior UT & Coating

Shell Course No.	Reading No.	UT Reading (Inches)	Coating Thickness at Same Location (Mils)
5	1	0.236	19.70
	2	0.247	16.70
	3	0.247	20.30
	4	0.245	18.40
	5	0.241	20.60
	6	0.238	22.90
	Average	0.242	19.77
6	1	0.254	29.40
	2	0.253	27.80
	3	0.254	23.20
	4	0.250	24.00
	5	0.249	22.10
	6	0.248	22.00
	Average	0.251	24.75
Rim Angle (3 locations)	1	0.370	
	2	0.369	
	3	0.368	
	Average	0.369	

Coating Thickness (all courses)	Average	22.12
	Minimum	15.80
	Maximum	32.90

Highlight Minimum UT Reading Per Course

Tank No.: 10
Location: Joint Base Andrews
EEI Project No.: 9364
Performed By: JEH, MCM, SCK
Date: 29-30 April 2019

Form 08 Shell: Exterior 1st Course UT

UT Equipment : Olympus 38 DL Plus

Vertical Welds	Reading No.	UT Reading 6"-12" From Tank Bottom (Inches)
1V-1	1	0.245
	2	0.245
	3	0.243
1V-2	4	0.243
1V-2	1	0.250
	2	0.251
	3	0.249
1V-3	4	0.248
1V-3	1	0.259
	2	0.260
	3	0.257
1V-4	4	0.253
1V-4	1	0.485
	2	0.486
	3	0.489
1V-5	4	0.491
1V-5	1	0.257
	2	0.255
	3	0.253
1V-6	4	0.251
1V-6	1	0.257
	2	0.259
	3	0.255
1V-7	4	0.252
1V-7	1	0.254
	2	0.253
	3	0.250
1V-8	4	0.247
1V-8	1	0.243
	2	0.239
	3	0.239
1V-9	4	0.234
1V-9	1	0.496
	2	0.498
	3	0.499
1V-1	4	0.499
	Average	0.304
	Minimum	0.234
	Maximum	0.499

Note: Shell plate is thickened with tapered edges

Tank No.: 10
Location: Joint Base Andrews
EEI Project No.: 9364
Performed By: JEH, MCM, SCK
Date: 29-30 April 2019

Form 11 External Shell Manhole/Nozzle: UT

Nozzle/ Manhole	Reading No.	Nozzle (Inches)	Reinf. Plate (Inches)	Cover (Inches)
Manhole 1	1	0.496	0.499	0.815
	2	0.497	0.499	0.816
	3	0.496	0.497	0.815
	Average	0.496	0.498	0.815
Issue	1	0.520	-	-
	2	0.508	-	-
	3	0.524	-	-
	Average	0.517	-	-
Receipt	1	0.438	0.496	-
	2	0.446	0.499	-
	3	0.433	0.498	-
	Average	0.439	0.498	-
Manhole 2	1	0.493	0.489	0.815
	2	0.495	0.491	0.815
	3	0.497	0.492	0.815
	Average	0.495	0.491	0.815
Water Draw-Off 1	1	0.218	-	-
	2	0.209	-	-
	3	0.215	-	-
	Average	0.214	-	-
Water Draw-Off 2	1	0.213	-	-
	2	0.205	-	-
	3	0.224	-	-
	Average	0.214	-	-
Low Suction	1	0.320	0.243	-
	2	0.349	0.243	-
	3	0.340	0.243	-
	Average	0.336	0.243	-

Tank No.: 10
Location: Joint Base Andrews
EEI Project No.: 9364
Performed By: JEH, MCM, SCK
Date: 29-30 April 2019

Form 16 Floor: Projection UT & Coating

1. Record data at each first course vertical shell joint for tanks with 10 or more joints.
2. Record data at a minimum of 10 equally spaced locations for tanks with less than 10 vertical shell welds.

Reading No.	Clockwise Distance from MH-1	UT Reading (Inches)	Coating Thickness at Same Location (Mils)	Floor Projection Distance (Inches)
1	0'-0"	0.271	32.00	1.375
2	13'-4"	0.306	22.80	1.750
3	26'-6"	0.304	21.70	1.000
4	40'-1"	0.304	29.40	1.250
5	53'-0"	0.303	33.40	1.125
6	66'-6"	0.306	25.50	1.500
7	80'-2"	0.304	29.90	1.625
8	93'-0"	0.278	27.40	1.500
9	106'-6"	0.295	24.80	1.500
10	120'-0"	0.307	35.50	1.375
	Average	0.298	28.24	1.400
	Minimum	0.271	21.70	1.000
	Maximum	0.307	35.50	1.750

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**	CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: GENERAL

NEW / EXISTING	Existing
YEAR BUILT	1960

TANK DATA: PHYSICAL PROPERTIES

FOUNDATION

TYPE OF FOUNDATION: Ringwall (INPUT Ringwall, Earth, Concrete Confining Ring, etc.)

TANK ANCHORED (YES OR NO): NO

NUMBER OF ANCHORS	N =		
DIAMETER OF BOLT CIRCLE	d =		FT
DIAMETER OF ANCHOR BOLTS	dB =		INCHES
SPACING OF ANCHOR BOLTS	S=		FT
ANCHOR BOLT YIELD STRENGTH	Fyab =		KSI
ANCHOR BOLT SHEAR STRENGTH	Fv_{bolt} =		KSI

AISC Bolt Allowable Stresses

Material	Fyab	Fu	Fnv	Fvbolt = Fnv / **W**
A36	36.00	58.00	Not listed	use Fv_{bolt} = 10.00
A307	36.00	60.00	27.00	Fv_{bolt} = 13.50
A320 L7	105.00	125.00	Not listed	use Fv = 0.17(Fu) = 21.25

W = 2.00 for Allowable Stress Design

COEFFICIENT OF FRICTION BETWEEN TANK AND FOUNDATION μ = 0.40

(μ max = 0.4 PER API 650 E.7.6., USE SMALLER μ BASED ON FOUNDATION CONSIDERATIONS)

FLOOR

MATERIAL		Unknown	
FLOOR THICKNESS	t_F =	0.2980	INCHES
FLOOR CORROSION ALLOWANCE	CA_{floor} =		INCHES
FLOOR THICKNESS BELOW SHELL	tb =		INCHES
ANNULAR PLATE (YES/NO)		NO	
ANNULAR PLATE THICKNESS	tann =		INCHES
ANNULAR PLATE WIDTH	Ls =		FT
YIELD STRENGTH OF FLOOR PLATE BELOW SHELL	F_{BY} =	30,000	PSI

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**		
		CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: PHYSICAL PROPERTIES

SHELL

DIAMETER $D =$ 42.500 FT

SHELL CORROSION ALLOWANCE $CA_{shell} =$ INCHES

OVERFLOW PORTS = None (Input YES if overflow ports are present, input NONE if no overflow ports)

TOP OF SHELL TO BOTTOM OF OVERFLOW PORT Hop = 0.000 FT (Input 0 if no overflow ports)

TYPE OF SHELL JOINTS Butt Welded (Input BUTT WELDED, LAP WELDED, or RIVETED)

USE JOINT EFFICIENCY PER API 650 FOR NEW TANK, PER API 653 FOR EXISTING TANK

	COURSE NO.	HEIGHT h FT	THICKNESS t INCHES	JOINT EFFICIENCY E	MATERIAL	YIELD STRESS Fy PSI	ALLOWABLE STRESS PRODUCT S_d PSI	ALLOWABLE STRESS HYDROTEST S_t PSI
BOTTOM COURSE	1	6.021	0.2400	0.85	Unknown	30000	23600	26000
	2	7.500	0.2380	0.85	Unknown	30000	23600	26000
	3	7.438	0.2480	0.85	Unknown	30000	26000	27000
	4	7.458	0.2450	0.85	Unknown	30000	26000	27000
	5	7.438	0.2420	0.85	Unknown	30000	26000	27000
	6	2.333	0.2510	0.85	Unknown	30000	26000	27000
RIM ANGLE		0.000	0.3690					

SHELL HEIGHT Hs = 38.188 FT

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**		
		CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: PHYSICAL PROPERTIES

ROOF AND ROOF FRAMING

ROOF SLOPE THETA = 5.00 DEG

COMMENT: Indicate here whether roof slope is assumed, calculated, or based on record drawings

ROOF THICKNESS	t_R =	0.1000	INCHES	
ROOF CORROSION ALLOWANCE	CA_{roof} =		INCHES	
WEIGHT OF ROOF FRAMING	r_F =	5.000	PSF	(if unknown, use 5 psf)
WEIGHT OF RIM ANGLE	r_A =	4.900	LB/LF	

ROOF FRAMING SYSTEM 0

(Input 0 no interior columns
or 1 single center column with simple span radial rafters only
or 2 single center column with simple span radial trusses only
or 3 single center column with trusses and framing
or 4 center column with perimeter columns)

(Leave cell blank if framing system 3 is NOT selected)

(Leave cell blank if framing system 3 is NOT selected)
(Leave cell blank if framing system 3 is NOT selected)
(Leave cell blank if framing system 3 is NOT selected)

COLUMN	SIZE	NUMBER OF COLUMNS	COLUMN WEIGHT (LB/LF)
CENTER	NONE	0	0.0
INNER COLUMNS	NONE	0	0.0
OUTER COLUMNS	NONE	0	0.0

(If no interior columns, input NONE in "SIZE" column input 0.0 in "NO. of COLUMNS" and "COLUMN WEIGHT" column)

RADIAL DISTANCE TO OUTER COLUMN R_2 = 0 FT (Input 0 if no radial columns)

APPURTENANCES

WEIGHT OF STAIRS, PIPING, ETC. 2 % (Input weight as a percentage of total weight of tank. Input 2% if unknown)

FLOATING PAN/ROOF

WT OF FLOATING PAN/ROOF Wpan = 10.87 K (Input weight of floating pan/roof, Input 0 if no pan/roof) (Petrex aluminum honeycomb pans weigh 0.717 psf)

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**		
		CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: LIQUID STORAGE

FILL HEIGHT Hf = 35.917 FT (Fill height can also be the design liquid level)

PRODUCT STORAGE Jet A (Input product storage service.
Example: GASOLINE, JP-4, JP-5, JP-8, DIESEL, WATER)

SPECIFIC GRAVITY G = 0.840 Specific gravities of various liquids

product	G
Gasoline	0.730
JP-4	0.751 to 0.802
JP-5	0.788 to 0.845
JP-8	0.775 to 0.840
Diesel (F-76)	0.830 to 0.860
Water	1.000
Jet-A	0.775 to 0.840

TANK DATA: LOADS

DIFFERENTIAL SETTLEMENT

TOLERANCE OF
FLOATING PAN SEAL Rtol = 4 INCHES (Input N/A if no floating pan)

DIFFERENTIAL SETTLEMENT DELTA = 0.00 FT (High point EL - Low point EL)
(Input 0 if no data)

ROOF LIVE LOAD

ROOF LIVE LOAD P_{LL} = 20 PSF REF: API 650 5.2.1.f

SNOW LOAD

CODE: ASCE 7-10

NOTE: FOR MILITARY PROJECTS USE UFC 3-301-01 FOR GROUND SNOW LOAD DATA

GROUND SNOW DATA		UFC		(Enter ASCE or UFC)
GROUND SNOW	Pg =	25	PSF	UFC 03-301-01
EXPOSURE FACTOR	Ce =	1		ASCE 7-10 TABLE 7-2
THERMAL FACTOR	Ct =	1.2		ASCE 7-10 TABLE 7-3
IMPORTANCE FACTOR	I =	1		ASCE 7-10 TABLE 1.5-2

ROOF SNOW LOAD PER
LOCAL BUILDING CODE $Pf_{Local\ Code}$ = PSF

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**		
		CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: LOADS

WIND LOAD

CODE: API 650 12th EDITION ADDENDUM 3

NOTES

1. ASCE 7-10 WIND VELOCITIES HAVE LRFD LOAD FACTORS AND RISK CATEGORIES BUILT IN. API 650 USES WORKING STRESS AND PERMITS USE OF ASCE 7-05 OR ASCE 7-10.
   THIS SPREADSHEET USES ASCE 7-10.
2. API 650 WIND LOAD AND VELOCITY PRESSURE IN SECTION 5.2.1(k)(1) ARE BASED ON ASCE 7 EXPOSURE C, IMPORTANCE FACTOR OF 1.00.
3. PER API 650 5.2.1.k, WIND PRESSURES MAY BE DETERMINED IN ACCORDANCE WITH ASCE 7.
4. TO ADJUST THE VELOCITY PRESSURE ON THE TANK SHELL AND ROOF FOR WIND OVERTURNING, ENTER THE EXPOSURE CATEGORY AND IMPORTANCE FACTOR.
5. STIFFENER EVALUATION IS BASED ON API 650 WHICH USES EXPOSURE CATEGORY C, IMPORTANCE FACTOR OF 1
6. FOR MILITARY PROJECTS USE UFC 3-301-01 FOR BASIC WIND SPEED.

RISK CATEGORY		III		ASCE 7-10 Table 1.5.1 or UFC 3-301-01
EXPOSURE CATEGORY		C		ASCE 7-10 sect 26.6 (B, C, D)
BASIC WIND SPEED DATA		UFC		(Enter ASCE of UFC)
BASIC WIND SPEED	V =	120	MPH	UFC 3-301-01
USE API 650 WIND PRESSURES MODIFIED FOR WIND SPEED (YES/NO)		No		API 650 5.2.1(k) (NOTE: API wind pressures are for Exposure C)
DESIGN INTERNAL PRESSURE	Pid =	0.00	PSF	
OPERATING PRESSURE	Pi =	0.00	PSF	Enter 0 if no internal pressure
INTERNAL PRESSURE FACTOR	Fp =	0.40		F = Ratio of operating pressure to design pressure, not less than 0.4
FILL HEIGHT FOR ALLOWABLE SHELL COMPRESSION	Ht_{wind} =	0.000	FT	Applies to anchored tank only (For worse case use Hf = 0 FT for empty tank)

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**		
		CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: LOADS

SEISMIC LOAD

CODE: API 650 12th EDITION, ADDENDUM 3 ANNEX E

SEISMIC USE GROUP (I, II, III)	=	III		API 650 E.3.1
SITE GROUND MOTION (API 650 E.4.1 MAPPED ASCE METHOD)				
SHORT PERIOD (0.2 S) ACCELERATION	Ss =	0.1200	%g	ASCE 7 FIG 22-1, 22-3, 22-5, and 22-6
1.0 S PERIOD ACCELERATION	S1 =	0.0500	%g	ASCE 7 FIG 22-2, 22-4, 22-5, and 22-6
REGIONAL- DEPENDENT TRANSITIONAL PERIOD	TL =	8.00	SEC	ASCE 7 FIG 22-12 THROUGH 22-16
SITE CLASS	=	D		ASCE 7 CHAPTER 20 AND API 650 E.4.4
SITE MODIFICATION COEFFICIENTS (ASCE 7 AND API 650 E.4.4)				
	Fa =	1.60		API 650 ANNEX E TABLE E.1
	Fv =	2.40		API 650 ANNEX E TABLE E.2
TANK MATERIAL		Steel		
TANK MATERIAL MODULUS OF ELASTICITY	E =	########	PSI	
	Hf/D =	0.8451		
COEFFICIENT FOR IMPULSIVE PERIOD	Ci =	6.07		API 650 ANNEX E FIGURE E.1 (BASED ON Hf/D)
SCALING FACTOR FROM MCE TO DESIGN LEVEL SPECTRAL ACCELERATIONS	Q=	2/3		(Q = 2/3 FOR ASCE -7 METHODS. FOR MILITARY DESIGN OF ESSENTIAL FACILITIES, Q = 3/4)
COEFFICIENT TO ADJUST FROM 5% TO 0.5% DAMPING	K =	1.5		K = 1.5 UNLESS SPECIFIED OTHERWISE

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

INPUT DATA

(Highlighted values are input data)

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	05/01/19
EEI PROJECT NO.:	**9364**		
		CHECKED BY:	JEH
TANK NO.	**10**	DATE:	08/08/19

