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# ***ENSURING THE INTEGRITY OF LARGE TANKS***

***NAEHSS 2011***

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DUE TO THE CORROSIVE NATURE OF MOST LIQUID FERTILIZER SOLUTIONS & THE SPECIFIC GRAVITIES (WEIGHT) OF THOSE SOLUTIONS, LIQUID FERTILIZER STORAGE TANKS REQUIRE ROUTINE AND QUALIFIED MECHANICAL INTEGRITY PRACTICES TO MAINTAIN A **SAFE** STORAGE ENVIRONMENT.

OUR DISCUSSIONS WILL FOCUS **EXISTING STORAGE TANKS** AND WHAT MECHANICAL INTEGRITY PRACTICES (API 653 INSPECTIONS) SHOULD BE PERFORMED AND AT WHAT INTERVALS.

ADDITIONAL DISCUSSION WILL FOCUS ON **NEW STORAGE TANK CONSTRUCTION** (API 650 SPECIFICATIONS).



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REFERENCES ARE MADE IN THIS DISCUSSION TO **API 653 AND API 650 SPECIFICATIONS**  
FOR WELDED STEEL TANKS AS WELL AS **THE FERTILIZER INSTITUTE, “ABOVEGROUND  
STORAGE TANKS CONTAINING LIQUID FERTILIZER, RECOMMENDED MECHANICAL  
INTEGRITY PRACTICES, DECEMBER 2009”**.

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## DEFINITIONS

### ***Aboveground Storage Tank (AST)*** –

Any storage tank, 100,000 gallons or greater, used for liquid fertilizer that is flat bottom, cylindrical, vertical with a fixed roof and constructed of carbon steel, stainless steel or aluminum.

***API*** – The American Petroleum Institute is the national trade association representing the petroleum industry in areas of exploration and production, transportation, refining and marketing.

***API 650*** – Standard 650 of the American Petroleum Institute, titled, “Welded Steel Tanks for Oil Storage.”

***API 653*** – Standard 653 of the American Petroleum Institute, titled, “Tank Inspection, Repair, Alteration and Reconstruction.”

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***Authorized Inspection Agency*** – One of the following types of organizations that employ certified API AST inspectors:

1. The inspection organization operated by the jurisdiction in which the AST is operated;
2. The inspection organization operated by an insurance company licensed or registered to provide AST insurance at the location in question;
3. An owner / operator organization that maintains its own inspection activities relating to ASTs it controls; or
4. An independent organization (company or individual) that contracts AST inspection services to an owner / operator as allowed by the local jurisdiction using API Authorized Inspectors.

***Authorized Inspector*** – An employee of an Authorized Inspection Agency that is **certified** as an AST Inspector per API 653 requirements.



**Baseline Inspection** – An initial, complete API 653 out-of-service internal and external inspection performed to establish the condition of an existing AST and to determine the AST's suitability for continued service.

**Bladders** – A non-adhering liner physically attached to the AST and constructed of synthetic material to provide physical separation of liquid product from the tank bottom and shell. Bladders, sometimes referred to as internal containment liners, are constructed of materials that are compatible with the contact materials.

**Coatings** – An applied lining material that is chemically/physically bonded to the substance being covered. Coating include, but are not limited to, paint, epoxy coatings (such as coal tar epoxy and epoxy phenolic), attached fiberglass covering and other such products.

**Liquid Fertilizer** – A non-pressurized mixture of water and one or more compounds of nitrogen, phosphorus or potassium that is produced and stored in commerce as a source of plant nutrients.

**RBI** – Risk Based inspection using a methodology acceptable to the authorized inspector and an experienced storage tank engineer.

**Soil-Side** – The exterior side of bottom plate regardless of what they come in contact with.



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***API 653 Inspection –***

**What does it mean and what is involved?**

***IF YOU CANNOT SEE IT, AN INSPECTOR MAY MISS A DEFECT.***

Tanks without coatings or bladders must be cleaned from the top of the internal shell down including the floor. This means scaffolding the tank interior and power washing with high pressure water and sometimes a bio-degradable surfactant to help cut the grease film created by certain products. In some cases, tanks may require a brush sandblast to remove hardened scale from the steel. Make sure the tank is properly prepared and ready for an inspection so you get the most for your inspection dollar.

## WHAT AN API INSPECTOR SHOULD BE LOOKING FOR

- On older tanks without any information about a tank history, inspectors have to make judgments as to the original specification the tank was constructed.



- Inspectors should conduct a visual inspection to look for shell and floor plate pitting, weld deterioration or other weld defects throughout the tank, both internal and external. The condition of the welds and weld heat-affected zones (HAZs) are of particular concern because these areas tend to be more commonly affected by exposure to liquid fertilizers.

- Inspector is looking for proper weld spacing, proper reinforcement pads on nozzles and shell man-ways.

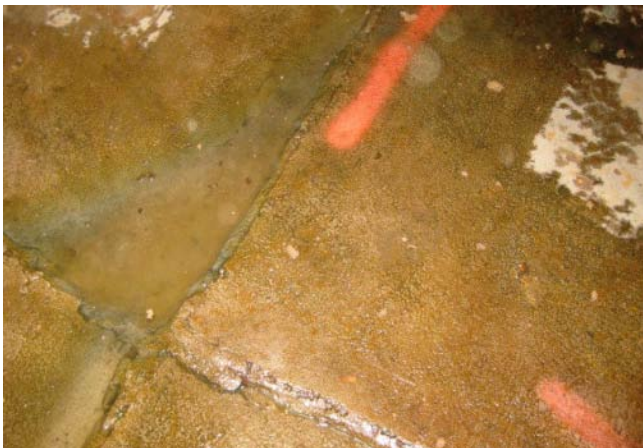


- Inspector should take accurate U.T (ultra-sonic thickness) measurements of the shell, floor and roof and map the location of the U.T. shots with readings taken and logged.



In some cases, a complete Magnetic Flux Leakage (MFL) scanning of the floor is necessary to identify soil side corrosion or cutting out test coupons to validate bottom side corrosion.

