CODE AWARENESS

API 650/653

MODULE – 1 TANK BASICS

TYPES OF TANKS

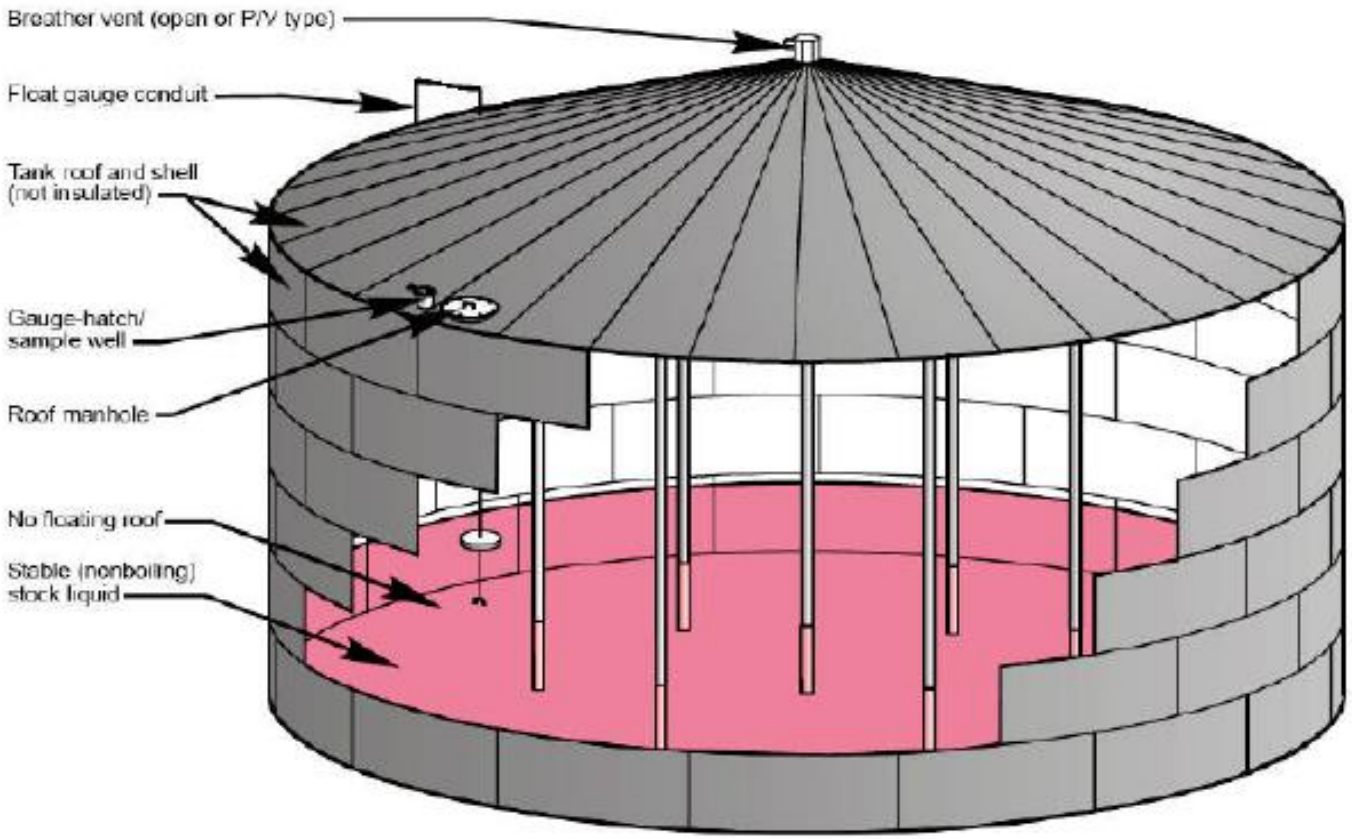
Fixed Cone Roof Tank

Fixed Dome Roof Tank

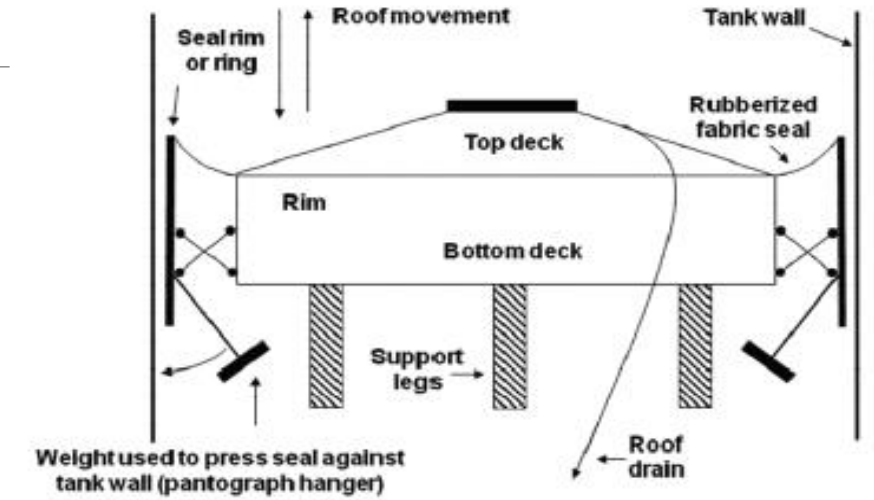
External Floating Tank

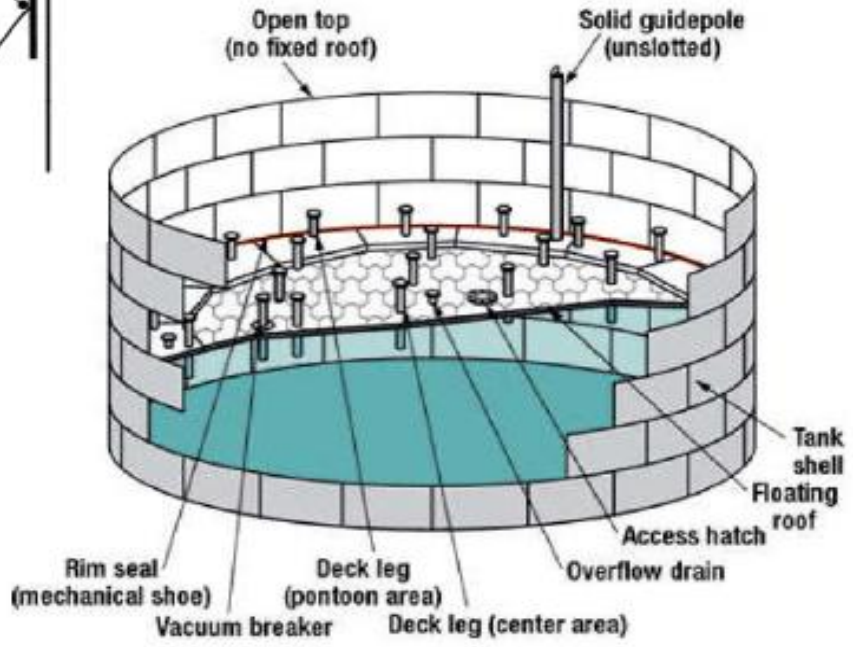
Internal Floating Tank

FIXED ROOF TANK

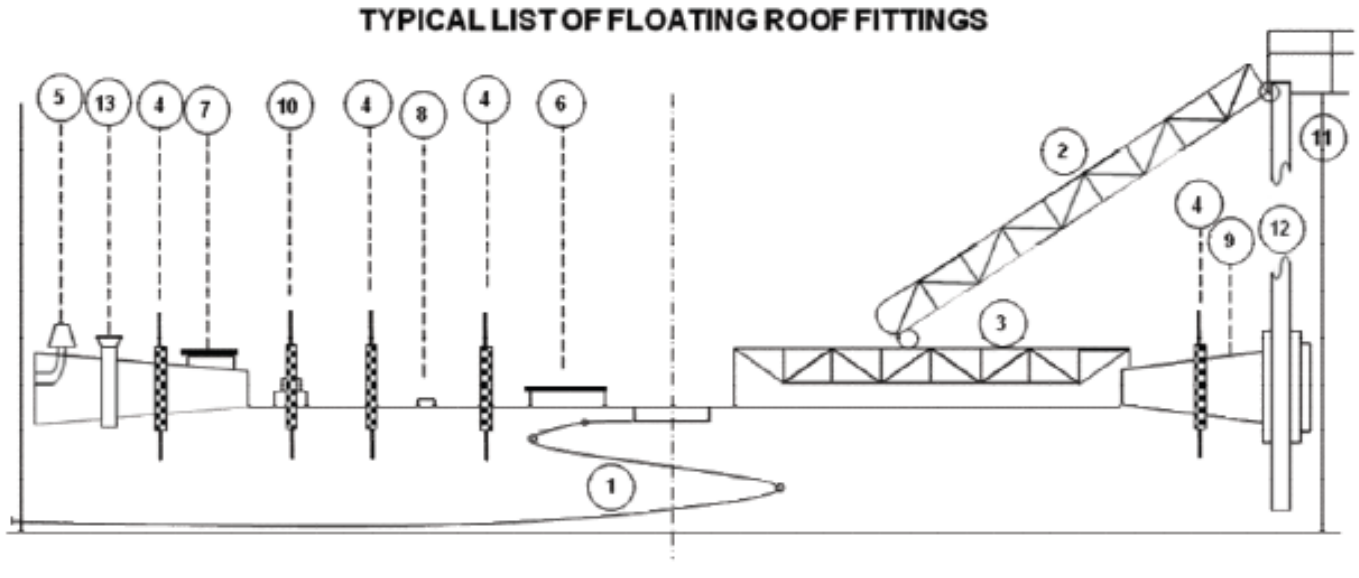


EXTERNAL FLOATING ROOF TANK