TANK DATA: SHELL CORROSION ANALYSIS

DEPTH OF CORRODED AREAS IN SHELL

AT SHELL VERTICAL WELDS	= Xw	INCH	(Input 0.0 if no corrosion or leave blank if no input)
AWAY FROM SHELL VERTICAL WELDS BY 1 INCH OR 2t	= Xs	INCH	(Input 0.0 if no corrosion or leave blank if no input)

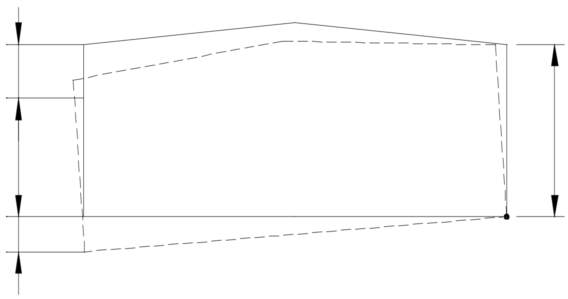
COURSE NO.	Xw INCH	Xs INCH
1		
2		
3		
4		
5		
6		

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

TANK DIFFERENTIAL SETTLEMENT



ALLOWABLE RIGID BODY TILT

BASED ON HOOP STRESS AT BOTTOM OF FIRST COURSE

ALLOWABLE TILT DELTA allow = $[(4S \times 12 (t - CA) \times E)/(G \times G_w \times D)] - 2 (Hf-1)$

ALLOW HOOP STRESS, 1ST COURSE	S =	23,600	PSI
1ST COURSE THICKNESS	t =	0.24	INCH
SHELL CORROSION ALLOWANCE	CA =	0.0000	INCH
1ST COURSE JOINT EFFICIENCY	E =	0.85	
SPECIFIC GRAVITY OF CONTENTS	G =	0.840	Jet A
UNIT WEIGHT OF WATER	G_w =	62.4	LB/FT^3
TANK DIAMETER	D =	42.50	FT
HEIGHT OF SHELL	Hs =	38.19	FT
FILL HEIGHT	Hf =	35.92	FT
FREEBOARD	Hd = Hs - Hf =	2.27	FT

FOR Jet A Service

DELTA allow = [(4(23600) x 12(0.24 -) x 0.85) / (0.84x62.4x42.5)] -2(35.917- 1) = 33.90 FT

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

TANK DIFFERENTIAL SETTLEMENT

ALLOWABLE RIGID BODY TILT

BASED ON OVERFLOWING

ALLOWABLE TILT DELTA allow = 2(Hd)

HEIGHT OF SHELL	Hs =	38.19	FT	
TOP OF SHELL TO BOT OF OVERFLOW PORT	Hop =	0.00	FT	
HEIGHT TO BOTTOM OF OVERFLOW PORT	Hp = Hs - Hop =	N/A	FT	Tank does not have overflow ports
FILL HEIGHT	Hf =	35.92	FT	
FREEBOARD	Hd =	2.27	FT	

DELTA allow = 2 (2.271) = 4.54 FT

BASED ON TOLERANCE OF FLOATING ROOF/PAN

ALLOWABLE TILT DELTA allow = 2 x SQR[Rtol x D]

FLOATING PAN SEAL TOLERANCE	Rtol =	4	INCH
TANK DIAMETER	D =	42.50	FT

DELTA allow = 2 SQR(4/12 x 42.5) = 7.53 FT

ALLOWABLE RIGID BODY TILT SUMMARY

AT FILL HEIGHT = 35.917 FT

ALLOWABLE SETTLEMENT BASED ON OVERFLOWING CRITERIA GOVERNS

DELTA allow = 4.54 FT

EVALUATE ACTUAL DIFFERENTIAL SETTLEMENT

DIFFERENTIAL SETTLEMENT	DELTA actual =	0.00	FT
ALLOWABLE TILT	DELTA allow =	4.54	FT

DELTA actual = 0 FT < DELTA allow = 4.54 FT PASSES CRITERIA

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

DEAD LOAD

TANK DIAMETER	D =	42.50	FT
HEIGHT OF SHELL	Hs =	38.19	FT

SHELL

WT/COURSE = [0.490 KCF (t/12)(h)(PI)(D)]

COURSE NO.	HEIGHT h FT	THICKNESS t INCH	WEIGHT K
1	6.021	0.240	7.88
2	7.5	0.238	9.73
3	7.438	0.248	10.06
4	7.458	0.245	9.96
5	7.438	0.242	9.81
6	2.333	0.251	3.19

RIM ANGLE 0.65

W_{shell} = 51.29 K = 51.29 K

WT/LF = $(W_{shell}) / (\pi D)$ = 51.29 / [(3.142) (42.5)] = 0.384 K/LF

WEIGHT OF RIM ANGLE r_A = 4.9 LB/LF

$W_{rim\ angle} = [(r_A/1000)(\pi)(D)]$
= 4.9/1000 x 3.142 x 42.5
= 0.65 K

FLOOR

FLOOR THICKNESS t_F = 0.298 INCH

WT = $[490\ PCF\ (t_F/12)(\pi)((D^2/4)]/1000$
= 490 x (0.298 / 12) x 3.142 x ((42.5)^2) / 4)] /1000 = 17.26 K

SUBTOTAL = 68.55 K

PROJECT: **In-Service API 653 Inspection** PREPARED BY: SCK
LOCATION: **JB Andrews, MD** DATE: 5/1/2019
EEI PROJECT NO: **9364**
CHECKED BY: JEH
TANK NO: **10** DATE: 08/08/19

DEAD LOAD

PREVIOUS PAGE SUBTOTAL = 68.55 K

ROOF

ROOF PLATE t_R = 0.1 INCH

WT = [490 PCF (t_R/12) (π) ((D^2/4)]/1000
= [490 x (0.1 / 12) x 3.142 x ((42.5) ^2) / 4)] /1000 = 5.79 K

ROOF FRAMING WEIGHT r_F = 5 PSF

WT = (r_F/1000) (π) [((D^2)/4]
= 5 / 1000 x 3.142 x[((42.5) ^2) /4] = 7.09 K

12.89 K = 12.89 K

INTERIOR COLUMNS

COLUMN	SIZE	NUMBER OF COLS	HEIGHT FT	COLUMN WEIGHT LB/LF	TOTAL WEIGHT K
CENTER	NONE	0	0	0.00	0.00
INNER COLUMNS	NONE	0	0	0.00	0.00
OUTER COLUMNS	NONE	0	0	0.00	0.00
					0.00

= 0.00 K

APPURTENANCES AND MISCELLANEOUS WEIGHT

STAIRS, PIPING, MISC. WT = 2% OF FOLLOWING LOADS:

SHELL WT = 51.29 K
ROOF WT = 12.89 K
TOTAL = 64.18 K

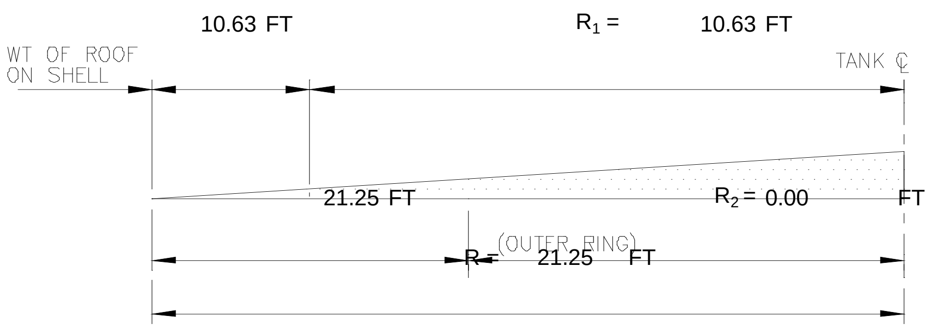
MISC WT = (2%) (64.18) = 1.28 K

TOTAL WEIGHT OF TANK = 82.72 K

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

DEAD LOAD

WEIGHT OF ROOF SUPPORTED BY SHELL



TOTAL WEIGHT OF ROOF

ROOF PLATE	$W_{TOTAL\ ROOF\ PL}$ =	5.79 K	
FRAMING	$W_{TOTAL\ FRAMING}$ =	7.09 K	
		12.89 K	= 12.89 K

ROOF DEAD LOAD SUPPORTED BY INTERIOR COLUMNS

Tank roof is not supported by interior columns, roof is supported by shell.
Therefore, entire roof dead load is supported by the shell.

0.00 K

ROOF DEAD LOAD SUPPORTED BY SHELL

K

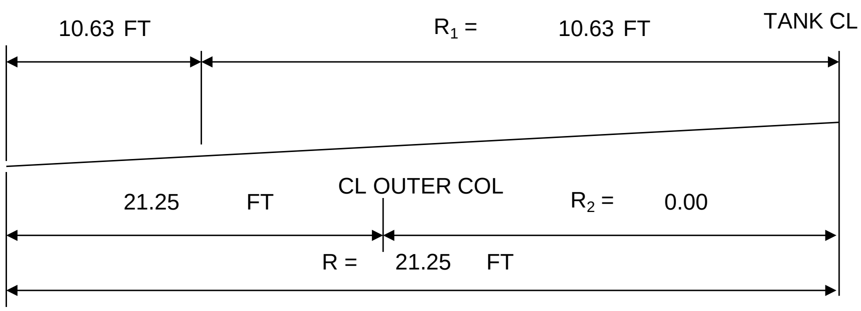
WROOF PL ON SHELL=	5.79
WFRAMING ON SHELL=	7.09
	12.89 K

WT/LF = $(W_{ROOF\ ON\ SHELL}) / (\pi D)$ = 12.89 / [(3.142) (42.5)] = 0.097 K/LF

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

ROOF LIVE LOAD

ROOF LIVE LOAD P_{LL} = 20 PSF



TOTAL ROOF LIVE LOAD

TOTAL ROOF LIVE LOAD = (PLL / 1000) (π) (D^2/4)
= (20 / 1000) x 3.142 x ((42.5 ^2) / 4) = 28.37 K

ROOF LIVE LOAD SUPPORTED BY INTERIOR COLUMNS

Tank roof is not supported by interior coulumns, roof is supported by shell.
Therefore, entire roof live load is supported by the shell.

ROOF LIVE LOAD SUPPORTED BY SHELL

WLL ON SHELL = = 28.37 K

W_{LL} = WLL ON SHELL / (π) (D) = 28.37 / (3.14) (42.5) = 0.213 K/FT

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

SNOW LOAD

CODE: ASCE 7-10

FLAT ROOF SNOW

$Pf = (0.7)\ Ce\ Ct\ Is\ Pg$ PSF EQ. 7.3-1

$Pf_{MIN} = (I)\ Pg$ for $Pg <= 20$ PSF

$Pf_{MIN} = (20)\ (I)$ for $Pg > 20$ PSF

GROUND SNOW	Pg =	25	PSF	UFC 3-301-01
EXPOSURE FACTOR	Ce =	1		ASCE 7-10 TABLE 7-2
THERMAL FACTOR	Ct =	1.2		ASCE 7-10 TABLE 7-3
IMPORTANCE FACTOR	Is =	1		ASCE 7-10 TABLE 1.5-2

Pf = (0.7)1) (1.2) (1) (25) = 21.00 PSF

Pg > 20, THEREFORE Pfmin = (20) (Is) = 20.00 PSF

Pf > Pfmin

ASCE Pf GOVERNS OVER ASCE PFmin

Pf = 21.00 PSF

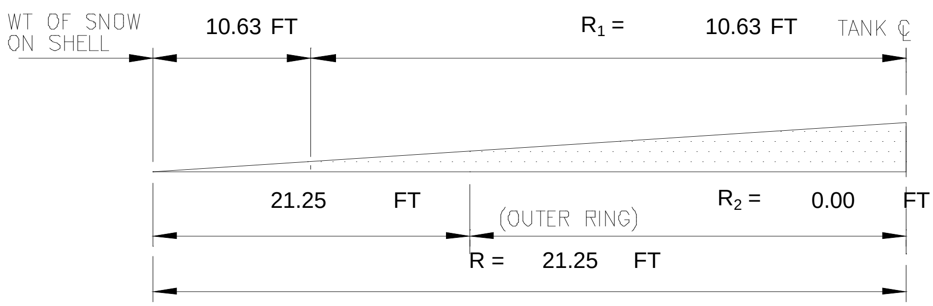
ROOF SNOW LOAD PER LOCAL BUILDING CODE

$Pf_{Local\ Code}$ = 0 PSF

$Pf_{Local\ Code}$ < ASCE Pf

ASCE Pf GOVERNS OVER PfLocal Code

ROOF SNOW LOAD = 21.00 PSF



TOTAL SNOW WEIGHT

TOTAL SNOW WEIGHT $= (Pf / 1000)\ (\pi)\ (D^2/4)$

= (21 / 1000) x 3.142 x ((42.5 ^2) / 4) = 29.79 K

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

SNOW LOAD

ROOF SNOW LOAD SUPPORTED BY INTERIOR COLUMNS

Tank roof is not supported by interior coulumns, roof is supported by shell.
Therefore, entire snow weight is supported by the shell.

ROOF SNOW LOAD SUPPORTED BY SHELL

WSNOW ON SHELL = = 29.79 K

W_{SN} = WSNOW ON SHELL / (π) (D) = 29.79 / (3.14) (42.5) = 0.22 K/FT

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

WIND LOAD EVALUATION: UN-ANCHORED TANK

CODE: API 650 AND ASCE 7-10

RISK CATEGORY	=	III		
EXPOSURE CATEGORY	=	C		
BASIC WIND SPEED	V =	120	MPH	From UFC 3-01-01
BASIC WIND SPEED x 0 .78	V =	93.6	MPH	Modified per API 650 12th Ed sect 5.2.1.k.1
USE API 650 EXPOSURE C WIND PRESSURES				
MODIFIED FOR WIND SPEED (YES/NO)	=	No		

TANK PARAMETERS

TANK DIAMETER	D =	42.50	FT
ROOF SLOPE = 5.00 DEG	=	0.0873	RAD
MEAN ROOF HT = (1/2)(D/2)(TAN THETA	=	0.93	FT
SHELL HEIGHT	Hs =	38.19	FT
MEAN ROOF HEIGHT ABOVE GROUND	=	39.12	FT
TO DETERMINE λ, USE MEAN ROOF HEIGHT	=	40	FT
INTERNAL PRESSURE	=	0.00	PSF
TANK ANCHORED	=	NO	
FILL HEIGHT	Hf =	35.92	FT
THICKNESS OF FLOOR BELOW SHELL	ta =	0.0000	INCHES
YIELD STRENGTH OF FLOOR BELOW SHELL	Fby =	30000.00	PSI

API 650 WIND PRESSURE (BASED ON EXPOSURE C, BASIC WIND SPEED = 120 MPH)

DESIGN WIND PRESSURE ON VERTICAL PROJECTED AREA OF CYLINDRICAL SURFACES, API 650 5.2.1(k)(1)

P_{SHELL} = (18) (V/120)^2 = 10.95 PSF

DESIGN WIND PRESSURE ON HORIZONTAL PROJECTED AREA OF CONICAL OR DOUBLY CURVED SURFACES, API 650 5.2.1(k)(1)

P_{ROOF} = (30)(V/120)^2 = 18.25 PSF

WIND PRESSURE ADJUSTMENT FACTOR FOR HEIGHT AND EXPOSURE - ASCE 7-10 FIG 28.6-1

ADJUSTMENT FACTOR FOR HEIGHT AND EXPOSURE, λ

MEAN ROOF HEIGHT	EXPOSURE B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

λ = 1.49 MEAN ROOF HEIGHT = 39.12 FT, EXPOSURE C

λ AT SITE = 1.49 MEAN ROOF HEIGHT = 39.12 FT, EXPOSURE C

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
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TANK NO:	**10**	DATE:	08/08/19