- Inspector should inspect roof rafters and attachments as well as roof support column(s) and identify areas of corrosion.
- Inspector should conduct a vacuum test of all floor weld seams along with a visual of welds.



- Inspector should conduct a settlement survey of the tank to check for planar tilt. If the tank has settlement problems, the maximum fill height may be reduced or commonly called “de-rating” of the tank.
- Inspector should look for shell distortions such as “peaking” or “banding” of the tank shell.

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## ***WHAT SHOULD BE INCLUDED IN THE INSPECTION REPORT TO THE OWNER***

- **An Executive Summary** describing the tank, location, owner, what inspection activities did they perform along with a Summary of Conclusions, maximum fill height for the tank and a Summary of Recommendations for any necessary repair or operating parameters.

## ***1.0 Executive Summary***

The inspection was conducted in accordance with client criterion for Non Destructive Examination (NDE) which included visual and Ultrasonic Thickness (UT) examinations. This inspection was conducted to collect data in order to evaluate the tank's mechanical integrity and fitness for continued service. Neither radiograph nor soil reports were available at the time of the inspection. Complete tank information is depicted on the Tank Data page, section 2.0.

Ultrasonic Thickness (UT) examinations of tank components (shell, roof and floor) were completed on all accessible surfaces. UT measurements were performed on the tank's shell plates in six (6) locations according to a consistent test pattern. On the lower courses, every sheet was numbered and tested. On the upper courses, four (4) sheets on each course were numbered and tested. On the roof plates, a single measurement was taken in the center of each plate. The sheet numbers and locations are depicted in the appendices, section 5.0.

## **Summary Conclusions:**

The tank shell is fit for continued service:

Shell UT readings are above minimum thickness requirements.

Welds are in full configuration.

The tank roof is fit for continued service:

Roof UT readings are above minimum requirements.

Welds on the roof plates are in good condition.

The tank floor is fit for continued service:

Welds on floor plates are above minimum requirements

Floor UT readings are above minimum thickness requirements.

RECOMMENDED MAXIMUM FILL HEIGHT IS XX' X" WITH xxxxxxxx SOLUTION .

## **Summary Recommendations:**

### **To meet API Specifications**

None.

### **Discretionary recommendations**

Apply an external coating to the tank

- **A Tank Data** page that highlights specific information for that tank, diameter and height, specific gravity of product stored and joint efficiency used in the shell calculations.

<b>Tank #:</b>	#	<b>Diameter:</b>	120'
<b>Client:</b>		<b>Height:</b>	32'
<b>Location:</b>		<b>Corr. Allowance</b>	
<b>Inspection Date:</b>		<b>Joint Efficiency:</b>	.095
<b>Type Inspection:</b>	API 653 Out-of-Service	<b>Specific Gravity</b>	1.33
<b>Test Methods:</b>	UT, Visual & Vacuum	<b>Plate Spec:</b>	A 36 M
<b>Manufacturer:</b>	XYZ Tank Company	<b>Course 1 t:</b>	0.312
<b>Year Built:</b>	2011	<b>Course 2 t:</b>	0.250
<b>Const. Code:</b>	API 650	<b>Course 3 t:</b>	0.250
<b>Capacity:</b>	gallons	<b>Course 4 t:</b>	0.250
<b>Shell Const:</b>	Butt-welded	<b>Course 5 t:</b>	
<b>Roof Type:</b>	Fixed / Cone	<b>Course 6 t:</b>	
<b>Foundation:</b>	Earthen	<b>Course 7 t:</b>	
<b>Max fill height:</b>	32'	<b>Course 8 t:</b>	
<b>Product:</b>	32% Nitrogen Solution	<b>Roof / Head 1 t:</b>	0.187
<b>Recommended Safe Fill Height</b>	31' 2"	<b>Bttm / Head 2 t:</b>	

- An in-depth discussion of the inspection results:

### **3.1 Foundation:**

3.1.1 The tank was constructed on a raised grade band. The foundation was observed to be in good condition.

3.1.2 A settlement survey of the tank was completed from the outside of the tank. Beginning at the north side of the tank moving clockwise around the tank, 12 equally-spaced measurements were performed around the outer circumference of the tank. Results from these findings reveal the foundation to be within the parameters of API Specifications and fit for continued service.

### **3.2 Shell:**

3.2.1 UT measurements were performed on all shell courses on the tank. A weld joint efficiency of 0.80 and a specific gravity of 1.33 were used in the minimum thickness calculations. Results reveal all shell courses to be above API minimum thickness requirements. The tank shell is fit for continued service.

3.2.2 Calculation results from this inspection reveal the maximum fill height of the tank to be 46', however to keep product below the internal rafters, the RECOMMENDED MAXIMUM FILL HEIGHT IS XX' XX" WITH XXXXXX.

3.2.3 Welds in external vertical and horizontal shell joints were found to be in good condition.

3.2.4 Welds of the internal shell plates were found to be in good condition.

3.2.5 The chime weld was visually examined inside and outside of the tank and found to be in good condition.

3.2.6 External coating was visually examined and found to be in good condition.

### **3.3 Appurtenances:**

3.3.1 The tank is equipped with:

two (2) 4" nozzles.

one (1) 24" man-way.

3.3.2 Welds on all nozzles and man-ways were visually examined and UT tested. Welds were found to be in good condition and fit for continued service. The nozzles and man-way were found to have proper reinforcement pads with threaded tell-tale holes for testing as required by API Specifications. Welds on nozzles and man-ways are fit for continued service.



### **3.4 Roof:**

3.4.1 The plates on the roof joints are lap-welded. UT measurements were performed in the center of each roof plate. Results reveal all roof plates to be above API minimum thickness requirements and fit for continued service.

3.4.2 Welds in roof plate joints were visually examined and found to be in good condition with no corrosion present.

3.4.3 The tank is equipped with one (1) 8" vent. Vent is equipped with a proper screen to prevent debris from entering roof vent and restricting air-flow during the filling and emptying processes. Roof welds were visually examined and found to be in good condition.