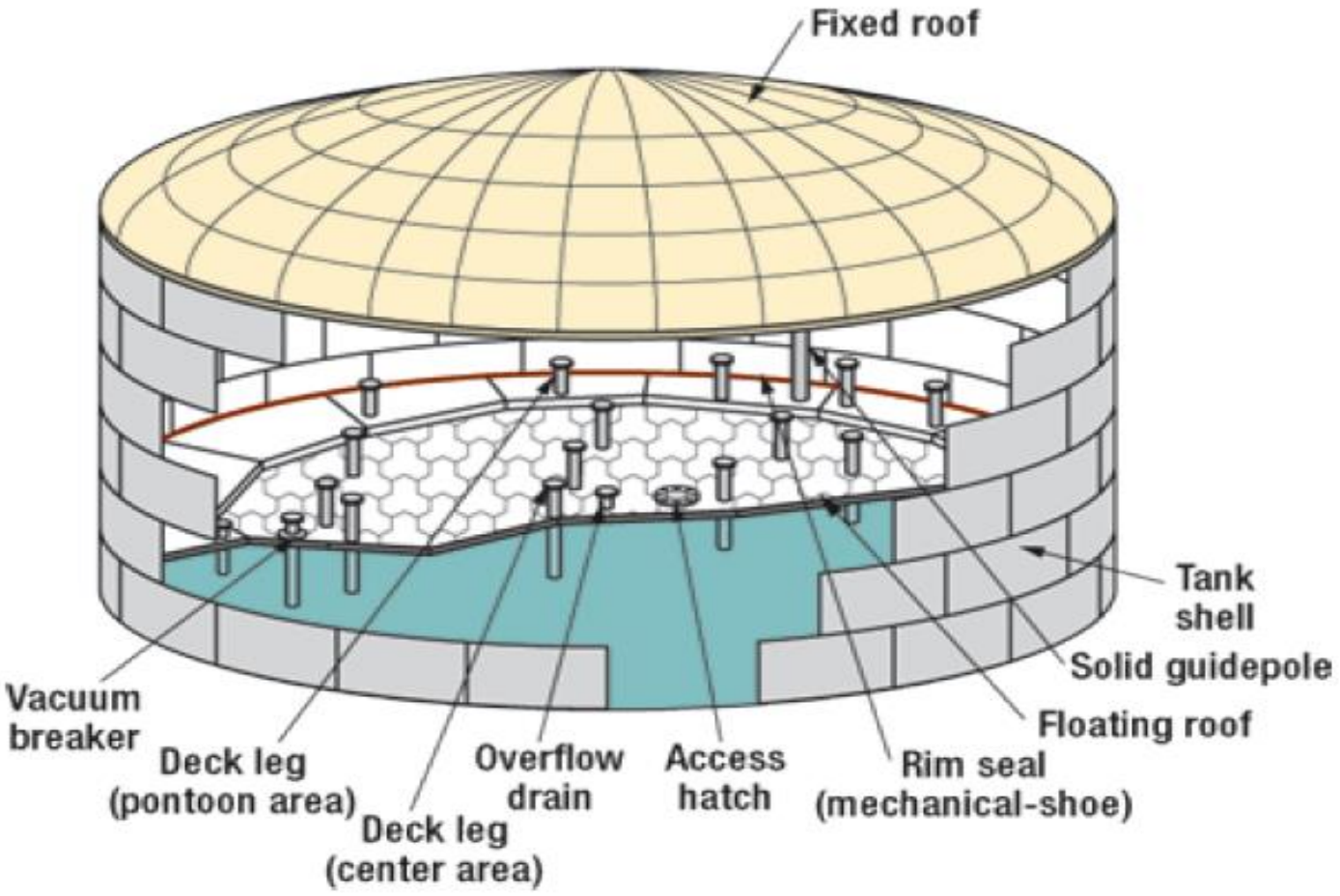


EXTERNAL FLOATING ROOF TANK



1. ROOF DRAIN
2. ROLLING LADDER
3. LADDER RUNWAY
4. SUPPORT LEGS
5. RIM VENT
6. DECK MANHOLE
7. PONTOON MANHOLE
8. DRAIN PLUG
9. FOAM DAM
10. AUTO BLEEDER VENT
11. AUTO LEVEL INDICATOR
12. ROOF GUIDE POLE & MANUAL DIPPING TUBE
13. SAMPLE HATCH

INTERNAL FLOATING ROOF TANK



CODE AWARENESS

API 650/653

MODULE – II MATERIALS AND DESIGN ASPECTS

Interpretation of API 650 /API 653

API 650 12th edition March 2013 addendum 2 Jan 2016

– Welded tanks for Oil Storage(Construction Code)

API 653 5th edition November 2014

- Tank Inspection,Repair,Alteration and Re-construction(Repair Code)

Interpretation of ‘OR’ & ‘AND’

OR – Either of the requirements shall be satisfied

AND – Both the requirements shall be satisfied

MATERIALS

Below listed are the standard/common materials used during maintenance,material grouping as API 650 Table 4.4(b)

1. SA 516 Gr.70 – Group IV and V
2. SA 36 – Group 1
3. SA 737 Gr.B – Group VI
4. BS 4360 Gr.A – Unassigned material
5. SA 283 Gr.C – Group 1
6. SA 573 Gr.70 – Group IV,IVA,V
7. ISO 630 Fe 510C – Non listed material