WIND LOAD EVALUATION: UN-ANCHORED TANK

ADJUSTED WIND PRESSURES FOR HEIGHT AND EXPOSURE

ADJUSTED P_{SHELL} = (λ AT SITE / λ) (P_{SHELL})
= (1.49 / (1.49) (10.95) 10.95 PSF

ADJUSTED P_{ROOF} = (λ AT SITE / λ) (P_{ROOF})
= (1.49 / (1.49) (18.25) 18.25 PSF

WIND OVERTURNING MOMENT

PROJECTED AREA OF SHELL

A_{SHELL} = (D)(Hs) = (42.5) (38.18‹ = 1,622.99 SF

PROJECTED AREA OF ROOF

A_{ROOF} = π (D)^2/4 = π (42.5)^2 /4 = 1,418.63 SF

WIND FORCE ON SHELL

Fw_{SHELL} = (ADJUSTED P_{SHELL}) (A_{SHELL})
= (10.95) (1622.99) / 1000 = 17.77 K

WIND UPLIFT FORCE ON ROOF

Fw_{ROOF} = (ADJUSTED P_{ROOF}) (A_{ROOF})
= (18.25) (1418.63) / 1000 = 25.89 K

OVERTURNING MOMENT FROM EXTERNAL WIND PRESSURE ON SHELL AND ROOF

Mw = (Fw_{SHELL})(Hs/2) + (Fw_{ROOF})(D/2)
= (17.77) (38.188/2) + (25.89) (42.5/2) = 889.59 K-FT

OVERTURNING MOMENT FROM EXTERNAL WIND PRESSURE ON SHELL

Mws = (Fw_{SHELL})(Hs/2)
= (17.77) (38.19/2) = 339.37 K-FT

INTERNAL PRESSURE OVERTURNING MOMENT

INTERNAL PRESSURE FORCE UPLIFT ON ROOF

Fpi_{ROOF} = (INTERNAL PRESSURE) (A_{ROOF})
= (0) (1418.63) / 1000 = 0.00 K

OVERTURNING MOMENT FROM INTERNAL PRESSURE

Mpi = (Fpi_{ROOF})(D/2)
= (0) (42.5/2) = 0.00 K-FT

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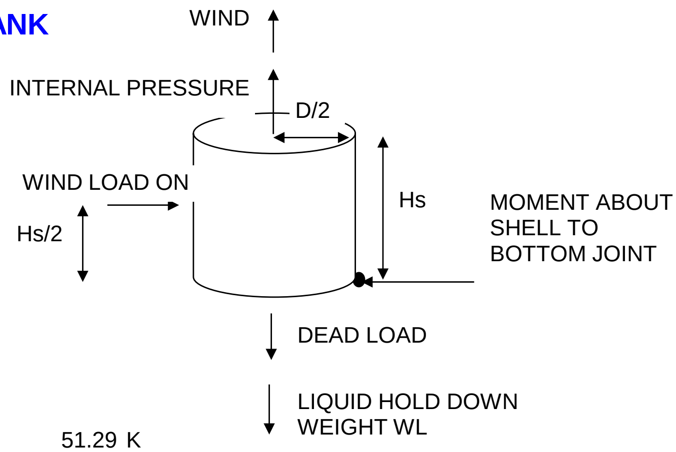
WIND LOAD EVALUATION: UN-ANCHORED TANK



RESISTANCE TO OVERTURNING (API 650 5.11.2)

RESISTANCE TO OVERTURNING CRITERIA

CASE 1: $0.6Mw + Mpi < M_{DL}/1.5 + M_{DLR}$

CASE 2: $Mw + F_P(Mpi) < (M_{DL} + M_F)/2 + M_{DLR}$

CASE 3: $Mws + F_P(Mpi) < M_{DL}/1.5 + M_{DLR}$

UNANCHORED TANK MUST SATISFY BOTH CRITERIA

DEAD LOAD RESISTING MOMENT

SHELL WEIGHT	=	51.29 K
WEIGHT OF ROOF ON SHELL	=	5.79 K
WEIGHT OF ROOF FRAMING SUPPORTED BY SHELL	=	7.09 K
WEIGHT OF ROOF PLATE + FRAMING SUPPORTED BY SHELL	=	12.89 K

RESISTING MOMENT FROM DEAD LOAD

M_{DL} = (SHELL WEIGHT)(D/2)
= (51.29) (42.5/2) = 1,089.89 K-FT

M_{DLR} = (ROOF + FRAMING WEIGHT)(D/2)
= (12.89) (42.5/2) = 273.82 K-FT

INTERNAL FLUID RESISTING MOMENT

WEIGHT OF LIQUID RESISTING OVERTURNING

PER API 650 5.11.2 UNANCHORED TANKS, THE WEIGHT OF LIQUID RESISTING OVERTURNING IS BASED ON ONE HALF THE DESIGN LIQUID HEIGHT AND A SPECIFIC GRAVITY OF 0.70 .

FILL HEIGHT Hf = 35.92 FT

wL = $4.67\ t_a\ [(Fby)(Hf)]^{0.5}$ LB PER LF OF CIRCUMFERENCE

ta = THICKNESS OF BOTTOM PLATE UNDER SHELL LESS CORROSION ALLOWANCE
ta = $t_b - CA_{floor}$

TANK DOES NOT HAVE AN ANNULAR PLATE, USE FLOOR THICKNESS BELOW SHELL tb to DETERMINE ta

tb = 0.0000 INCHES FLOOR THICKNESS BELOW SHELL
ta = 0 - 0 = 0.2980 INCHES

WIND LOAD EVALUATION: UN-ANCHORED TANK

INTERNAL FLUID RESISTING MOMENT

WEIGHT OF LIQUID RESISTING OVERTURNING

TANK DOES NOT HAVE AN ANNULAR PLATE, USE THICKNESS OF FLOOR BELOW SHELL TO DETERMINE WEIGHT OF LIQUID RESISTING OVERTURNING

SPACE RESERVED FOR TANK WITH ANNULAR PLATE

SPACE RESERVED FOR TANK WITH ANNULAR PLATE

ta = 0.2980 INCHES

wL = 4.67 (0.298) SQRT[(30000) (35.917)] 1,444.59 lb/lf

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WIND LOAD EVALUATION: UN-ANCHORED TANK

INTERNAL FLUID RESISTING MOMENT

WEIGHT OF LIQUID RESISTING OVERTURNING

=

WEIGHT OF LIQUID (HOLD DOWN WEIGHT)

WL = LESSER OF 0.45(Hf)D OR (wL)(πD)

0.45(Hf)D = 0.45 (35.917) (42.5) = 686.91 K
(wL)(πD) = (1444.59) (π) (42.5) / 1000 = 192.88 K GOVERNS

WL = 192.88 K

RESISTING MOMENT FROM INTERNAL LIQUID

M_F = (WL)(D/2)

= (192.88) (42.5 /2) = 4,098.70 K-FT

RESISTANCE TO OVERTURNING (API 650 5.11.2)

CASE 1: $0.6Mw + Mpi < M_{DL}/1.5 + M_{DLR}$

$0.6Mw + Mpi$ = 0.6 (889.59) +0 = 533.76 K-FT
$M_{DL}/1.5 + M_{DLR}$ = (1089.89)/1.5 + 273.82 = 1,000.42 K-FT

533.76 < 1,000.42 PASS CRITERIA

CASE 2: $Mw + F_P(Mpi) < (M_{DL} + M_F)/2 + M_{DLR}$

$Mw + F_P(Mpi)$ = (889.59) + (0.4) (0) = 889.59 K-FT
$(M_{DL} + M_F)/2 + M_{DLR}$ = (1089.89 + 4098.7)/2 + (273.82) = 2,868.12 K-FT

889.59 < 2,868.12 PASS CRITERIA

CASE 3: $Mws + F_P(Mpi) < M_{DL}/1.5 + M_{DLR}$

$Mws + F_P(Mpi)$ = (339.37) + (0.4) (0) = 339.37 K-FT
$M_{DL}/1.5 + M_{DLR}$ = (1089.89)/1.5 + 273.82 = 1,000.42 K-FT

339.37 < 1,000.42 PASS CRITERIA

MINIMUM LIQUID HEIGHT TO RESIST OVERTURNING (APPLIES TO CASE 2 ONLY)

$Mw + F_P(Mpi)$ = $(M_{DL} + M_F)/2 + M_{DLR}$
M_F = $2[Mw + Fp(Mpi) - M_{DLR}] - M_{DL}$ = (WL)(D/2)
WL = $\{2[Mw + Fp(Mpi) - M_{DLR}] - M_{DL}\} / (D/2)$ = 6.67 K
WL = (wa)(πD)
wa = [WL / (πD)] (1000 LB/K) = 49.92 LB/LF
wa = 4.67 ta [(Fby)(Hf)]^0.5
Hf = (wa / 4.67 tb)^2 / (Fby) = #DIV/0! FT

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WIND LOAD EVALUATION: UN-ANCHORED TANK

RESISTANCE TO SLIDING

WIND BASE SHEAR

V = 17.77 K (WIND FORCE ON SHELL)

SLIDING RESISTANCE

Vs = μ(Ws + Wr + Wf + Wp)

COEFFICIENT OF FRICTION	μ =	0.40	
SHELL WEIGHT	Ws =	51.29	K
ROOF WEIGHT	Wr =	12.89	K
FLOOR WEIGHT	Wf =	17.26	K
FILL HEIGHT	Hf =	35.92	FT
CONTENTS WEIGHT	Wp =	(πD^2/4)(62.4)(G)(Hf)	
	Wp =	[(π) (42.5)^2 / 4] (62.4)(0.84) (35.92)/1(=	2,670.74 K

FOR EMPTY TANK

Hf = 0 FT

Wp = [(π) (42.5)^2 / 4] (62.4)(0.84) (0)/1000 = 0.00 K

Vs = (0.4) (51.29 + 12.89 + 17.26 + 0) = 32.58 K

Vs = 32.58 K > V = 17.77 K

FOR EMPTY TANK SLIDING RESISTANCE CRITERIA SATISFIED

MINIMUM PRODUCT HEIGHT REQUIRED TO SATISFY SLIDING RESISTANCE

V = Vs

V = μ(Ws + Wr + Wf + Wp)

Wp = (V / μ) - (Ws + Wr + Wf) = (πD^2/4)(62.4)(G)(Hf)

Hf min = [(V / μ) - (Ws + Wr + Wf)] / [(πD^2/4)(62.4)(G)]

Hf min = [(17.77 / 0.4) - (51.29 + 12.89 + 17.26)] {1000 / [(π) (42.5^2) / 4) (62.4) (0.84)] }

Hf min = < 0 FT

SUMMARY

1. TANK MEETS RESISTANCE TO OVERTURNING CRITERIA
2. TANK MEETS SLIDING RESISTANCE CRITERIA

COMMENT: Tank is adequate to resist all wind loads.

PROJECT: **In-Service API 653 Inspection** PREPARED BY: SCK
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SHELL STIFFENER REQUIREMENTS

EVALUATION CRITERIA

API 650 CRITERIA, Sec. 5.9.6

TRANSFORMED SHELL HEIGHT

TRANSFORMED SHELL HEIGHT	$H_{tr} = SUM(W_{tr})$	FT
TRANSFORMED SHELL COURSE HEIGHT	$W_{tr} = SQRT [(t_{TOP} / t)^5] x W$	
COURSE HEIGHT	= W	FT
THICKNESS OF TOP COURSE	$= t_{TOP}$	INCH

COURSE NO	t INCH	W FT	W_{tr} FT
1	0.240	6.021	6.735
2	0.238	7.5	8.566
3	0.248	7.438	7.665
4	0.245	7.458	7.923
5	0.242	7.438	8.149
6	0.251	2.333	2.333

Htr = 41.37 FT

3-SECOND GUST DESIGN WIND VELOCITY

V	=	120 MPH	From ASCE 7-10 or UFC 3-01-01
V	=	93.6 MPH	Modified per API 650 12th Ed sect 5.2.1.k.1

MAXIMUM HEIGHT OF UNSTIFFENED SHELL

H_1 = 600,000 (tTOP) SQRT [(tTOP / D)^3] (120 / V)^2

H_1 = 600,000 x (0.251 x SQRT[(0.251 / 42.5)^3)] (120 /93.6)^2 = 112.35 FT

SHELL STIFFENER REQUIREMENTS

H_1 = 112.35 FT > Htr = 41.37 FT

INTERMEDIATE SHELL STIFFENERS NOT REQUIRED

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SHELL STIFFENER REQUIREMENTS

MAXIMUM WIND VELOCITY WITHOUT SHELL STIFFENERS

$H_1 \geq$ Htr

SET H_1 = Htr

600,000 (tTOP) SQR [(tTOP / D)^3] (120/V)^2 = Htr

SOLVING FOR V:

Vmax = 120 / { SQRT [Htr / (600,000 (tTOP) SQRT (tTOP / D)^3)

Vmax = 120 / { SQRT [41.371 / (600,000 (0.251) SQRT (0.251 / 42.5)^3} = 154.24 MPH

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SEISMIC EVALUATION: UN-ANCHORED TANK

TANK PARAMETERS

DIAMETER	D =	42.50	FT
SHELL HEIGHT	Hs =	38.19	FT
WEIGHT OF SHELL	Ws =	51.29	K
PRODUCT STORAGE	=	Jet A	
FILL HEIGHT	H =	35.92	FT
PRODUCT SPECIFIC GRAVITY	G =	0.840	
TYPE OF FOUNDATION	=	Ringwall	
TANK ANCHORED	=	NO	
TANK HAS ANNULAR PLATE	=	NO	

E.3 PERFORMANCE BASIS

SEISMIC USE GROUP	SUG =	III	
IMPORTANCE FACTOR	I =	1.5	API 650 ANNEX E TABLE E.5

E.4 SITE GROUND MOTION

E.4.2 MAPPED ASCE METHOD

Ss	=	0.1200	%g
S1	=	0.0500	%g
TL	=	8.00	SEC
So = 0.4Ss	=	0.0480	%g

E.4.6 SITE CLASS

SITE CLASS = D

E.4.5 SITE MODIFICATION COEFFICIENTS

Fa	=	1.60
Fv	=	2.40

ASCE 7 ADJUSTED MCE SPECTRAL RESPONSE ACCELERATION PARAMETERS

Sms	=	(Fa) (Ss)	=	0.1920
Sm1	=	(Fv) (S1)	=	0.1200

SCALING FACTOR FROM MCE TO DESIGN LEVEL SPECTRAL ACCELERATIONS

Q = 2/3

ASCE 7 DESIGN SPECTRAL RESPONSE ACCELERATION PARAMETERS

S_{DS}	=	Q (Sms)	=	0.1280
S_{D1}	=	Q (Sm1)	=	0.0800

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.4 SITE GROUND MOTION

E.4.5 STRUCTURAL PERIOD OF VIBRATION

IMPULSIVE NATURAL PERIOD

Ti = (1 / 27.8) [Ci (Hf) / SQRT (tu / D)] [SQRT (p) / SQRT (E)] E.4.5.1-1a

Ci = 6.0735318 FIGURE E.1
Hf = 35.92 FT
Ws = 51.29 K
tu = EQUIVALENT UNIFORM THICKNESS OF TANK SHELL, INCHES
tu = 12 Ws / [(Hs) (Π) (D) (0.490 K/FT^3)]
tu = (12) (51.29) / [(38.188) (Π) (42.5) (0.4 = 0.246 INCHES
p = 52.416 LB/FT^3 DESITIY OF FLUID IN TANK (Jet A)
E = 29000000 PSI ELASTIC MODULUS OF TANK MATERIAL

Ti = (1 / 27.8) [(6.07353176470588) (35.917) / SQRT (0.246 / 42.5)] [SQRT (52.416 / 29000000)]
Ti = 0.139 SEC

CONVECTIVE (SLOSHING) PERIOD, Tc

Ks = 0.578 / [tanh(3.68Hf/D)]^0.5 E.4.5.2-2c
= 0.578 / [tanh(3.68(35.917)/42.5)]^0.5 = 0.5792

Tc = Ks(D)^0.5 E.4.5.2-2b
= 0.58(42.5)^5 = 3.776 SEC

E.5.1.1 RESPONSE MODIFICATION FACTORS

TABLE E.4 RESPONSE MODIFICATION FACTORS FOR ASD METHODS

ANCHORAGE SYSTEM	Rwi (IMPULSIVE)	Rwc (CONVECTIVE)
1 SELF-ANCHORED	3.5	2
2 MECHANICALLY ANCHORED	4	2

ANCHORAGE SYSTEM = SELF-ANCHORED
Rwi = 3.5
Rwc = 2

E.4.6.1 SPECTRAL ACCELERATION COEFFICIENTS

IMPULSIVE SPECTRAL ACCELERATION PARAMETER, Ai

Ai = S_{DS} (I/Rwi) E4.6.1-1
Ai MIN ≥ 0.007 E4.6.1-2
FOR $S_1 \geq 0.6$: Ai > 0.5S1(I/Rwi) E4.6.1-3