3.4.4 The roof of the tank is equipped with one (1) 20" man-way. Welds on man-way were visually examined and found to be in good condition.

3.4.5 The coating on the roof is in good condition.

### **3.5 Floor:**

3.5.1 The plates on the floor are lap-welded. UT readings were completed on all floor plates. Readings range from .244 to .273. Results reveal floor plates to be above API minimum thickness requirements and fit for continued service.

3.5.2 All weld joints were vacuum tested and no evidence of leaks were found in the weld seams.

### **3.6 Ancillary Equipment:**

3.6.1 Access to the tank roof was made by way of a spiral stairway welded to the shell. The stairway is equipped with a proper handrail for safety as required by OSHA. Welds on stairway, handrail and attachments were visually examined and found to be in good condition. The external coating was found to be failing.

3.6.2 The tank's center roof support column and roof support rafters appear to be in good condition.

- A recommendations section depicting required repairs prior to placing tank back in service:

#### **4.0 Recommendations**

##### **4.1 Foundation:**

Jack and level tank to pass settlement survey as required.

Recommend remove soil and dirt from the external chime to prevent external corrosion.

##### **4.2 Shell:**

Repair weld joint corrosion damage where marked, with a certified welder to API Specifications.

Install patches over excessive pitting areas where marked to remove tank from de-rated status.

##### **4.3 Appurtenances:**

Recommend installing tell-tale holes on nozzles for testing.

Repair welds on man-way where marked with paint, with a certified welder to API Specifications.

##### **4.4 Roof:**

Recommend installing a screen on vent to prevent debris from entering and restricting air flow on filling and emptying processes.

Recommend applying an external coating to roof to prevent corrosion.

##### **4.5 Floor:**

Repair weld joint corrosion damage where marked, with a certified welder to API Specifications.

Install patches over excessive pitting areas where marked to remove tank from de-rated status.

- Shell remaining life (RL) calculations.
- Roof and floor remaining life (RL) calculations.
- Settlement Survey data and calculations.
- A mapping and log of all U.T. readings taken on the floor, shell and roof.
- Pictures taken during inspection.
- NDE (non-destructive examination) certificates of the inspector and NDE Level of achievement.

## Tank Shell Minimum Thickness and Remaining Life Calculations

Date 8/17/2010

File No	Report No	Client	Inspector	Tank No	Temp. (°F)
41	HTS-10- 118		Richard Buntt	#2	

### SHELL MINIMUM THICKNESS CALCULATIONS

$$t_{min} = \frac{2.6D(H-1)G}{SE}$$

**Where:**

**H** = The height above the bottom of the course of study to the maximum liquid level height of the product, in feet (meters). For corroded or pitted areas, H = the height from the bottom of the corroded or pitted area to the maximum liquid level height of the product, in feet (meters).

**t<sub>min</sub>** = The calculated minimum acceptable shell thickness, in inches (must be greater than 0.1 inch (2.5 mm) for any course). The minimum acceptable shell thickness allowed by API-653 for tank size, in inches (mm) or an alternate t<sub>min</sub> based on low pressure calculations (int and/or ext pressures) or nominal thickness minus design corrosion allowance.

**D** = Nominal diameter of tank, in feet (meters).

**G** = Highest specific gravity of the contents (including test water if tank will, or may, be tested in the future).

**S** = Maximum allowable stress, in psi. For welded tanks; use the smaller of 0.80Y or 0.429T for bottom and second course or the smaller of 0.88Y or 0.472T for all other courses. For riveted tanks; S = 21,000 psi. (145 MPa)

**Y** = Specified minimum yield strength of the plate, in psi; use 30,000 psi (200 MPa) if not known (N/A for riveted tanks).

**T** = The smaller of the specified minimum tensile strength of the plate or 80k psi (550 MPa); use 55,000 psi (380 MPa) if not known (N/A for riveted tanks).

**E** = Original joint efficiency for the tank. For welded tanks; use API-653, Table 4-2 ; use E = 1.0 when evaluating the retirement thickness in a corroded plate, when away from welds or joints by at least the greater of one inch (250 mm) or twice the plate thickness. For riveted tanks; use E = 1.0 for shell plates greater than 6 inches (150 mm) away from rivets; use the value of E from API-653 Table 2-1 when within 6 inches (150 mm) of rivets.

D (ft) 53    G 1.35    E 1.00    Fill Height (ft) 32.0

	Material	Crs H (ft)	H (ft)	S (psi)	t <sub>min</sub> (in)
Course 1	A 36M	8.00	32.00	24900	0.232
Course 2	A 36M	8.00	24.00	24900	0.172
Course 3	A 36M	8.00	16.00	27400	0.102
Course 4	A 36M	8.00	8.00	27400	0.100



## Tank Shell Minimum Thickness and Remaining Life Calculations

Date

File No	Report No	Client	Inspector	Tank No	Temp. (°F)
41	HTS-10- 118		Richard Buntt	#2	

### SHELL REMAINING LIFE CALCULATIONS

**Ca** = tact-tmin = Remaining Corrosion Allowance (inches (mm))  
**Cr** = tprev-tact / Y = Corrosion Rate (inches (mm) per year)  
**RL** = Ca / Cr = Remaining Life (years)  
**Y** =  = Tank age (years)

*Where:*

**Ca** = Remaining corrosion allowance of the shell course under consideration, in inches (mm).

**Cr** = Corrosion rate of the shell course under consideration, in inches (mm) per year.

**FHc** = Calculated Fill Height =  $SE_{tact}/2.6DG+1$  ( $SE_{tact}/4.6DG+.3$ )

**tact** = Minimum thickness measurement of the shell course under consideration, as recorded at the time of inspection, in inches (mm).

**tmin** = minimum required thickness of shell course, at the maximum allowable fill height, in inches (mm)

**tprev** = previous thickness measurement of shell course under consideration, as recorded at last inspection or nominal thickness if no previous thickness measurements, in inches (mm).