MATERIAL COMPARISON CHART AS PER STANDARD EN10025-2

Annex A
(informative)
List of corresponding former designations

Table A.1 - List of corresponding former designations

Designation according EN 10025-2:2004		Equivalent former designations in												
		According EN 10025:1990 +A1:1993		According EN 10025:1990	Germany according to DIN 17 100	France according to NF A 35-501	United Kingdom according to BS 4360	Spain according to UNE 36-080	Italy according to UNI 7070	Belgium according to NBN A 21-101	Sweden according to SS 14 followed by number steel grade	Portugal according to NP 1729	Austria according to M 3116	Norway according to number steel grade
S185	1.0035	S185	1.0035	Fe 310-0	St 33	A 33		A 310-0	Fe 320	A 320	13 00-00	Fe 310-0	St 320	
		S235JR	1.0037	Fe 360 B	St 37-2	E 24-2			Fe 360 B	AE 235-B	13 11-00	Fe 360-B		NS 12 120
		S235JRG1	1.0036	Fe 360 BFU	USt 37-2			AE 235 B-FU					USt 360 B	NS 12 122
S235JR	1.0038	S235JRG2	1.0038	Fe 360 BFN	RSt 37-2		40 B	AE 235 B-FN			13 12-00		RSt 360 B	NS 12 123
S235J0	1.0114	S235J0	1.0114	Fe 360 C	St 37-3 U	E 24-3	40 C	AE 235 C	Fe 360 C	AE 235-C		Fe 360-C	St 360 C	NS 12 124
													St 360 CE	
*	*	S235J2G3	1.0116	Fe 360 D1	St 37-3 N	E 24-4	40 D	AE 235 D	Fe 360 D	AE 235-D		Fe 360-D	St 360 D	NS 12 124
S235J2	1.0117	S235J2G4	1.0117	Fe 360 D2	--									
S275JR	1.0044	S275JR	1.0044	Fe 430 B	St 44-2	E 28-2	43 B	AE 275 B	Fe 430 B	AE 255-B	14 12-00	Fe 430-B	St 430 B	NS 12 142
S275J0	1.0143	S275J0	1.0143	Fe 430 C	St 44-3 U	E 28-3	43 C	AE 275 C	Fe 430 C	AE 255-C		Fe 430-C	St 430 C	NS 12 143
													St 430 CE	
*	*	S275J2G3	1.0144	Fe 430 D1	St 44-3 N	E 28-4	43 D	AE 275 D	Fe 430 D	AE 255-D	14 14-00	Fe 430-D	St 430 D	NS 12 143
S275J2	1.0145	S275J2G4	1.0145	Fe 430 D2	--						14 14-01			
S355JR	1.0045	S355JR	1.0045	Fe 510 B	--	E 36-2	50 B	AE 355 B	Fe 510 B	AE 355-B		Fe 510-B		
S355J0	1.0553	S355J0	1.0553	Fe 510 C	St 52-3 U	E 36-3	50 C	AE 355 C	Fe 510 C	AE 355-C		Fe 510-C	St 510 C	NS 12 153
*	*	S355J2G3	1.0570	Fe 510 D1	St 52-3 N		50 D	AE 355 D	Fe 510 D	AE 355-D		Fe 510-D	St 510 D	NS 12 153
S355J2	1.0577	S355J2G4	1.0577	Fe 510 D2	--									
*	*	S355K2G3	1.0595	Fe 510 DD1	--	E 36-4	50 DD			AE 355-DD		Fe 510-DD		
S355K2	1.0596	S355K2G4	1.0596	Fe 510 DD2	--									
S450J0	1.0590						55C							
E295	1.0050	E295	1.0050	Fe 490-2	St 50-2	A 50-2		A 490	Fe 490	A 490-2	15 50-00 15 50-01	Fe 490-2	St 490	
E335	1.0060	E335	1.0060	Fe 590-2	St 60-2	A 60-2		A 590	Fe 590	A 590-2	16 50 00 16 50-01	Fe 590-2	St 590	
E360	1.0070	E360	1.0070	Fe 690-2	St 70-2	A 70-2		A 690	Fe 690	A 690-2	16 55 00 16 55-01	Fe 690-2	St 690	

* When a product is delivered in the N condition +N shall be added to the designation (see 4.2.2).