S1 = 0.0500 < 0.6 CRITERIA BASED ON S1 DOES NOT GOVERN

SDS (I/Rwi) = 0.128 (1.5 / 3.5) = 0.055 GOVERNS

Ai MIN ≥ 0.007

Ai = 0.055

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.4 SITE GROUND MOTION

E.4.6.1 SPECTRAL ACCELERATION COEFFICIENTS

CONVECTIVE SPECTRAL ACCELERATION PARAMETER, AC

FOR $Tc \leq TL$

Ac = $KS_{D1}(1/Tc)(I/Rwc)$ $\leq$ Ai E.4.6.1-4

K = 1.5 K = COEFFICIENT TO ADJUST FROM 5% TO 0.5% DAMPING,
K = 1.5 UNLESS SPECIFIED OTHERWISE

FOR $Tc > TL$

Ac = $KS_{D1}(TL/Tc^2)(I/Rwc)$ $\leq$ Ai E4.6.1-5

Tc = 3.78 SEC
TL = 8.00 SEC

Tc < TL E4.6.1-4 GOVERNS

Ac = 1.5(0.08) (1/3.78) (1.5/2) = 0.024 < Ai

Ac = 0.024

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

DESIGN / EVALUATION PARAMETERS

WEIGHT OF TANK FLOOR	Wf =	17.26 K	
WEIGHT OF SHELL	Ws =	51.29 K	
WT OF ROOF AND FRAMING	=	12.89 K	
WT OF FLOATING PAN/ROOF	Wpan =	10.87 K	
ROOF SNOW LOAD	=	29.79 K	
TOTAL WEIGHT OF ROOF INCLUDING FRAMING AND 10% OF BALANCED ROOF DESIGN SNOW LOAD	Wr =	15.86 K	API 650 E2.2
PRODUCT STORAGE	=	Jet A	
FILL HEIGHT	Hf =	35.917 FT	
PRODUCT SPECIFIC GRAVITY	G =	0.84	

WEIGHT OF CONTENTS Wp = π (D^2 / 4) (Hf) Уw (G) / 1000
= π (42.5^2 / 4) (35.917) (62.4) (0.84) / 1000 = 2,670.74 K

E.6.1.1 EFFECTIVE WEIGHT OF PRODUCT

IMPULSIVE WEIGHT Wi

FOR D/H $\geq$ 1.333

Wi = {tanh [0.866 (D/H)] / 0.866 (D/H)} Wp E.6.1.1-1

FOR D/H < 1.333

Wi = [1.00 - 0.218 (D/H)] Wp E.6.1.1-2

D/H = 1.183 < 1.333 E.6.1.1-2 GOVERNS

Wi = [1.00 - 0.218 (42.5/35.917)] 2670.74 = 1,981.81 K

CONVECTIVE (SLOSHING) WEIGHT Wc

Wc = 0.230 (D/H) tanh(3.67H/D) Wp E.6.1.1-3

Wc = 0.230 (42.5/35.917) tanh[(3.67) 35.917/42.5] 2670.7 = 723.92 K

SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.1.2.1 CENTER OF ACTION FOR RINGWALL OVERTURNING MOMENT

THE RINGWALL MOMENT, Mrw, IS THE PORTION OF THE TOTAL OVERTURNING MOMENT THAT ACTS AT THE BASE OF THE TANK SHELL PERIMETER. THIS MOMENT IS USED TO DETERMINE LOADS ON A RINGWALL FOUNDATION, THE TANK ANCHORAGE FORCES, AND TO CHECK THE LONGITUDINAL SHELL COMPRESSION.

HEIGHT TO THE CENTER OF THE IMPULSIVE FORCE Wi

Xi = HEIGHT FROM BOTTOM OF SHELL TO CENTER OF IMPULSIVE FORCE Wi

FOR D/H $\geq$ 1.333

Xi = 0.375H E.6.1.2.1-1

FOR D/H < 1.333

Xi = [0.5 -0.094(D/H)] H E6.1.2.1-2

D/H = 1.183 < 1.333 E.6.1.2.1-2 GOVERNS

Xi = [0.5-0.094(42.5/35.917)] = 13.964 FT

HEIGHT TO THE CENTER OF THE CONVECTIVE FORCE WC

Xc = HEIGHT FROM BOTTOM OF SHELL TO CENTER OF CONVECTIVE FORCE Wc

Xc = [1.0 - {(cosh(3.67H/D) -1) / ((3.67H/D) sinh(3.67H/D)) }] H E.6.1.2.1-3

Xc = [1.0 - {(cosh((3.67) (35.917/42.5)) -1) / ((3.67) (35.917/42.5) sinh((3.67) (35.917/42.5)) }] (35.917)

Xc = 25.334 FT

SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.1.2.2 CENTER OF ACTION FOR SLAB OVERTURNING MOMENT

THE SLAB MOMENT, Ms, IS THE TOTAL OVERTURNING MOMENT ACTING ACROSS THE ENTIRE TANK BASE CROSS SECTION. THIS OVERTURNING MOMENT IS USED TO DESIGN SLAB AND PILE CAP FOUNDATIONS.

HEIGHT TO THE CENTER OF THE IMPULSIVE FORCE Wi

Xis = HEIGHT FROM BOTTOM OF SHELL TO CENTER OF IMPULSIVE FORCE Wi

FOR D/H $\geq$ 1.333

Xis = 0.375 [1.00 + 1.333 { (0.866(D/H) / tanh (0.866 (D/H)) - 1.00}] H   E6.1.2.2-1

FOR D/H < 1.333

Xis = [0.5+0.060(D/H)] H   E.6.1.2.2-2

D/H = 1.183 < 1.333   EQ E.6.1.2.2-2 GOVERNS

Xis = [0.5+0.060 (42.5/35.917)] (35.917)

Xis = 20.509 FT

HEIGHT TO THE CENTER OF THE CONVECTIVE FORCE Wc

Xcs = HEIGHT FROM BOTTOM OF SHELL TO CENTER OF CONVECTIVE FORCE Wc

Xcs = [1.0 - {(cosh(3.67H/D) -1.937) / ((3.67H/D) sinh(3.67H/D)) }] H   E.6.1.2.2-3

Xcs = [1.0 - {(cosh(3.67(35.917/42.5) -1.937) / ((3.67(35.917/42.5) sinh(3.67(35.917/42.5)) }] (35.917)

Xcs = 26.312 FT

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

HEIGHT TO THE CENTROID OF SHELL

COURSE NO.	WEIGHT K	CENTROID FT	M K-FT
1	7.88	3.011	23.72
2	9.73	10.511	102.29
3	10.06	17.949	180.51
4	9.96	25.407	253.10
5	9.81	32.845	322.32
6	3.19	35.178	112.31
RIM ANGLE	0.65	38.188	24.98
	51.29		1019.22
MISC. WEIGHT	1.28	19.094	24.51
	52.57		1043.72

Xs = 1043.72 / 52.57 = 19.85 FT

HEIGHT TO THE CENTROID OF ROOF

Xr = 38.19 FT

HEIGHT TO THE CENTROID OF FLOATING PAN/ROOF

Xpan = 35.92 FT

E.6.1.3 VERTICAL SEISMIC EFFECTS

Av = $0.47S_{DS}$

Av = 0.47 (0.128) = 0.0602

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.1.4 DYNAMIC LIQUID HOOP FORCES

Y = DISTANCE DOWN FROM LIQUID SURFACE TO ANALYSIS POINT.

SINCE DYNAMIC HOOP FORCES ARE COMBINED WITH HYDROSTATIC HOOP FORCES WHICH ARE CALCULATED AT ONE FOOT ABOVE THE BOTTOM OF EACH SHELL COURSE, USE Y BASED ON DISTANCE FROM LIQUID SURFACE TO ONE FOOT ABOVE THE BOTTOM OF EACH SHELL COURSE.

IMPULSIVE HOOP MEMBRANE FORCE Ni

FOR D/H $\geq$ 1.333

Ni = 4.5 Ai GDH [(Y/H) - 0.5 (Y/H)^2] tanh {0.866 (D/H)} LB/IN E.6.1.4-1b

FOR D/H < 1.333 AND Y< 0.75D

Ni = 2.77 Ai G(D^2) [(Y/0.75D) - 0.5 (Y/0.75D)^2] LB/IN E.6.1.4-2b

FOR D/H < 1.333 AND Y$\geq$ 0.75D

Ni = 1.39 Ai G(D^2) LB/IN E.6.1.4-3b

D	=	42.500	FT	
H	=	35.917	FT FILL HEIGHT	
D/H	=	1.183	<	1.333
Ai	=	0.055		
G	=	0.840		

IMPULSIVE HOOP FORCES AT ONE FOOT ABOVE THE BOTTOM OF EACH SHELL COURSE

	COURSE NO.	THICKNESS t INCHES	HEIGHT FT	ELEV AT BOT OF COURSE B	Y = H - B - 1 FT	0.75D	IMPULSIVE FORCE Ni LB/IN	STRESS Ni / t PSI
BOTTOM	1	0.2400	6.021	0.000	34.917	31.875	116	482
	2	0.2380	7.500	6.021	28.896	31.875	114	480
	3	0.2480	7.438	13.521	21.396	31.875	103	415
	4	0.2450	7.458	20.959	13.958	31.875	79	322
	5	0.2420	7.438	28.417	6.500	31.875	42	174
	6	0.2510	2.333	35.855	0.000	31.875	0	0

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.1.4 DYNAMIC LIQUID HOOP FORCES

CONVECTIVE HOOP MEMBRANE FORCE Nc

Nc = 0.98 Ac G(D^2) cosh [3.68 (H - Y) / D] / cosh [3.68 H /D] } LB/IN E.6.1.4-4b

D = 42.500 FT
H = 35.917 FT FILL HEIGHT
Ac = 0.024
G = 0.840

CONVECTIVE HOOP FORCES AT ONE FOOT ABOVE THE BOTTOM OF EACH SHELL COURSE

	COURSE NO.	THICKNESS t INCHES	HEIGHT FT	ELEV AT BOT OF COURSE B	Y = H - B - 1 FT	CONVECTIVE FORCE Nc LB/IN	STRESS Nc / t PSI
BOTTOM	1	0.2400	6.021	0.000	34.917	3	13
	2	0.2380	7.500	6.021	28.896	4	16
	3	0.2480	7.438	13.521	21.396	6	24
	4	0.2450	7.458	20.959	13.958	11	44
	5	0.2420	7.438	28.417	6.500	20	84
	6	0.2510	2.333	35.855	0.000	35	141

PRODUCT HYDROSTATIC DESIGN HOOP FORCE

PRODUCT DESIGN HOOP STRESS Sd

Sd = [2.6 x D (H -1+ DELTA/2) x G] / (t-CA) PSI

Sd IS BASED ON API 650 EQUATION FOR SHELL THICKNESS MODIFIED FOR SETTLEMENT

FILL HEIGHT	Hf =	35.917	FT
TANK DIAMETER	D =	42.50	FT
HEIGHT OF LIQUID ABOVE BOTTOM OF SHELL COURSE	=	H	FT
DIFFERENTIAL SETTLEMENT	DELTA =	0.00	FT
PRODUCT SPECIFIC GRAVITY	G =	0.840	Jet A
JOINT EFFICIENCY	=	E	PER API 650 OR API 653
SHELL COURSE THICKNESS	=	t	INCHES
SHELL CORROSION ALLOWANCE	CA_{shell} =	0.000	INCHES

PRODUCT DESIGN HOOP FORCE Nh = (Sd)(t) LB/IN

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.1.4 DYNAMIC LIQUID HOOP FORCES

PRODUCT HYDROSTATIC DESIGN HOOP FORCE

PRODUCT HYDROSTATIC HOOP FORCES AT ONE FOOT ABOVE THE BOTTOM OF EACH SHELL COURSE

	COURSE NO.	t INCHES	CA_{shell} INCHES	h FT	B FT	H=(Hf - B) FT	JOINT EFFICIENCY E	Sd PSI	Nh LB/IN
BOTTOM	1	0.2400	0.0000	6.02	0.00	35.92	0.85	13,504	3,241
	2	0.2380	0.0000	7.50	6.02	29.90	0.85	11,269	2,682
	3	0.2480	0.0000	7.44	13.52	22.40	0.85	8,008	1,986
	4	0.2450	0.0000	7.46	20.96	14.96	0.85	5,288	1,296
	5	0.2420	0.0000	7.44	28.42	07.50	0.85	2,493	603
	6	0.2510	0.0000	2.33	35.86	00.06	0.85	-347	-87

E.6.2.4 ALLOWABLE HOOP STRESS

THE ALLOWABLE HOOP STRESS SHALL BE THE LESSER OF:

1. THE BASIC ALLOWABLE MEMBRANE STRESS FOR THE SHELL PLATE MATERIAL, INCREASED BY 33%

2. 0.9Fy X JOINT EFFICIENCY

	COURSE NO.	MATERIAL ALLOW STRESS Sd PSI	YIELD STRESS Fy PSI	JOINT EFFICIENCY E	4/3(Sd) PSI	0.9Fy(E) PSI	ALLOWABLE HOOP STRESS PSI
BOTTOM	1	23,600	30,000	0.850	31,467	22,950	22,950
	2	23,600	30,000	0.850	31,467	22,950	22,950
	3	26,000	30,000	0.850	34,667	22,950	22,950
	4	26,000	30,000	0.850	34,667	22,950	22,950
	5	26,000	30,000	0.850	34,667	22,950	22,950
	6	26,000	30,000	0.850	34,667	22,950	22,950

PROJECT: **In-Service API 653 Inspection**
LOCATION: **JB Andrews, MD**
EEI PROJECT NO: **9364**
TANK NO: **10**

PREPARED BY: SCK
DATE: 5/1/2019

CHECKED BY: JEH
DATE: 08/08/19

SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.1.4 DYNAMIC LIQUID HOOP FORCES

COMBINED STRESS DUE TO PRODUCT HYDROSTATIC DESIGN HOOP FORCE AND DYNAMIC HOOP FORCES

St = {Nh ± [(Ni)^2 + (Nc)^2 + (AvNh/2.5)^2]^0.5} / t E.6.1.4-6

	COURSE NO.	Nh LB/IN	Ni LB/IN	Nc LB/IN	Av	AvNh LB/IN	t INCH	St PSI	ALLOW STRESS PSI	
BOTTOM	1	3,241	116	3	0.0602	195	0.2400	14,086	22,950	PASS
	2	2,682	114	4	0.0602	161	0.2380	11,821	22,950	PASS
	3	1,986	103	6	0.0602	119	0.2480	8,466	22,950	PASS
	4	1,296	79	11	0.0602	78	0.2450	5,637	22,950	PASS
	5	603	42	20	0.0602	36	0.2420	2,696	22,950	PASS
	6	-87	0	35	0.0602	-5	0.2510	-205	22,950	PASS

E.6.1.5 OVERTURNING MOMENT

RINGWALL MOMENT

Mrw = SQRT{ [Ai(WiXi + WsXs + WrXr + WpanXpan)]^2 + [Ac(WcXc)]^2 } E.6.1.5-1

Mrw = SQRT{ [0.055((1981.81)(13.964)+(51.29)(19.85)+(15.86)(38.188)+(10.87)(35.92)]^2 + [(0.024)(723.92)(25.334)]^2}