**RL** = Estimated remaining life of the shell course under consideration, in years.

**Y** = Time span between thickness readings or age of the tank if nominal thickness is used for tprev, in years.

Course	tprev	tact	tmin	Ca	Cr	RL	FHc
<b>Course 1</b>	0.312	0.301	0.232	0.069	0.0009	75.7	41.29
<b>Course 2</b>	0.250	0.240	0.172	0.068	0.0008	81.8	41.12
<b>Course 3</b>	0.250	0.241	0.102	0.139	0.0008	185.5	52.50
<b>Course 4</b>	0.250	0.234	0.100	0.134	0.0013	100.5	59.47



**API-653 ATMOSPHERIC STORAGE TANK FIXED ROOF EVALUATION  
MINIMUM THICKNESS, REMAINING LIFE, PRESSURE CALCULATIONS**

Date 10/12/2010

File No	Report No	Client	Inspector	Tank No	Temp. °F	Ca
60	HTS-10-271		Doug Perry	#1		0.000

**Where:**

*Ca* = remaining corrosion allowance of the tank component under consideration, in inches ( $t_{act} - t_{min}$ ).

*Cr* = corrosion rate of the tank component under consideration, in inches per year ( $(t_{prev} - t_{act}) / Y$ ).

*oz* = unit of measurement, (weight, in ounces, per square inch), (16 oz per pound)

*psi* = unit of measurement, (weight, in pounds, per square inch)

*RL* = estimated remaining life of the tank component under consideration, in years ( $Ca / Cr$ ).

*t<sub>act</sub>* = actual thickness measurement of the tank component under consideration, as recorded at the time of inspection, in inches.

*t<sub>min</sub>* = minimum required thickness of tank component, at the design MAWP at the design temperature (200°F for atm AST's), in inches (greater of  $psi/wt$  or 0.090").

*t<sub>nom</sub>* = design nominal thickness of tank component under consideration, in inches.

*t<sub>prev</sub>* = previous thickness measurement of the tank component under consideration, as recorded at last inspection or nominal thickness if no previous thickness measurements, in inches.

*t<sub>yn</sub>* = thickness of the tank component under consideration at the next inspection at twice the calculated corrosion rate, in inches ( $t_{act} - (2 \cdot Cr \cdot Y_n)$ ).

*wt* = weight of plate per cubic inch.

*wc* = unit of measurement, (height, in inches, of water column bearing on 1 square inch area), (27.7 *wc* per pound)

*Y* = time span between thickness readings or age of the tank component if *t<sub>nom</sub>* is used for *t<sub>prev</sub>*, in years.

*Y<sub>n</sub>* = estimated time span to next inspection of the tank component under consideration, in years

**ROOF PLATES - REMAINING LIFE**

Y	t <sub>prev</sub>	t <sub>act</sub>	t <sub>min</sub>	Cr	Ca	RL
15	0.187	0.176	0.090	0.00073	0.086	117

**ROOF MAXIMUM ALLOWABLE INTERNAL PRESSURE**

Material Category	wt	Y <sub>n</sub>	t <sub>yn</sub>	psi	oz.	wc
CS/Crom. Stl	0.2833	5	0.169	0.048	0.765	1.32

**RELIEF VALVE SETTING EVALUATION**

Setting	Unit	=	Max Allowed
		(psi)	0.765 oz

Relief setting is satisfactory

Ultrasonic Thickness Measurements were performed in the center of each roof plate at the time of the examination.



**STORAGE TANK FLOOR EVALUATION**  
**MINIMUM REMAINING THICKNESS (MRT) CALCULATIONS**

Date

File No	Report No	Client	Initials	Tank No	Temp. °F
<input type="text" value="60"/>	<input type="text" value="HTS-10-271"/>	<input type="text"/>	<input type="text" value="Doug Perry"/>	<input type="text" value="#1"/>	<input type="text"/>

Liner	CP Protec.	50mil Liner	Leak Det.	Ca	Shell tmin	Shell tnom	D	H	S
<input type="text" value="No"/>	<input type="text" value="No"/>	<input type="text" value="No"/>	<input type="text" value="No"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

**Where;**

- Ca = corrosion allowance, in inches.**
- MRT = minimum remaining thickness at the end of interval Or. This value must meet the requirements of Table 4-1 and sections 2.4.7.4 and 2.4.8.**
- Or = In-service interval of operation (years to next internal inspection) not to exceed that allowed by 4.4.2.**
- RTbc = minimum remaining thickness from bottom side corrosion after repairs.**
- RTip = minimum remaining thickness from internal corrosion after repairs.**
- StPr = maximum rate of corrosion not repaired on the top side. StPr = 0 for coated areas of the bottom. The expected life of the floor must equal or exceed Or to use StPr = 0.**
- tmin = minimum allowable thickness in accordance with requirements of Table 4-1 and sections 2.4.7.4 and 2.4.8**
- t = original (nominal) thickness of floor plate under consideration, in inches.**
- UPr = maximum rate of corrosion on the bottom side. To calculate the corrosion rate, use the minimum remaining thickness after repairs. Assume a linear rate based on the age of the tanks. UPr = 0 for areas that have effective cathodic protection.**
- D = nominal diameter of tank, in ft.,**
- H = Height, in feet, from the bottom of the 1st shell course to the maximum allowable fill height**
- S = Stresses are calculated from  $[2.34 D (H-1)]/t$**

GENERAL PLATES - AFTER INSPECTION / REPAIRS									
Age	to	RTbc	RTip	UPr	StPr	Or	MRT	tmin	Results
15	0.250	0.237	0.237	0.00087	0.00087	5	0.228	0.100	ACCEPTABLE

PLATES IN CRITICAL ZONE (3") - AFTER INSPECTION / REPAIRS									
Age	to	RTbc	RTip	UPr	StPr	Or	MRT	tmin	Results
15	0.250	0.237	0.237	0.00087	0.00087	5	0.228	0.100	ACCEPTABLE

ANNULAR PLATES - AFTER INSPECTION / REPAIRS									
Age	to	RTbc	RTip	UPr	StPr	Or	MRT	tmin	Results
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Ultrasonic Thickness Measurements were performed in five designated locations on each floor plate.