Mrw = 1,691.14 K-FT

SLAB MOMENT

Ms = SQRT{ [Ai(WiXis + WsXs + WrXr + WpanXpan)]^2 + [Ac(WcXcs)]^2 } E.6.1.5-2

Ms = SQRT{ [0.055((1981.81)(20.509)+(51.29)(19.85)+(15.86)(38.188)+(10.87)(35.92))]^2 + [(0.024)(723.92)(26.312)]^2}

Ms = 2,390.37 K-FT

E.6.2.1.1 RESISTANCE TO DESIGN LOADS: SELF-ANCHORED TANK

WEIGHT OF LIQUID RESISTING OVERTURNING

Wa = $7.9(t_a)$ [(Fby)(Hf)(G_e)]^0.5 ≤ 1.28(H)(D)(Ge) LB/FT E.6.2.1.1-1b

EQUATION E.6.2.1.1.-1b APPLIES WHETHER OR NOT A THICKENED BOTTOM ANNULUS IS USED. THE VALUE OF L SHALL BE SET TO 0.035D AND THE VALUE OF Wa SHALL BE SET EQUAL TO 1.28 HGe

THICKNESS OF BOTTOM PLATE UNDER SHELL LESS CORROSION ALLOWANCE

ta = $t_b - CA_{floor}$

TANK DOES NOT HAVE AN ANNULAR PLATE, USE FLOOR THICKNESS BELOW SHELL tb to DETERMINE ta

tb = 0.0000 INCHES FLOOR THICKNESS BELOW SHELL

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ta = 0 - 0 = 0.2980 INCHES

SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.2.1.1 RESISTANCE TO DESIGN LOADS: SELF-ANCHORED TANK

WEIGHT OF LIQUID RESISTING OVERTURNING

TANK DOES NOT HAVE AN ANNULAR PLATE, USE THICKNESS OF FLOOR BELOW SHELL TO DETERMINE WEIGHT OF LIQUID RESISTING OVERTURNING

SPACE RESERVED FOR TANK WITH ANNULAR PLATE

EFFECTIVE SPECIFIC GRAVITY

G_e = G (1-0.4Av)
= 0.84 [1-(0.4)(0.0602)] = 0.820

SPACE RESERVED FOR TANK WITH ANNULAR PLATE

ta = 0.2980 INCHES

Wa = 7.9(0.298) [(30000)(35.917)(0.82)]^0.! = 2,212.61 LB/FT
1.28(Hf)(D)(G_e) = 1.28 (35.917)(42.5)(0.82) = 1,602.19 LB/FT GOVERNS

Wa = 1,602.19 LB/FT GOVERNS = 1.602 K/FT

SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.2.1.1 RESISTANCE TO DESIGN LOADS: SELF-ANCHORED TANK

ANCHORAGE RATIO

J = Mrw / {D^2 [wt(1-0.4Av) + Wa -0.4(wint)]} E.6.2.1.1.1-1

RINGWALL MOMENT	Mrw	=	1691.14	K-FT	
WEIGHT OF TANK SHELL	Ws	=	51.29	K	
WEIGHT OF ROOF ACTING ON SHELL		=	12.89	K	
ROOF SNOW LOAD ON SHELL		=	29.79	K	
WEIGHT OF ROOF ACTING ON SHELL + 10% SNOW LOAD	Wrs	=	15.86	K	
	wrs	=	Ws/πD	K/FT	
	wrs	=	0.119	K/FT	
TANK AND ROOF WEIGHT ACTING AT BASE OF SHELL	wt	=	[Ws/πD]+wrs		E.6.2.1.1.1-2
	wt	=	[51.29 / π(42.5)] +0.119	K/FT	
	wt	=	0.503	K/FT	
	Av	=	0.0602		
	Wa	=	1.602	K/FT	
UPLIFT FORCE DUE TO INTERNAL PRESSURE PER FOOT OF SHELL	Pi	=	0.00	PSF	
	wint	=	(Pi / 1000) ($\pi D^2/4$) / πD	K/FT	
	wint	=	(0 / 1000) (π)(42.5^2 / 4) / (π)(42.5)		
	wint	=	0.000	K/FT	

J = 1691.14 / {(42.5)^2 [(0.503)(1-0.4(0.0602)) + 1.602 - 0.4(0)]}

= 0.4473

J < 0.785, NO CALCULATED UPLIFT, TANK IS SELF-ANCHORED

E.6.2.2.1 SHELL COMPRESSION IN SELF-ANCHORED TANKS (BOTTOM SHELL COURSE)

FOR J < 0.785

σ_c = [wt(1 + 0.4Av) + 1.273Mrw / D^2] (1/12ts) E.6.2.2.1b

FOR J > 0.785

σ_c = { { [wt(1 + 0.4Av) + Wa] / [0.607 - 0.18667(J)^2/3]] -Wa } (1/12ts) E.6.2.2.2b

SINCE J = 0.4473 < 0.785

σc = [0.5031(1 + 0.4(0.0602)) + 1.273(1691.14 / (42.5)^2] {1/ [(12)(0.24)]}

σc = 0.593 KSI

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.6 DESIGN

E.6.2.2.3 ALLOWABLE SHELL COMPRESSION IN BOTTOM COURSE

WHEN $(G\ Hf\ D^2) / t^2 \geq 10^6$

$$Fc = \frac{10^6 t}{D} \quad \text{PSI} \qquad \text{E.6.2.2.3-1b}$$

WHEN $(G\ Hf\ D^2) / t^2 < 10^6$

$$Fc = \frac{10^6 t}{2.5 D} + (600)\ SQRT[(G)(Hf)] \quad \text{PSI} \quad <= 0.5(Fty) \qquad \text{E.6.2.2.3-2b}$$

(G)(Hf)(D^2)/t^2 = (0.84)(35.917)(42.5)^2 / (0.24)^2 = 946,095 < 10^6 USE E.6.2.2.3-2b

Fc = {[(10^6)(0.24)/(2.5)(42.5)]+(600xSQR(0.84x35.917)}/1000 = 5.55 KSI

0.5 x Fty = 0.5 x 30000 / 1000 = 15.00 KSI

Fc = 5.55 KSI GOVERNS

σ_c = 0.593 KSI < Fc = 5.55 KSI

SHELL COMPRESSION CRITERIA SATISFIED, TANK IS SELF-ANCHORED

E.6.1 SEISMIC BASE SHEAR

V = SQRT[(Vi)^2 + (Vc)^2)] E.6.1-1

Vi = Ai(Ws + Wr + Wf + Wi) E.6.1-2

Vi = 0.055 (51.29 + 17.26 + 1981.81) = 112.77 K

Vc = AcWc E.6.1-3

Vc = (0.024)(723.92) = 17.37 K

V = SQRT[(112.77)^2 + (17.37^2)] = 114.10 K

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SEISMIC EVALUATION: UN-ANCHORED TANK

E.7.6 SLIDING RESISTANCE

Vs = μ(Ws + Wr + Wf + Wp)(1.0-0.4Av) E.7.6-1

Wp = (π)(D^2)/4)(62.4)(G)(Hf) TOTAL WEIGHT OF TANK CONTENTS

Wp = [(π) (42.5)^2 / 4] (62.4) (0.84) (35.917) / 1000 = 2,670.74 K

Vs = (0.4) (51.29 + 12.89 + 17.26 + 2670.74) [1.0 - 0.4 (0.06016)] = 1,074.38 K

Vs = 1074.38 K > V = 114.10 K

SLIDING RESISTANCE CRITERIA SATISFIED

E.7.2 SLOSHING WAVE HEIGHT

d_s = $0.42DA_f$ CALCULATED WAVE HEIGHT E.7.2-1

FOR SUG I AND II

WHEN Tc $\leq$ 4

A_f = $K(SD_1)(I)(1/Tc)$ E.7.2-2

WHEN Tc > 4

A_f = $K(SD_1)(I)(4/Tc^2)$ E.7.2-3

FOR SUG III

WHEN Tc $\leq$ TL

A_f = $K(SD_1)(I)(1/Tc)$ E.7.2-4

WHEN Tc $\geq$ TL

A_f = $K(SD_1)(I)(TL/Tc^2)$ E.7.2-5

SUG	=	III
Tc	=	3.78
TL	=	8.00
K	=	1.50
SD1	=	0.0800

THEREFORE

A_f = (1.5)(0.08)(1.5)(1 / 3.78) = 0.0477

d_s = 0.42(42.5)(0.0477) = 0.85 FT WAVE HEIGHT

REFER TO API 650 TABLE E.7 FOR FREEBOARD REQUIREMENTS

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SEISMIC EVALUATION: UN-ANCHORED TANK

SUMMARY

1. TANK DOES NOT HAVE AN ANNULAR PLATE. THICKNESS OF TANK BOTTOM BELOW SHELL IS USED TO DETERMINE WEIGHT OF LIQUID RESISTING OVERTURNING.
2. ANCHORAGE RATIO J = 0.4473
3. J < 0.785, NO CALCULATED UPLIFT, TANK IS SELF-ANCHORED
4. SHELL COMPRESSIVE STRESS IN BOTTOM COURSE MEETS CRITERIA, I.E. σc = 0.593 KSI < Fc = 5.55 KSI.
5. V = 114.1 K < Vs = 1074.38 K, SLIDING REISTANCE CRITERIA SATISFIED
6. COMBINED HOOP STRESS PLUS DYNAMIC HOOP FORCES PASSES CRITERIA

CONCLUSIONS

TANK IS SELF-ANCHORED.

COMMENT: Tank is adequate to resist all seismic loads.

LONGITUDINAL SHELL STRESS: GRAVITY LOADS

ALLOWABLE STRESS

GENERAL CRITERIA

WHEN $(G\ Hf\ D^2) / t^2 > 10^6$

$$Fc = \frac{10^6\,t}{D} \quad \text{PSI} \qquad \text{E.6.2.2.3-1b}$$

WHEN $(G\ Hf\ D^2) / t^2 < 10^6$

$$Fc = \frac{10^6\,t}{2.5\,D} + (600)\ SQRT[(G)(Hf)] \quad \text{PSI} \quad <= 0.5(Fty) \qquad \text{E.6.2.2.3-2b}$$

ALLOWABLE STRESS IN SHELL COURSE: EMPTY TANK

FOR EMPTY TANK, Hf = 0

$GHfD^2 / t^2 = 0$ EQ. E.6.2.2.3-2b GOVERNS

SHELL COMPRESSIVE STRESS: DEAD LOAD

COMPRESSIVE STRESS S = UNIT WEIGHT/ 12t

	COURSE NO.	THICKNESS INCH	WEIGHT K	CUMULATIVE WEIGHT K	UNIT WEIGHT K/FT	STRESS KSI	ALLOW STRESS KSI	
BOTTOM	1	0.24	7.88	64.18	0.481	0.167	2.259	PASS
	2	0.238	9.73	56.30	0.422	0.148	2.240	PASS
	3	0.248	10.06	46.56	0.349	0.117	2.334	PASS
	4	0.245	9.96	36.51	0.273	0.093	2.306	PASS
	5	0.242	9.81	26.55	0.199	0.068	2.278	PASS
	6	0.251	3.19	16.73	0.125	0.042	2.362	PASS

RIM ANGLE	0.65
ROOF DEAD LOAD ON SHELL	12.89

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
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LONGITUDINAL SHELL STRESS: GRAVITY LOADS

SHELL COMPRESSIVE STRESS: DEAD LOAD + ROOF LIVE LOAD

COMPRESSIVE STRESS S = UNIT WEIGHT/ 12t

	COURSE NO.	THICKNESS INCH	WEIGHT K	CUMULATIVE WEIGHT K	UNIT WEIGHT K/FT	STRESS KSI	ALLOW STRESS KSI	
BOTTOM	1	0.24	7.88	92.55	0.693	0.241	2.259	PASS
	2	0.238	9.73	84.67	0.634	0.222	2.240	PASS
	3	0.248	10.06	74.94	0.561	0.189	2.334	PASS
	4	0.245	9.96	64.88	0.486	0.165	2.306	PASS
	5	0.242	9.81	54.92	0.411	0.142	2.278	PASS
	6	0.251	3.19	45.11	0.338	0.112	2.362	PASS

RIM ANGLE	0.65
ROOF DEAD LOAD ON SHELL	12.89
ROOF LIVE LOAD ON SHELL	28.37

SHELL COMPRESSIVE STRESS: DEAD LOAD + ROOF SNOW LOAD

COMPRESSIVE STRESS S = UNIT WEIGHT/ 12t

	COURSE NO.	THICKNESS INCH	WEIGHT K	CUMULATIVE WEIGHT K	UNIT WEIGHT K/FT	STRESS KSI	ALLOW STRESS KSI	
BOTTOM	1	0.24	7.88	93.97	0.704	0.244	2.259	PASS
	2	0.238	9.73	86.09	0.645	0.226	2.240	PASS
	3	0.248	10.06	76.36	0.572	0.192	2.334	PASS
	4	0.245	9.96	66.30	0.497	0.169	2.306	PASS
	5	0.242	9.81	56.34	0.422	0.145	2.278	PASS
	6	0.251	3.19	46.52	0.348	0.116	2.362	PASS

RIM ANGLE	0.65
ROOF DEAD LOAD ON SHELL	12.89
ROOF SNOW LOAD ON SHELL	29.79

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

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SHELL HYDROSTATIC HOOP STRESS (API 650 AND API 653 MODIFIED FOR SETTLEMENT)

HOOP STRESS AT BOTTOM OF EACH SHELL COURSE

BASED ON PRODUCT SERVICES Sd = [2.6 x D (H -1+ DELTA/2) x G] / (t-CA)
BASED ON HYDROTEST St = [2.6 x D (H -1+ DELTA/2) x G] / t

TANK DIAMETER	D =	42.50	FT
HT OF LIQUID ABOVE BOT. OF COURSE	=	H	FT
DIFFERENTIAL SETTLEMENT	DELTA =	0.00	FT
SPECIFIC GRAVITY	G =	0.840	Jet A
	G =	1.00	WATER HYDROTEST
COURSE THICKNESS	=	t	INCH
SHELL CORROSION ALLOWANCE	=	CA_{shell}	INCHES
SHELL HEIGHT	Hs =	38.19	FT
FILL HEIGHT	Hf =	35.92	FT
COURSE HEIGHT	=	h	FT
HEIGHT TO BOTTOM OF COURSE	=	B	FT
ALLOWABLE STRESS	=	S	PSI
JOINT EFFICIENCY			
AT JOINTS:	E =	PER API 653	
SHELL PLATE AWAY FROM VERTICAL WELDS:	E =	1.00	AWAY FROM WELDS BY GREATER OF 1 INCH OR 2t
SHELL PLATE AWAY FROM RIVETS:	E =	1.00	AWAY FROM RIVETS BY 6 INCHES OR MORE

HOOP STRESS: PRODUCT SERVICE Jet A

COURSE NO.	t INCHES	CA_{shell} INCHES	h FT	B FT	H=(Hf - B) FT	Sd STRESS PSI	JOINT EFFICIENCY E	ALLOWABLE STRESS, (S)(E) AT JOINT PSI		SHELL PLATE PSI	
1	0.240	0	6.02	0.00	35.92	13,504	0.85	20,060	PASS	23,600	PASS
2	0.238	0	7.50	6.02	29.90	11,269	0.85	20,060	PASS	23,600	PASS
3	0.248	0	7.44	13.52	22.40	8,008	0.85	22,100	PASS	26,000	PASS
4	0.245	0	7.46	20.96	14.96	5,288	0.85	22,100	PASS	26,000	PASS
5	0.242	0	7.44	28.42	07.50	2,493	0.85	22,100	PASS	26,000	PASS
6	0.251	0	2.33	35.86	00.06	-347	0.85	22,100	PASS	26,000	PASS

HOOP STRESS: HYDROSTATIC TEST

COURSE NO.	t INCHES	CA_{shell} INCHES	h FT	B FT	H=(Hf - B) FT	St STRESS PSI	JOINT EFFICIENCY E	ALLOWABLE STRESS, (S)(E) AT JOINT PSI		SHELL PLATE PSI	
1	0.240	0	6.02	0.00	35.92	16,076	0.85	22,100	PASS	26,000	PASS
2	0.238	0	7.50	6.02	29.90	13,416	0.85	22,100	PASS	26,000	PASS
3	0.248	0	7.44	13.52	22.40	9,533	0.85	22,950	PASS	27,000	PASS
4	0.245	0	7.46	20.96	14.96	6,295	0.85	22,950	PASS	27,000	PASS
5	0.242	0	7.44	28.42	07.50	2,968	0.85	22,950	PASS	27,000	PASS
6	0.251	0	2.33	35.86	00.06	-413	0.85	22,950	PASS	27,000	PASS

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

SHELL MINIMUM THICKNESS (API 650 AND API 653 MODIFIED FOR SETTLEMENT)

SHELL MINIMUM THICKNESS PRODUCT $t_{d\ min}$ = [2.6 D (H -1+DELTA/2) G] / SE + CA BUT NOT LESS THAN 0.1 INCH

HYDROTEST $t_{t\ min}$ = [2.6 D (H -1+DELTA/2) G] / SE BUT NOT LESS THAN 0.1 INCH

PARAMETERS

TANK DIAMETER	D =	42.50 FT
HEIGHT OF LIQUID ABOVE BOTTOM OF COURSE	H =	Hf -B FT
FILL HEIGHT	Hf =	35.92 FT
HEIGHT TO BOTTOM OF COURSE	=	B FT
DIFFERENTIAL SETTLEMENT	DELTA =	0 FT
SPECIFIC GRAVITY	G =	0.840 Jet A
	G =	1.000 WATER HYDROTEST
COURSE THICKNESS	=	t INCH
COURSE HEIGHT	=	h FT
ALLOWABLE STRESS	=	S PSI
SHELL CORROSION ALLOWANCE	CAshell =	0 INCHES
JOINT EFFICIENCY		

AT JOINTS: E = PER API 653
SHELL PLATE AWAY FROM VERTICAL WELDS: E = 1.00 AWAY FROM WELDS BY GREATER OF 1 INCH OR 2
SHELL PLATE AWAY FROM RIVETS: E = 1.00 AWAY FROM RIVETS BY 6 INCHES OR MORE

SHELL MINIMUM THICKNESS: PRODUCT SERVICE Jet A

COURSE				t_{min} at JOINTS					t_{min} IN PLATE AWAY FROM JOINTS			
NO.	h	B	H=(Hf - B)	SE	$t_{d\ min}$	t_{actual}		SE	$t_{d\ min}$	t_{actual}	
	FT	FT	FT	PSI	INCH	INCH		PSI	INCH	INCH	
1	6.02	0.00	35.92	20,060	0.162	0.240	PASS	23,600	0.137	0.240	PASS
2	7.50	6.02	29.90	20,060	0.134	0.238	PASS	23,600	0.114	0.238	PASS
3	7.44	13.52	22.40	22,100	0.100	0.248	PASS	26,000	0.100	0.248	PASS
4	7.46	20.96	14.96	22,100	0.100	0.245	PASS	26,000	0.100	0.245	PASS
5	7.44	28.42	07.50	22,100	0.100	0.242	PASS	26,000	0.100	0.242	PASS
6	2.33	35.86	00.06	22,100	0.100	0.251	PASS	26,000	0.100	0.251	PASS

SHELL MINIMUM THICKNESS: HYDROSTATIC TEST

COURSE				t_{min} at JOINTS				t_{min} IN PLATE AWAY FROM JOINTS			
NO.	h	B	H=(Hf - B)	SE	$t_{t\ min}$	t_{actual}		SE	$t_{t\ min}$	t_{actual}	
	FT	FT	FT	PSI	INCH	INCH		PSI	INCH	INCH	
1	6.02	0.00	35.92	22,100	0.175	0.240	PASS	26,000	0.148	0.240	PASS
2	7.50	6.02	29.90	22,100	0.144	0.238	PASS	26,000	0.123	0.238	PASS
3	7.44	13.52	22.40	22,950	0.103	0.248	PASS	27,000	0.100	0.248	PASS
4	7.46	20.96	14.96	22,950	0.100	0.245	PASS	27,000	0.100	0.245	PASS
5	7.44	28.42	07.50	22,950	0.100	0.242	PASS	27,000	0.100	0.242	PASS
6	2.33	35.86	00.06	22,950	0.100	0.251	PASS	27,000	0.100	0.251	PASS

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

SHELL MINIMUM THICKNESS (API 650 AND API 653 MODIFIED FOR SETTLEMENT)

SHELL MINIMUM THICKNESS: MAXIMUM ALLOWABLE PIT DEPTH

API 653 CRITERIA: SECTION 4.3.2.2

FOR WIDELY SCATTERED PITS: THE SUM OF THE LENGTH OF PITS ALONG A VERTICAL LINE SHALL NOT EXCEED 2 INCHES IN AN 8 INCH LINE

MAXIMUM PIT DEPTH $dpit = t_{actual} - CA - 0.5 \times t_{min}$

ACTUAL SHELL THICKNESS AWAY FROM PIT $= t_{actual}$ INCH

MINIMUM PERMISSIBLE SHELL THICKNESS $= t_{min}$ INCH

CORROSION ALLOWANCE CA = 0 INCH

RECOMMENDED CORROSION ALLOWANCE = 0.125 INCH BUT NOT LESS THAN 0.0625 INCH FOR CONTINUED SERVICE UNTIL NEXT INSPECTION

ANALYSIS RESULTS: PRODUCT SERVICE Jet A

COURSE NO.	t_{actual} INCH	MAX PIT AT JOINTS t_{min} INCH	MAX PIT AT JOINTS dpit INCH	MAX PIT IN SHELL t_{min} INCH	MAX PIT IN SHELL dpit INCH
1	0.240	0.162	0.159	0.137	0.171
2	0.238	0.134	0.171	0.114	0.181
3	0.248	0.100	0.198	0.100	0.198
4	0.245	0.100	0.195	0.100	0.195
5	0.242	0.100	0.192	0.100	0.192
6	0.251	0.100	0.201	0.100	0.201

ANALYSIS RESULTS: HYDROSTATIC TEST

COURSE NO.	t_{actual} INCH	MAX PIT AT JOINTS t_{min} INCH	MAX PIT AT JOINTS dpit INCH	MAX PIT IN SHELL t_{min} INCH	MAX PIT IN SHELL dpit INCH
1	0.240	0.175	0.153	0.148	0.166
2	0.238	0.144	0.166	0.123	0.177
3	0.248	0.103	0.196	0.100	0.198
4	0.245	0.100	0.195	0.100	0.195
5	0.242	0.100	0.192	0.100	0.192
6	0.251	0.100	0.201	0.100	0.201

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

SHELL MINIMUM THICKNESS (API 650 AND API 653 MODIFIED FOR SETTLEMENT)

SHELL MINIMUM THICKNESS: LOCALIZED AREAS OF CORROSION

CRITERIA FOR CONTINUED OPERATION

$t_1 >= t_{min}$ t1 = lowest average thickness

$t_2 >= 0.6 \times t_{min}$ t2 = least thickness excluding pits

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT: **In-Service API 653 Inspection** PREPARED BY: SCK
LOCATION: **JB Andrews, MD** DATE: 5/1/2019
EEI PROJECT NO: **9364**
CHECKED BY: JEH
TANK NO: **10** DATE: 08/08/19

HYDROSTATIC TEST FILL HEIGHT (API 650 AND API 653 MODIFIED FOR SETTLEMENT)

HYDROSTATIC TEST FILL HEIGHT Hf = [(t x (SE) / (2.6 x D x G)] + 1+ B - (DELTA / 2)

COURSE THICKNESS = t INCH
ALLOWABLE STRESS = S PSI
JOINT EFFICIENCY
AT JOINTS: E = PER API 650 OR API 653 DEPENDING ON NEW OR EXISTING TANK
SHELL PLATE AWAY FROM VERTICAL WELDS: E = 1.00 AWAY FROM WELDS BY GREATER OF 1 INCH OR 2t
SHELL PLATE AWAY FROM RIVETS: E = 1.00 AWAY FROM RIVETS BY 6 INCHES OR MORE
TANK DIAMETER D = 42.50 FT
SPECIFIC GRAVITY (WATER) G = 1.00
ELEV. TO BOTTOM OF COURSE = B FT
DIFFERENTIAL SETTLEMENT DELTA = 0.00 FT

HYDROTEST FILL HEIGHT BASED ON ACTUAL NOMINAL THICKNESS

DEPTH OF CORROSION IN SHELL
AT SHELL VERTICAL JOINTS = Xw INCH

AWAY FROM SHELL JOINTS = Xs INCH

BASED ON SHELL JOINTS

COURSE NO.	t_{actual} INCH	h FT	B FT	Xw INCH	t_{actual} -Xw INCH	SE PSI	Hf FT	
1	0.240	6.02	0.00	0.000	0.240	22,100	49.00	GOVERNS
2	0.238	7.50	6.02	0.000	0.238	22,100	54.62	
3	0.248	7.44	13.52	0.000	0.248	22,950	66.03	
4	0.245	7.46	20.96	0.000	0.245	22,950	72.84	
5	0.242	7.44	28.42	0.000	0.242	22,950	79.68	
6	0.251	2.33	35.86	0.000	0.251	22,950	88.99	

BASED ON SHELL PLATE

COURSE NO.	t_{actual} INCH	h FT	B FT	Xs INCH	IN SHELL t_{actual} -Xs INCH	SE PSI	Hf FT
1	0.240	6.02	0.00	0.000	0.240	26,000	57.47
2	0.238	7.50	6.02	0.000	0.238	26,000	63.02
3	0.248	7.44	13.52	0.000	0.248	27,000	75.12
4	0.245	7.46	20.96	0.000	0.245	27,000	81.82
5	0.242	7.44	28.42	0.000	0.242	27,000	88.55
6	0.251	2.33	35.86	0.000	0.251	27,000	98.19

TANK EVALUATION CALCULATIONS

VERSION 8.02 TANK EVALUATION
REL 9/15/2007 EXP 5/1/2045 #####
REV 6/14/2019

PROJECT:	**In-Service API 653 Inspection**	PREPARED BY:	SCK
LOCATION:	**JB Andrews, MD**	DATE:	5/1/2019
EEI PROJECT NO:	**9364**		
		CHECKED BY:	JEH
TANK NO:	**10**	DATE:	08/08/19

HYDROSTATIC TEST FILL HEIGHT (API 650 AND API 653 MODIFIED FOR SETTLEMENT)

HYDROTEST FILL HEIGHT BASED ON NO CORROSION

DEPTH OF CORROSION IN SHELL
AT SHELL VERTICAL JOINTS Xw = 0.000 INCH

AWAY FROM SHELL JOINTS Xs = 0.000 INCH

BASED ON SHELL JOINTS

COURSE NO.	t_{actual} INCH	h FT	B FT	Xw INCH	t_{actual} -Xw INCH	SE PSI	Hf FT	
1	0.240	6.02	0.00	0.000	0.240	22,100	49.00	GOVERNS
2	0.238	7.50	6.02	0.000	0.238	22,100	54.62	
3	0.248	7.44	13.52	0.000	0.248	22,950	66.03	
4	0.245	7.46	20.96	0.000	0.245	22,950	72.84	
5	0.242	7.44	28.42	0.000	0.242	22,950	79.68	
6	0.251	2.33	35.86	0.000	0.251	22,950	88.99	

BASED ON SHELL PLATE

COURSE NO.	t_{actual} INCH	h FT	B FT	Xs INCH	t_{actual} -Xs INCH	SE PSI	Hf FT
1	0.240	6.02	0.00	0.000	0.240	26,000	57.47
2	0.238	7.50	6.02	0.000	0.238	26,000	63.02
3	0.248	7.44	13.52	0.000	0.248	27,000	75.12
4	0.245	7.46	20.96	0.000	0.245	27,000	81.82
5	0.242	7.44	28.42	0.000	0.242	27,000	88.55
6	0.251	2.33	35.86	0.000	0.251	27,000	98.19

CORROSION RATE CALCULATIONS
API 653 Fifth Edition, November 2014

REL 2/4/2015
REV 3/24/2016

TANK NO.	10	**PREPARED BY:**	SCK
LOCATION	Joint Base Andrews, MD	**DATE:**	5/1/2019
EEI PROJECT NO	9364		

TANK SHELL

Note: This spreadsheet calculates corrosion rates and not the minimum thickness required to remain in service.

Is Tank equipped with leak detection under the floor per API 650 Appendix I: No

Year Constructed 1960 Year of Inspection 2019 Age of Shell 59 years

	Assumed Original Nominal Metal Thickness		**Mill Tolerance (ASTM A6)**		**Mill Tolerance Original Shell Thickness Range**			
Course 1	0.250	inches	0.030	inches	0.240	to	0.280	inches
Course 2	0.250	inches	0.030	inches	0.240	to	0.280	inches
Course 3	0.250	inches	0.030	inches	0.240	to	0.280	inches
Course 4	0.250	inches	0.030	inches	0.240	to	0.280	inches
Course 5	0.250	inches	0.030	inches	0.240	to	0.280	inches
Course 6	0.250	inches	0.030	inches	0.240	to	0.280	inches

	Measured Minimum Thickness		**Mill Tolerance Check**
Course 1	0.240	inches	The Thickness of Course 1 is Within Mill Tolerance
Course 2	0.238	inches	The Thickness of Course 2 is Less than Mill Tolerance
Course 3	0.248	inches	The Thickness of Course 3 is Within Mill Tolerance
Course 4	0.245	inches	The Thickness of Course 4 is Within Mill Tolerance
Course 5	0.242	inches	The Thickness of Course 5 is Within Mill Tolerance
Course 6	0.251	inches	The Thickness of Course 6 is Within Mill Tolerance

	Corrosion Rate	
Course 1	N/A	Corrosion Rate is Negligible
Course 2	0.00020	inches/year
Course 3	N/A	Corrosion Rate is Negligible
Course 4	N/A	Corrosion Rate is Negligible
Course 5	N/A	Corrosion Rate is Negligible
Course 6	N/A	Corrosion Rate is Negligible

The Straight Line Corrosion Rate for the Shell is: 0.00020 inches/year located in Course 2

Minimum Shell Thickness from Tank Evaluation Spreadsheet	0.134	inches
Difference Between Measured Thickness and Minimum	0.104	inches
Service Period Based on Current Corrosion Rate	Greater than 20	years

API 653 TANK SETTLEMENT EVALUATION

TANK NO.	**10**	**INPUT BY:**	**JEH**
LOCATION:	**JB Andrews, MD**	**DATE:**	**5/31/2019**
EEI Project No.	**9364**		
SURVEY DATE:	**4/30/2019**		

REL: 1/18/2000
REV: 8/28/2013
AUTHOR: S. DIGREGORIO

INPUT DATA

TANK HEIGHT	H =	**38.833**	FT		
TANK DIAMETER	D =	**42.500**	FT		
YIELD STRENGTH	Y =	**30000.000**	PSI		
NO. OF SURVEY POINTS	N =	**8.000**	(Input number of points, up to 30 max)		
MODULUS OF ELASTICITY	E =	**29000000.000**	PSI		
LOCATION OF SURVEY POINT NO. 1	=	**MH-1 + 4'**			