**SHELL SETTLEMENT SURVEY**  
**API-653 APPENDIX B SETTLEMENT EVALUATION**

Date

File No  Report No  Client  Inspector  Tank No  1st Crs Plt Spec

$$S \leq 11L^2Y/2EH$$

U = Measured out-of-plane settlement in relation to a cosine curve, in feet  
 S = Deflection, in feet, (out-of-plane distortion)  
 L = Arc length between measurement points, in feet  
 Y = Yield strength, in pounds per square inch (psi)  
 E = Young's modulus, in pounds per square inch (psi)  
 H = Tank height, in feet

D	L	Y	E	H	S - Max Permissible
<input type="text" value="52"/>	<input type="text" value="20.42"/>	<input type="text" value="30000"/>	<input type="text" value="29000000"/>	<input type="text" value="31.5"/>	<input type="text" value="0.075"/>

	Feet	Inches	Feet	U	S	Results	High Point
Point 1	<input type="text" value="3"/>	<input type="text" value="9.000"/>	<input type="text" value="3.75"/>	<input type="text" value="0.000"/>	<input type="text" value="0.002"/>	<input type="text" value="SAT"/>	<input type="text" value="3.75"/> Ft
Point 2	<input type="text" value="3"/>	<input type="text" value="9.200"/>	<input type="text" value="3.77"/>	<input type="text" value="0.007"/>	<input type="text" value="0.000"/>	<input type="text" value="SAT"/>	Low Point
Point 3	<input type="text" value="3"/>	<input type="text" value="9.400"/>	<input type="text" value="3.78"/>	<input type="text" value="0.014"/>	<input type="text" value="-0.001"/>	<input type="text" value="SAT"/>	<input type="text" value="3.80"/> Ft
Point 4	<input type="text" value="3"/>	<input type="text" value="9.600"/>	<input type="text" value="3.80"/>	<input type="text" value="0.022"/>	<input type="text" value="0.016"/>	<input type="text" value="SAT"/>	
Point 5	<input type="text" value="3"/>	<input type="text" value="9.400"/>	<input type="text" value="3.78"/>	<input type="text" value="-0.002"/>	<input type="text" value="-0.009"/>	<input type="text" value="SAT"/>	
Point 6	<input type="text" value="3"/>	<input type="text" value="9.400"/>	<input type="text" value="3.78"/>	<input type="text" value="-0.008"/>	<input type="text" value="0.008"/>	<input type="text" value="SAT"/>	Planar Tilt
Point 7	<input type="text" value="3"/>	<input type="text" value="9.200"/>	<input type="text" value="3.77"/>	<input type="text" value="-0.030"/>	<input type="text" value="-0.010"/>	<input type="text" value="SAT"/>	<input type="text" value="0.05"/> Ft
Point 8	<input type="text" value="3"/>	<input type="text" value="9.200"/>	<input type="text" value="3.77"/>	<input type="text" value="-0.032"/>	<input type="text" value="0.008"/>	<input type="text" value="SAT"/>	<input type="text" value="0.60"/> In.
Point 9	<input type="text" value="3"/>	<input type="text" value="9.000"/>	<input type="text" value="3.75"/>	<input type="text" value="-0.050"/>	<input type="text" value="-0.010"/>	<input type="text" value="SAT"/>	
Point 10	<input type="text" value="3"/>	<input type="text" value="9.000"/>	<input type="text" value="3.75"/>	<input type="text" value="-0.049"/>	<input type="text" value="-0.024"/>	<input type="text" value="SAT"/>	
Point 11	<input type="text" value="3"/>	<input type="text" value="9.000"/>	<input type="text" value="3.75"/>	<input type="text" value="-0.046"/>	<input type="text" value="-0.009"/>	<input type="text" value="SAT"/>	Cosine Curve R^2
Point 12	<input type="text" value="3"/>	<input type="text" value="9.200"/>	<input type="text" value="3.77"/>	<input type="text" value="-0.025"/>	<input type="text" value="0.008"/>	<input type="text" value="SAT"/>	<input type="text" value="0.24"/>
Point 13	<input type="text" value="3"/>	<input type="text" value="9.200"/>	<input type="text" value="3.77"/>	<input type="text" value="-0.019"/>	<input type="text" value="-0.010"/>	<input type="text" value="SAT"/>	
Point 14	<input type="text" value="3"/>	<input type="text" value="9.400"/>	<input type="text" value="3.78"/>	<input type="text" value="0.006"/>	<input type="text" value="0.017"/>	<input type="text" value="SAT"/>	
Point 15	<input type="text" value="3"/>	<input type="text" value="9.200"/>	<input type="text" value="3.77"/>	<input type="text" value="-0.002"/>	<input type="text" value="0.000"/>	<input type="text" value="SAT"/>	
Point 16	<input type="text" value="3"/>	<input type="text" value="9.000"/>	<input type="text" value="3.75"/>	<input type="text" value="-0.010"/>	<input type="text" value="-0.009"/>	<input type="text" value="SAT"/>	

**Notes:**

Sixteen equally spaced settlement measurements were performed around the outside circumference of the tank at the floor plate that sticks out beyond the shell.