SURVEY DATA	
MAX. ELEV:	100.060
MIN. ELEV:	99.980
AVE EL	100.020
AMPLITUDE	0.040

ARC LENGTH BETWEEN PT: L = (PI)D/N = 16.69 FT

S(ALLOW) = L2 x Y x 11 / 2[EH] = 0.0408 FT

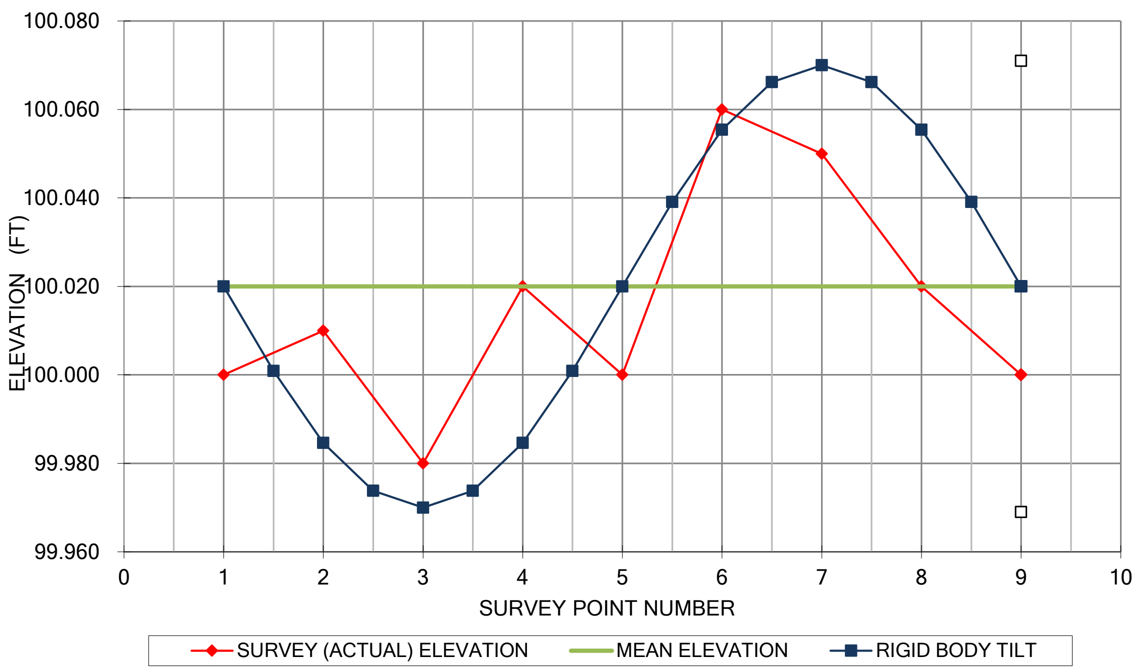
SURVEY POINT NO.	ELEV.	THETA (DEGREES)	RIGID BODY TILT ELEV. (FT)	OUT OF PLANE SETTLEMENT Ui (FT)	OUT OF PLANE DEFLECTION Si (FT)	$S_{(ALLOW)}$ 0.0408 (FT)	
1	**100.000**	180.00	100.020	-0.020	-0.0150	0.0408	PASS
2	**100.010**	225.00	99.985	0.025	0.0304	0.0408	PASS
3	**99.980**	270.00	99.970	0.010	-0.0204	0.0408	PASS
4	**100.020**	315.00	99.985	0.035	**MAX.** 0.0404	0.0408	PASS
5	**100.000**	0.00	100.020	-0.020	-0.0400	0.0408	PASS
6	**100.060**	45.00	100.055	0.005	0.0246	0.0408	PASS
7	**100.050**	90.00	100.070	-0.020	-0.0046	0.0408	PASS
8	**100.020**	135.00	100.055	-0.035	-0.0154	0.0408	PASS
1	**100.000**	180.00	100.020	-0.020	-0.0150	0.0408	PASS

API 653 TANK SETTLEMENT EVALUATION

TANK NO.	**10**	**INPUT BY:**	**JEH**
LOCATION:	**JB Andrews, MD**	**DATE:**	**5/31/2019**
EEI Project No.	**9364**		
SURVEY DATE:	**4/30/2019**		

0 REL: 1/18/2000
REV: 8/28/2013
AUTHOR: S. DIGREGORIO

TANK SHELL SETTLEMENT



NOTES: 1. THE HIGHEST SURVEY POINT NUMBER N SHOWN ON THE ABOVE GRAPH CORRESPONDS TO POINT NUMBER 1 ON THE TANK

RIGID BODY TILT

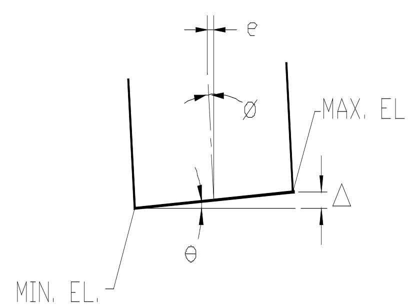
MAXIMUM DIFFERENTIAL SETTLEMENT BETWEEN MAX. ELEV. AND MIN. ELEVATION:

MAX. ELEVATION =	100.060		
MIN. ELEVATION =	99.980		
DELTA =	0.080 FT	=	0.96 IN.

ANGLE OF SLOPE
THETA = SIN -1 (DELTA / D) = SIN -1 (0.08/42. = 0.11 deg.

ANGLE OF TILT
PHI = THETA = 0.11 deg.

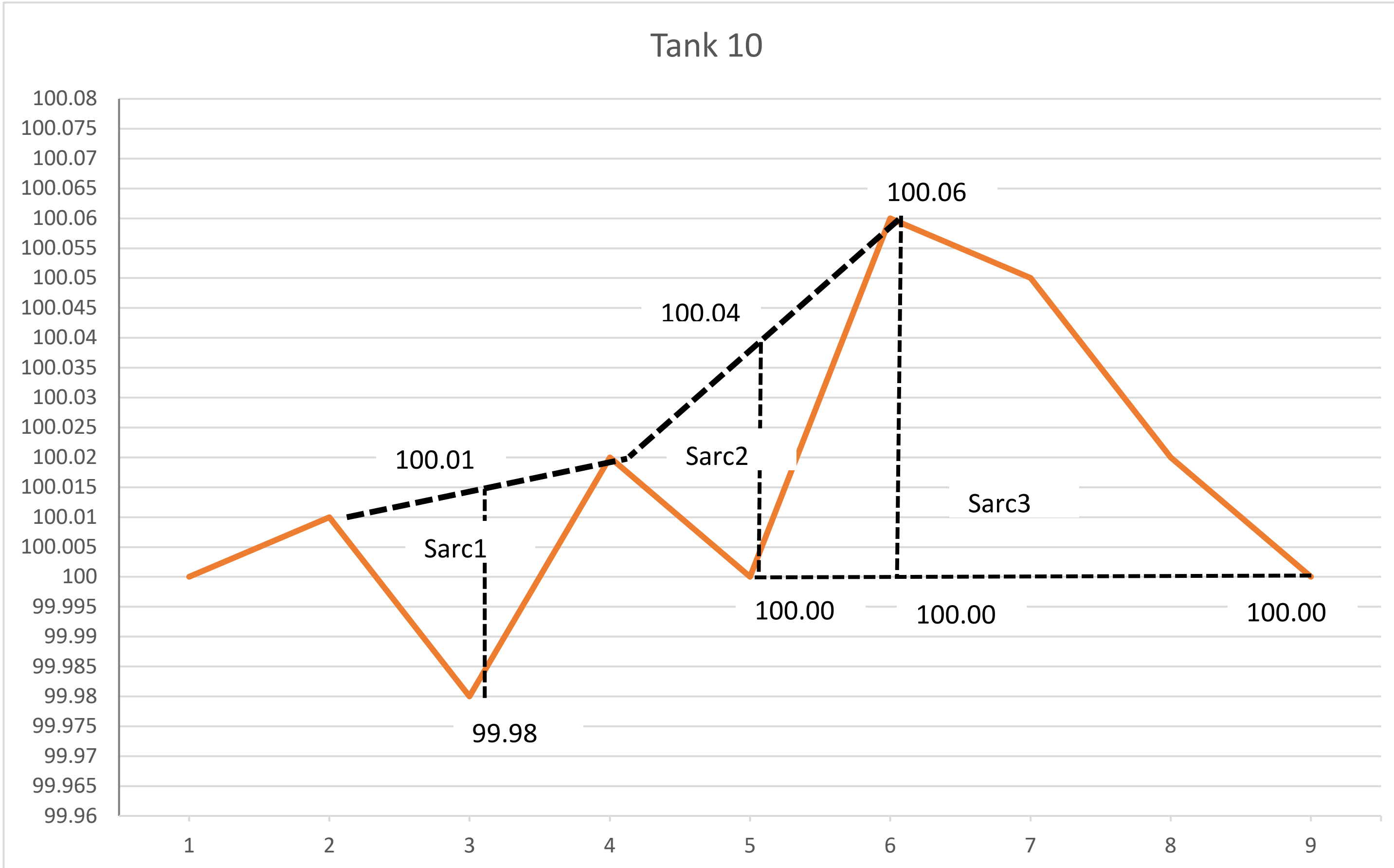
AMOUNT OF TILT
e = 38.833 SIN(PHI)= 0.07 FT = 0.88 IN



Note: R^2 = 0.118 which is less than 0.9. Per API 653 B.2.2.5, the optimum cosine curve method is not valid. Refer to the next pages for settlement evaluation.

Tank 10 API 653 Section B.2.2.5 Settlement Analysis

Survey Point	Elev ft
1	100
2	100.01
3	99.98
4	100.02
5	100
6	100.06
7	100.05
8	100.02
1	100



API 653 Equation

B.3.2.2 When using the procedure in B.2.2.5 to determine out-of-plane settlement, the permissible out-of-plane settlement is given by the following equation (see Note):

$$S_{max,\,in} = \min\left[K \times S_{arc} \times \left(\frac{D}{H}\right) \times \left(\frac{Y}{E}\right), 4.0\right]$$

Tank Diameter ft	Open Top Tanks, K	Fixed Roof Tanks, K
$D \le 50$	28.7	10.5
$50 < D \le 80$	7.8	5.8
$80 < D \le 120$	6.5	3.9
$120 < D \le 180$	4.0	2.3
$180 < D \le 240$	3.6	Not applicable
$240 < D \le 300$	2.4	Not applicable
$300 < D$	Not applicable	Not applicable

where

$S_{max,\,in}$ is permissible out-of-plane settlement, in inches;

S_{arc} is effective settlement arc, see B.2.2.5.1, in feet;

D is tank diameter, in feet (ft);

Y is yield strength of the shell material, in pound force per square inch (lbf/in.^{2});

E is Young's Modulus, in pound force per square inch (lbf/in.^{2});

H is tank height, in feet.

NOTE This equation is based on "Final Report on the Study of Out-of-Plane Tank Settlement," J. Andreani, N. Carr, Report to API SCAST, May, 2007.

D =	42.5	ft	(Tank Diameter)
K =	28.7		(Coefficient, Open top tank with D $\le$ 50 ft)
Y =	36,000	psi	(Yield Strength)
H =	38.833	ft	(Tank Height)
E =	29,000,000	psi	(Young's Modulus)
L =	16.69	ft	(Distance between survey points)

Settlement Calculation

Sarc1:

Sarc = L x (No Survey points of arc)
= 16.69 x 2
= 33.38 ft

Smax = 1.30 in <---Governs
4.00 in

Smeasured = 100.01-99.98 = 0.03 ft
= 0.36 in < 1.30 in allowable, OK

Sarc2:

Sarc = L x (No Survey points of arc)
= 16.69 x 2
= 33.38 ft

Smax = 1.30 in <---Governs
4.00 in

Smeasured = 100.04-100.00 = 0.04 ft
= 0.48 in < 1.30 in allowable, OK

Sarc3:

Sarc = L x (No Survey points of arc)
= 16.69 x 4
= 66.76 ft

Smax = 2.60 in <---Governs
4.00 in

Smeasured = 100.06-100.00 = 0.06 ft
= 0.72 in < 1.30 in allowable, OK

Results: Tank settlement is within allowable limits.

API 653 INSPECTION
TANK 10
US ARMY CORPS OF ENGINEERS, OMAHA DISTRICT
JOINT BASE ANDREWS, MARYLAND

LEGEND

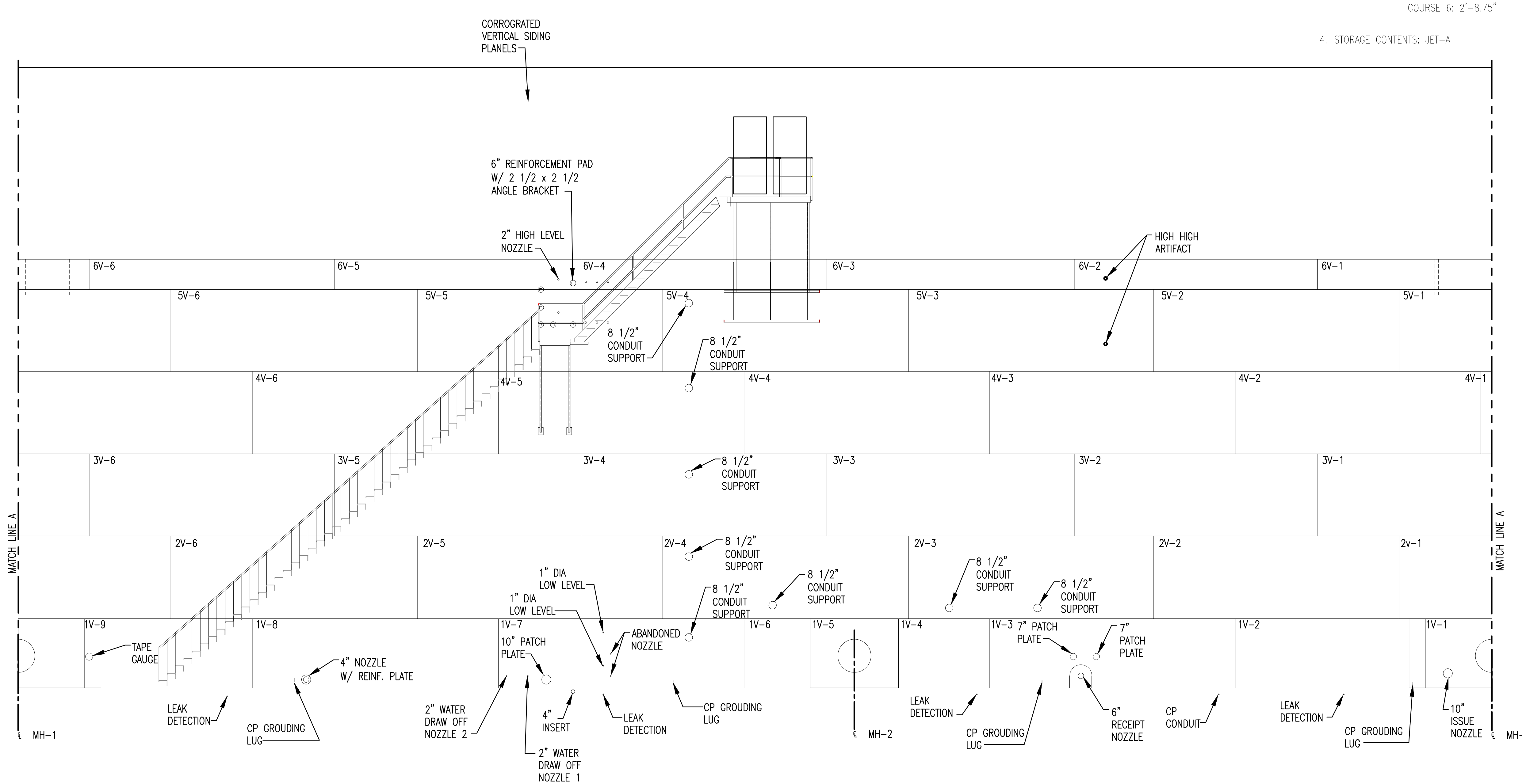
A1	ROOF PLATE DESIGNATION
L-#	FLOOR EDGE PROFILE LOCATION
3V-#	THIRD COURSE SHELL VERTICAL JOINT DESIGNATION

NOTE

A FULL OUT-OF-SERVICE TANK INSPECTION WAS PERFORMED BY ENTERPRISE ENGINEERING, INC, FALMOUTH, MAINE ON APRIL 29 TO APRIL 30, 2019, IN ACCORDANCE WITH API 653, 5th EDITION, NOVEMBER 2014.

TANK INFORMATION

1. TYPE OF CONSTRUCTION: WELDED STEEL ABOVEGROUND TANK.
2. YEAR OF CONSTRUCTION 1960.
3. TANK SIZE: DIAMETER: 42'-6"
   SHELL HEIGHT: 40'-0"
   COURSE 1: 6'-3.25"
   COURSE 2: 7'-6"
   COURSE 3: 7'-5.25"
   COURSE 4: 7'-5.5"
   COURSE 5: 7'-5.25"
   COURSE 6: 2'-8.75"
4. STORAGE CONTENTS: JET-A



TANK 10 SHELL ELEVATION

SCALE: 3/16" = 1'-0"

GRAPHIC SCALE

4 0 4 8 12 FT

SCALE: 3/16" = 1'-0"
IF SHEET IS LESS THAN 22" x 34"
IT IS A REDUCED PRINT - SCALE REDUCED ACCORDINGLY

REV	DATE	BY	DESCRIPTION

DRAWING PLOTTED: 6/03/19
DRAWING STATUS: FINAL
CAD DWG. FILE: TANK 10 S.dwg
CAD SOFTWARE: ACAD REL. 2017

THIS ORIGINAL DRAWING RELEASED TO THE CLIENT ON ________.
DATE

ENTERPRISE ENGINEERING INC. ASSUMES NO RESPONSIBILITY FOR ANY SUBSEQUENT REVISIONS TO THIS DRAWING.