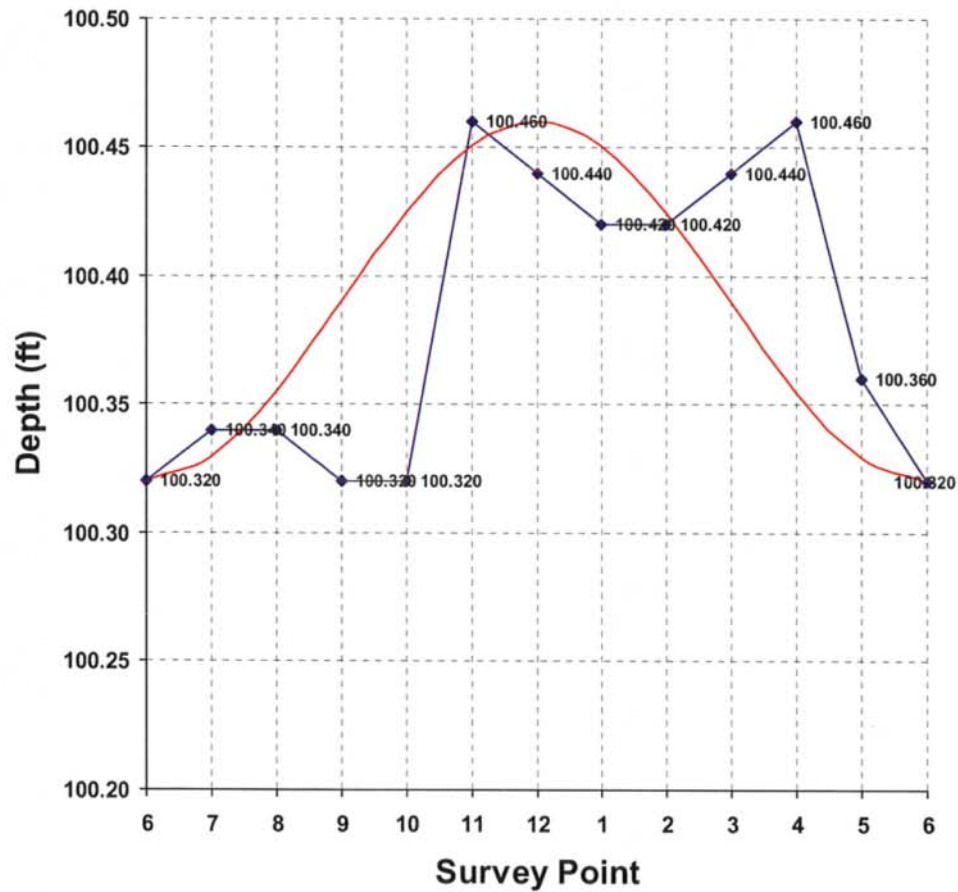


SHELL SETTLEMENT SURVEY  
API-653 APPENDIX B SETTLEMENT EVALUATION

Date 8/7/2010

Report No	Client	Inspector	Tank No	1st Crs Plt Spec
HTS-10-155		Richard Buntt	#17	A 36M

### API653 Survey Calculation



# API-653 STORAGE TANK EVALUATION

## AST Component Inspection Data

Report No	Client	Inspector	Vessel	Date
HTS-10			#2	

### Component Thickness Measurements (in inches)

CML	Component	Location	tml-1	tml-2	tml-3	tml-4	tml-5	tml-6	Minimum
001	Shell Crs 1	Plt1	0.342	0.345	0.334	0.336	0.345	0.335	0.334
002	Shell Crs 1	Plt2	0.340	0.328	0.350	0.357	0.333	0.371	0.328
003	Shell Crs 1	Plt3	0.323	0.337	0.325	0.316	0.323	0.332	0.316
004	Shell Crs 1	Plt4	0.327	0.364	0.355	0.361	0.325	0.366	0.325
005	Shell Crs 1	Plt5	0.334	0.348	0.344	0.363	0.340	0.373	0.334
006	Shell Crs 1	Plt6	0.352	0.355	0.358	0.359	0.350	0.347	0.347
007	Shell Crs 2	Plt1	0.221	0.282	0.247	0.218	0.226	0.243	0.218
008	Shell Crs 2	Plt2	0.224	0.231	0.226	0.229	0.222	0.256	0.222
009	Shell Crs 2	Plt3	0.219	0.224	0.229	0.220	0.218	0.270	0.218
010	Shell Crs 2	Plt4	0.213	0.233	0.209	0.252	0.207	0.252	0.207
011	Shell Crs 2	Plt5	0.214	0.266	0.248	0.226	0.227	0.250	0.214
012	Shell Crs 2	Plt6	0.251	0.233	0.223	0.253	0.223	0.273	0.223
013	Shell Crs 3	Plt1 N.	0.212	0.204	0.195				0.195
014	Shell Crs 3	Plt2 S.	0.210	0.205	0.204				0.204
015	Shell Crs 3	Plt3 E.	0.189	0.185	0.183				0.183
016	Shell Crs 3	Plt4 W.	0.211	0.204	0.207				0.204
017	Shell Crs 4	Plt1 N.	0.196	0.217	0.194				0.194
018	Shell Crs 3	Plt2 S.	0.203	0.200	0.212				0.200
019	Shell Crs 4	Plt3 E.	0.189	0.190	0.195				0.189
020	Shell Crs 4	Plt4 W.	0.189	0.183	0.187				0.183
021	Roof	Plt1	0.213						0.213
022	Roof	Plt2	0.185						0.185
023	Roof	Plt3	0.186						0.186

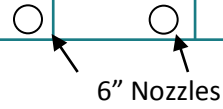


# Shell CML Locations

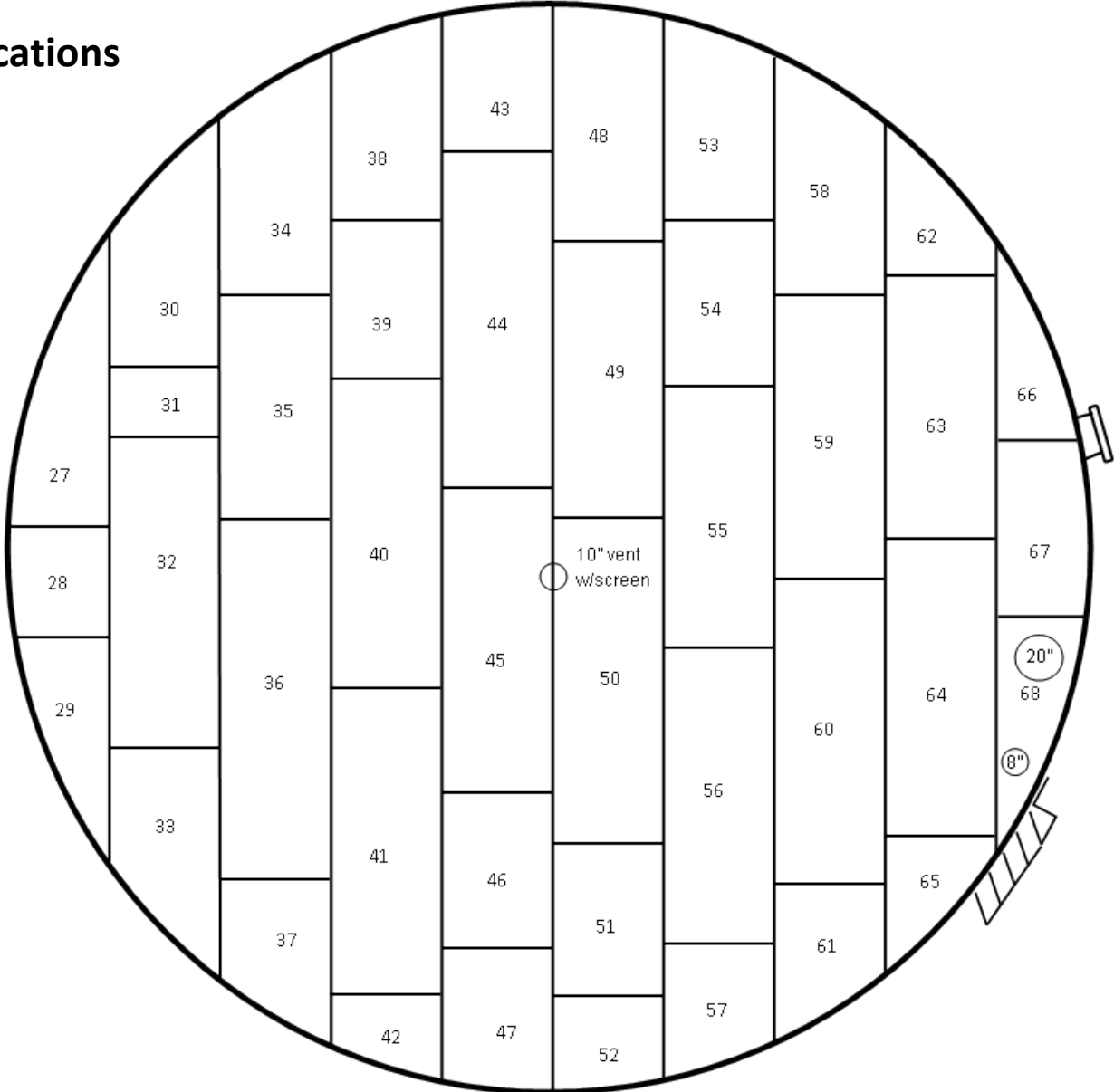
NORTH	SOUTH	EAST	WEST
23	24	25	26
19	20	21	22

10	11	12	13	14	15	16	17	18
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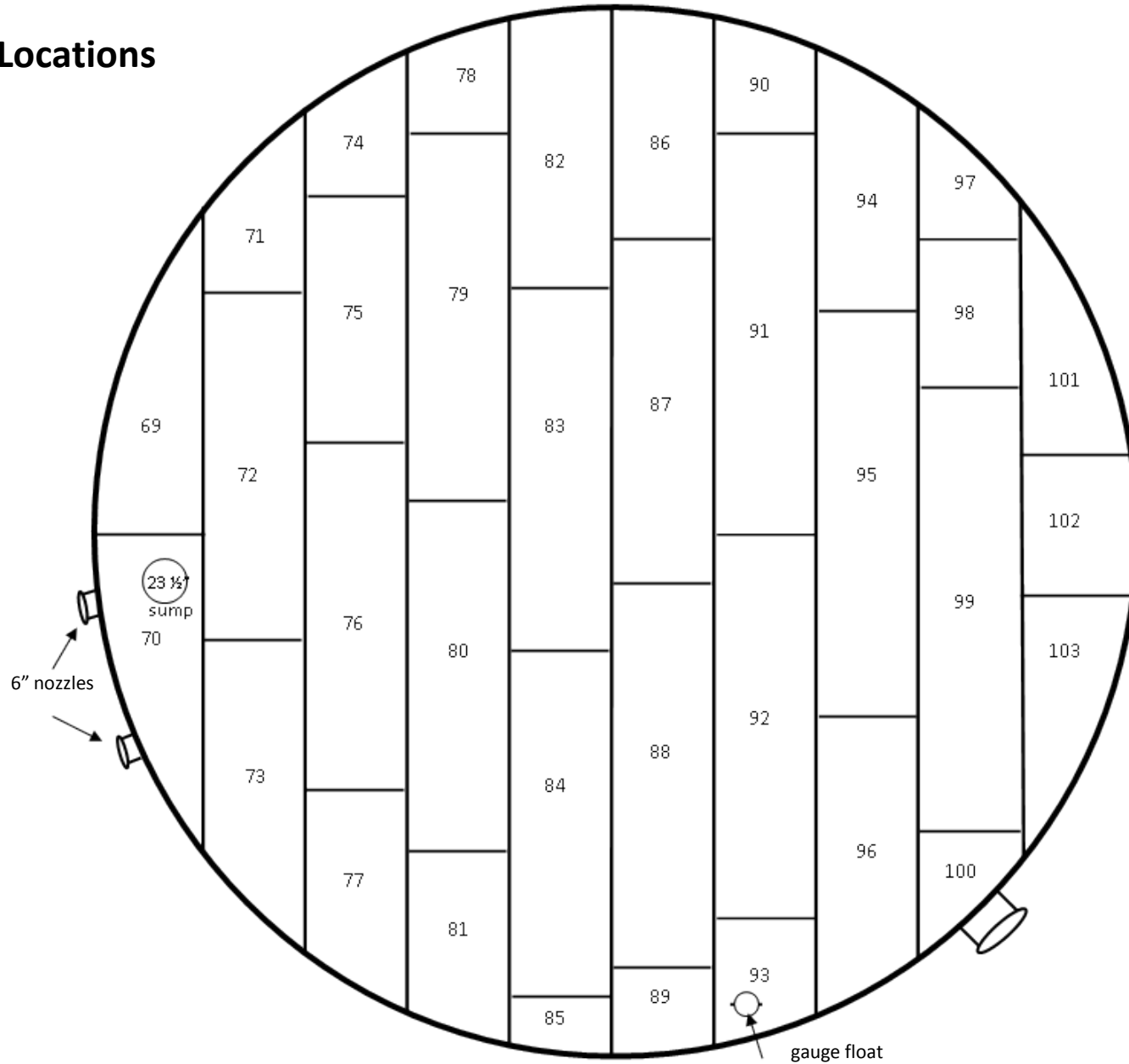
24" 1	2	3	4	5	6	7	8	9
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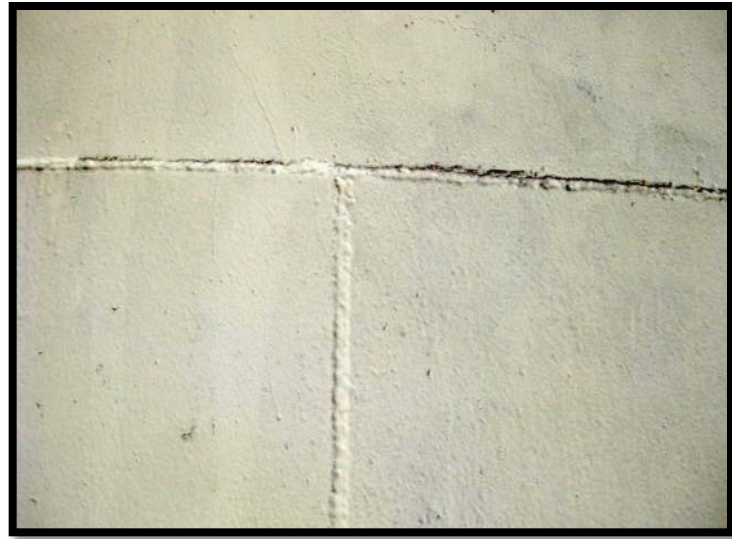
# Roof CML Locations