DESIGN: JEH
DRAWN: MJB
CHECKED: JEH
APPROVED:
SCALE: SCALE
SEAL

ENTERPRISE ENGINEERING, INC

CLIENT/PROJECT
US ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
JOINT BASE ANDREWS, MARYLAND
TANK 10

DRAWING TITLE
SHELL ELEVATION

DWG NO. S-1
REV
PROJ NO. 9364
FILE
SHEET 1 OF 1

TABLE 06: OSHA ACCESS STRUCTURE REPORT

The tank roof is accessed via a circumferential stair welded to the tank shell.

Description:
The stair is equipped with both a handrail and a guardrail IAW AW 78-24-27.

Reference: 29 CFR 1910 Subpart D - Walking-Working Surfaces

1910.25(c)(1) Standard stairs are installed at angles between 30 to 50 degrees from the horizontal.
Measured angle is approximately 42 degrees - OK

1910.25(c)(2) Have a maximum riser height of 9.5 inches.
Measured riser height is 8". - OK

1910.25(c)(3) Have a minimum tread depth of 9.5 inches.
Measured tread depth is 9" - OK

1910.25(c)(4) Have a minimum width of 22 inches.
Measured width is 24" - MEETS ORIGINAL CODE OF CONSTRUCTION, OK

1910.29(b)(1) The top edge height of guardrail systems are 42 inches, plus or minus 3 inches, above the walking-working surface.
Measured height is 42" - OK

1910.29(f)(1)(i) Handrails are not less than 30 inches and not more than 38 inches, as measured from the leading edge of the stair tread to the top surface of the handrail.
Measured height is 30" - OK

The stair meets the requirements of 29 CFR 1910 Subpart D

Comments:
None.

APPENDIX B: API 653 CHECKLISTS FOR TANK INSPECTIONS

Tank In-Service Inspection Checklist		
	Item	**Completed X**
C.1.1	**Foundation**	
	Measure foundation levelness and bottom elevations (see Annex B for extent of measurements).	X
C.1.1.1	**Concrete Ring**	
a	Inspect for broken concrete, spalling, and cracks, particularly under backup bars used in welding butt-welded annular rings under the shell.	X
b	Inspect drain openings in ring, back of waterdraw basins and top surface of ring for indications of bottom leakage.	X
c	Inspect for cavities under foundation and vegetation against bottom of tank.	X
d	Check that runoff rainwater from the shell drains away from tank.	X
e	Check for settlement around perimeter of tank.	X
C.1.1.2	**Asphalt**	
a	Check for settling of tank into asphalt base which would direct runoff rain water under the tank instead of away from it.	N/A
b	Look for areas where leaching of oil has left rock filler exposed, which indicates hydrocarbon leakage.	N/A
C.1.1.3	**Oiled Dirt or Sand**	
	Check for settlement into the base which would direct runoff rain water under the tank rather than away from it.	N/A
C.1.1.4	**Rock**	
	Presence of crushed rock under the steel bottom usually results in severe underside corrosion. Make a note to do additional bottom plate examination (ultrasonic, hammer testing, or turning of coupons) when the tank is out of service.	N/A
C.1.1.5	**Site Drainage**	
a	Check site for drainage away from the tank and associated piping and manifolds.	X
b	Check operating condition of the dike drains.	X
C.1.1.6	**Housekeeping**	
	Inspect the area for buildup of trash, vegetation, and other inflammables buildup.	X
C.1.1.7	**Cathodic Protection**	
	Review cathodic protection potential readings.	N/A
C.1.2	**Shells**	
C.1.2.1	**External Visual Inspection**	
a	Visually inspect for paint failures, pitting, and corrosion.	X

Tank In-Service Inspection Checklist		
	Item	**Completed X**
b	Clean off the bottom angle area and inspect for corrosion and thinning on plate and weld.	X
c	Inspect the bottom-to-foundation seal, if any.	X
C.1.2.2	**Internal (Floating Roof Tank)**	
	Visually inspect for grooving, corrosion, pitting, and coating failures.	N/A
C.1.2.3	**Riveted Shell Inspection**	
a	Inspect external surface for rivet and seam leaks.	N/A
b	Locate leaks by sketch or photo (location will be lost when shell is abrasive cleaned for painting).	N/A
c	Inspect rivets for corrosion loss and wear.	N/A
d	Inspect vertical seams to see if they have been full fillet lap-welded to increase joint efficiency.	N/A
e	If no record exists of vertical riveted seams, dimension and sketch (or photograph) the rivet pattern: number of rows, rivet size, pitch length, and note whether the joint is butt-riveted or lap-riveted.	N/A
C.1.2.4	**Wind Girder (Floating Roof Tanks)**	
a	Inspect wind girder and handrail for corrosion damage (paint failure, pitting, corrosion product buildup), especially where it occurs at tack-welded junction, and for broken welds.	X
b	Check support welds to shell for pitting, especially on shell plates.	X
c	Note whether supports have reinforcing pads welded to shell.	X
C.1.3	**Shell Appurtenances**	
C.1.3.1	**Manways and Nozzles**	
a	Inspect for cracks or signs of leakage on weld joint at nozzles, manways, and reinforcing plates.	X
b	Inspect for shell plate dimpling around nozzles, caused by excessive pipe deflection.	X
c	Inspect for flange leaks and leaks around bolting.	X
d	Inspect sealing of insulation around manways and nozzles.	N/A
e	Check for inadequate manway flange and cover thickness on mixer manways.	X
C.1.3.2	**Tank Piping Manifolds**	
a	Inspect manifold piping, flanges, and valves for leaks.	X
b	Inspect fire fighting system components.	N/A
c	Check for anchored piping which would be hazardous to the tank shell or bottom connections during earth movement.	N/A
d	Check for adequate thermal pressure relief of piping to the tank.	X
e	Check operation of regulators for tanks with purge gas systems.	N/A
f	Check sample connections for leaks and for proper valve operation.	N/A
g	Check for damage and test the accuracy of temperature indicators.	N/A
h	Check welds on shell-mounted davit clips above valves 6 in. and larger.	N/A
C.1.3.3	**Autogauge System**	
a	Inspect autogauge tape guide and lower sheave housing (floating swings) for leaks.	X
b	Inspect autogauge head for damage.	X

Tank In-Service Inspection Checklist		
Item		Completed X
c	Bump the checker on autogauge head for proper movement of tape.	X
d	Identify size and construction material of autogauge tape guide (floating roof tanks).	N/A, tape is not equipped with guides
e	Ask operator if tape tends to hang up during tank roof movement (floating roof tanks).	X
f	Compare actual product level to the reading on the autogauge (maximum variation is 2 in.).	X
g	On floating roof tanks, when the roof is in the lowest position, check that no more than two ft of tape are exposed at the end of the tape guide.	N/A
h	Inspect condition of board and legibility of board-type autogauges.	N/A
i	Test freedom of movement of marker and float.	N/A
C.1.3.4	**Shell-Mounted Sample Station**	
a	Inspect sample lines for function of valves and plugging of lines, including drain or return-to-tank line.	N/A
b	Check circulation pump for leaks and operating problems.	N/A
c	Test bracing and supports for sample lines and equipment.	N/A
C.1.3.5	**Heater (Shell Manway Mounted)**	
	Inspect condensate drain for presence of oil indicating leakage.	N/A
C.1.3.6	**Mixer**	
a	Inspect for proper mounting flange and support.	N/A
b	Inspect for leakage.	N/A
c	Inspect condition of power lines and connections to mixer.	N/A
C.1.3.7	**Swing Lines: Winch Operation**	
a	Non-floating. Raise, then lower the swing line with the winch, and check for cable tightness to confirm that swing line lowered properly.	N/A
b	Floating. With tank half full or more, lower the swing line, then let out cable and check if swing has pulled cable tight, indicating that the winch is operating properly.	N/A
c	Indicator. Check that the indicator moves in the proper direction: Floating swing line indicators show a lower level as cable is wound up on the winch. Non-floating swing line indicators show the opposite.	N/A
C.1.3.8	**Swing Lines: External Guide System**	
	Check for leaks at threaded and flanged joints.	N/A
C.1.3.9	**Swing Lines: Identify Ballast Varying Need**	
	Check for significant difference in stock specific gravity.	N/A
C.1.3.10	**Swing Lines: Cable Material and Condition**	
a	For non-stainless-steel cable, check for corrosion over entire length.	N/A
b	All cable: check for wear or fraying.	N/A

Tank In-Service Inspection Checklist		
Item		Completed X
C.1.3.11	**Swing Lines: Product Sample Comparison**	
	Check for water or gravity differences that would indicate a leaking swing joint.	N/A
C.1.3.12	**Swing Lines: Target**	
	Target should indicate direction of swing opening (up or down) and height above bottom where suction will be lost with swing on bottom support.	N/A
C.1.4	**Roofs**	
C.1.4.1	**Deck Plate Internal Corrosion**	
	For safety, before accessing the roof, check with ultrasonic instrument or lightly use a ball peen hammer to test the deck plate near the edge of the roof for thinning. (Corrosion normally attacks the deck plate at the edge of a fixed roof and at the rafters in the center of the roof first.)	N/A
C.1.4.2	**Deck Plate External Corrosion**	
	Visually inspect for paint failure, holes, pitting, and corrosion product on the roof deck.	X
C.1.4.3	**Roof Deck Drainage**	
	Look for indication of standing water. (Significant sagging of fixed roof deck indicates potential rafter failure. Large standing water areas on a floating roof indicate inadequate drainage design or, if to one side, a nonlevel roof with possible leaking pontoons.)	X
C.1.4.4	**Level of Floating Roof**	
	At several locations, measure distance from roof rim to a horizontal weld seam above the roof. A variance in the readings indicates a nonlevel roof with possible shell out-of-round, out-of-plumb, leaking pontoons, or hang-up. On small diameter tanks, an unlevel condition can indicate unequal loading at that level.	Observations made from shed access door
C.1.4.5	**Gas Test Internal Floating Roof**	
	Test for explosive gas on top of the internal floating roof. Readings could indicate a leaking roof, leaking seal system, or inadequate ventilation of the area above the internal floating roof.	N/A
C.1.4.6	**Roof Insulation**	
a	Visually inspect for cracks or leaks in the insulation weather coat where runoff rain water could penetrate the insulation.	N/A
b	Inspect for wet insulation under the weather coat.	N/A
c	Remove small test sections of insulation and check roof deck for corrosion and holes near the edge of the insulated area.	N/A

Tank In-Service Inspection Checklist		
Item		**Completed X**
C.1.4.7	**Floating Roof Seal Systems**	
a	Inspect the condition of the seal, measure and record maximum rim spaces and seal to shell gaps around the full roof circumference at the level of inspection. NOTE Inspection of the seal and measurement of the rim spaces and seal-to-shell gaps at more than one level may be necessary to more fully determine if any problems exist at other levels of tank operation).	Observations made from shed access door
b	Measure and record annular space at 30-ft spacing (minimum of four quadrants) around roof and record. Measurements should be taken in directly opposite pairs.	N/A
1)	________ ________ Opposite pair 1.	N/A
2)	________ ________ Opposite pair 2.	N/A
c	Check if seal fabric on primary shoe seals is pulling shoes away from shell (fabric not wide enough).	N/A
d	Inspect fabric for deterioration, holes, tears, and cracks.	N/A
e	Inspect visible metallic parts for corrosion and wear.	N/A
f	Inspect for openings in seals that would permit vapor emissions.	N/A
g	Inspect for protruding bolt or rivet heads against the shell.	N/A
h	Pull both primary and secondary seal systems back all around the shell to check their operation.	N/A
i	Inspect secondary seals for signs of buckling or indications that their angle with the shell is too shallow.	N/A
j	Inspect wedge-type wiper seals for flexibility, resilience, cracks, and tears.	N/A
C.1.5	**Roof Appurtenances**	
C.1.5.1	**Sample Hatch**	
a	Inspect condition and functioning of sample hatch cover.	X
b	On tanks governed by Air Quality Monitoring District rules, check for the condition of seal inside hatch cover.	X
c	Check for corrosion and plugging on thief and gauge hatch cover.	X
d	Where sample hatch is used to reel gauge stock level, check for marker and tab stating hold-off distance.	X
e	Check for reinforcing pad where sample hatch pipe penetrates the roof deck.	X
f	On floating roof sample hatch and recoil systems, inspect operation of recoil reel and condition of rope.	N/A
g	Test operation of system.	N/A
h	On ultra clean stocks such as JP4, check for presence and condition of protective coating or liner inside sample hatch (preventing rust from pipe getting into sample).	N/A
C.1.5.2	**Gauge Well**	
a	Inspect visible portion of the gauge well for thinning, size of slots, and cover condition.	X

Tank In-Service Inspection Checklist		
Item		Completed X
b	Check for a hold-off distance marker and tab withhold-off distance (legible).	N/A
c	On floating roofs, inspect condition of roof guide for gauge well, particularly the condition of the rollers for grooving.	N/A
d	If accessible, check the distance from the gauge well pipe to the tank shell at different levels.	N/A
e	If tank has a gauge well washer, check valve for leakage and for presence of a bull plug or blind flange.	N/A
C.1.5.3	**Fixed Roof Scaffold Support**	
	Inspect scaffold support for corrosion, wear, and structural soundness.	N/A
C.1.5.4	**Autogauge: Inspection Hatch and Guides (Fixed Roof)**	
a	Check the hatch for corrosion and missing bolts.	X
b	Look for corrosion on the tape guide's and float guide's wire anchors.	X
C.1.5.5	**Autogauge: Float Well Cover**	
a	Inspect for corrosion.	N/A
b	Check tape cable for wear or fraying caused by rubbing on the cover.	N/A
C.1.5.6	**Sample Hatch (Internal Floating Roof)**	
a	Check overall conditions.	N/A
b	When equipped with a fabric seal, check for automatic sealing after sampling.	N/A
c	When equipped with a recoil reel opening device, check for proper operations.	N/A
C.1.5.7	**Roof-mounted Vents (Internal Floating Roof)**	
	Check condition of screens, locking and pivot pins.	N/A
C.1.5.8	**Gauging Platform Drip Ring**	
	On fixed roof tanks with drip rings under the gauging platform or sampling area, inspect for plugged drain return to the tank.	N/A
C.1.5.9	**Emergency Roof Drains**	
	Inspect vapor plugs for emergency drain: that seal fabric discs are slightly smaller than the pipe ID and that fabric seal is above the liquid level.	N/A
C.1.5.10	**Removable Roof Leg Racks**	
	Check for leg racks on roof.	N/A
C.1.5.11	**Vacuum Breakers**	
	Report size, number, and type of vacuum breakers. Inspect vacuum breakers. If high legs are set, check for setting of mechanical breaker in high leg position.	N/A
C.1.5.12	**Rim Vents**	
a	Check condition of the screen on the rim vent cover.	N/A
b	Check for plating off or removal of rim vents where jurisdictional rules do not permit removal.	N/A
C.1.5.13	**Pontoon Inspection Hatches**	

Tank In-Service Inspection Checklist		
Item		**Completed X**
a	Open pontoon inspection hatch covers and visually check inside for pontoon leakage.	N/A
b	Test for explosive gas (an indicator of vapor space leaks).	N/A
c	If pontoon hatches are equipped with locked down coves, check for vent tubes. Check that vent tubes are not plugged up. Inspect lock-down devices for condition and operation.	N/A
C.1.6.1	**Accessways**	
	See Tank Out-of-service Inspection Checklist, Item C.2.12.	X

NOTES:

APPENDIX C: PHOTOGRAPHS

C.1: Tank 10 North View

C.2: Tank 10 East View

C.3: Tank 10 South View

C.4: Tank 10 West View

C.5: MH-1

C.6: Product Saver

C.7: High Level Alarms

C.8: Shed Roof Condition

C.9: Piping in Containment Area

C.10: Top of Rolling Ladder

C.11: Containment Dike

C.12: Containment Dike