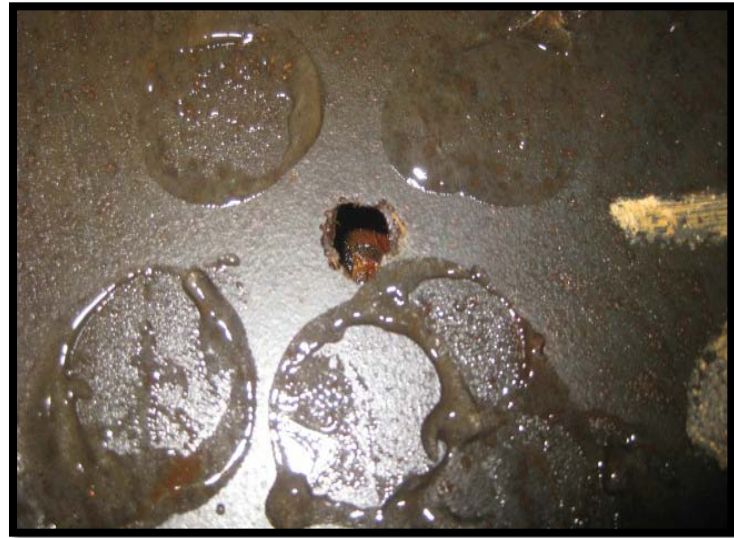
# Floor CML Locations













## ***API 650 STANDARD FOR NEW TANK CONSTRUCTION***

API 650 is the worldwide recognized standard for new tank construction, regardless of the service for field welded tanks.

Just because a tank erection company says the tank is constructed to API 650 Standard, does not mean they always follow API 650 Standard and specifications. Ask the right questions before entering into a contract to design and build your companies next storage tank.



## Questions you need to ask and verify:

- Ask for design calculations from the tank erector and verify that the correct specific gravity for your product is used so you know you are getting a tank of adequate thickness for each shell course.
- Verify the specification of the plate being used. This also means the floor and roof. API specifies the use A-36 modified material or greater. In colder regions, based upon lowest mean temperatures, Grade 516-60 or Grade 516-70 is required on the bottom shell course due to brittle fracture concerns.

You have the right to ask for and receive mill test certifications on all of the steel used for your tank. Competitive reasons have some tank erection companies using de-coil material on the roof and floor plate (and sometimes on the shell) which do not have mill test heat numbers stamped on the plate. De-coil material does not usually meet the minimum or maximum thickness tolerances required.



- If the tank is to be 100' or larger, ask if the design includes an annular ring attached to the shell.
- Ask if the tank erector can provide to you the Weld Procedure Manual they use. You have a right to have a copy and review those procedures prior to any erection. Ask if the tank erector can provide you with individual welder testing certifications for each welder assigned to the tank erection. Your company has the right get this information prior to erection.



- Radiograph (spot X-Ray) is a requirement of API 650. A independent third party X-Ray company should be used. Most radiograph companies are familiar with the requirements of API 650 for spot X-ray. Formulas are called out in API 650 for the number of shots taken and location of those shots based upon the thickness of the material, number of welders welding on the tank and the tank diameter.

Do not allow the erector to specify the location of the X-Ray shots. Remember, this is a quality control check for your tank and you do not want X-Rays taken only where the best welder was performing the work.

- Ask what other quality control measures the erector is performing such as diesel or penetrant test of chime (floor to shell weld) and vacuum testing of floor weld seams.
- If at any point you are concerned about your tank erection or any of the above, your company has the right to bring in a independent third party API Certified Inspector to inspect the work.
- **Bottom line, make sure you are getting what you specified and paid to have completed.**