MATERIALS

Table 4.4b—Material Groups (USC)

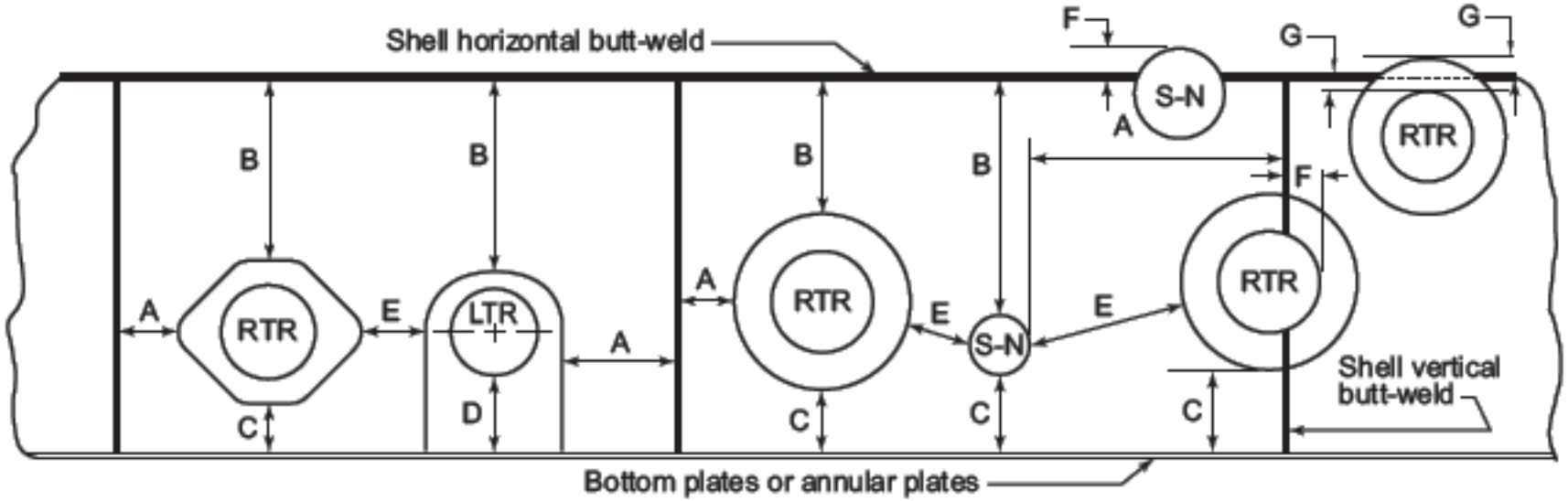
(See Figure 4.1b and Note 1 below.)

Group I As Rolled, Semi-killed		Group II As Rolled, Killed or Semi-killed		Group III As Rolled, Killed Fine-Grain Practice		Group IIIA Normalized, Killed Fine-Grain Practice	
Material	**Notes**	**Material**	**Notes**	**Material**	**Notes**	**Material**	**Notes**
A283 C		A131 B	6	A573-58		A573-58	9
A285 C	2	A36	5	A516-55		A516-55	9
A131 A		G40.21-38W		A516-60		A516-60	9
A36	3	Grade 250	7	G40.21-38W	8	G40.21-38W	8, 9
Grade 235	3			Grade 250	8	Grade 250	8, 9
Grade 250	5						

Group IV As Rolled, Killed Fine-Grain Practice		Group IVA As Rolled, Killed Fine-Grain Practice		Group V Normalized, Killed Fine-Grain Practice		Group VI Normalized or Quenched and Tempered, Killed Fine-Grain Practice Reduced Carbon	
Material	**Notes**	**Material**	**Notes**	**Material**	**Notes**	**Material**	**Notes**
A573-65		A662 C		A573-70	9	A131 EH 36	
A573-70		A573-70	10	A516-65	9	A633 C	
A516-65		G40.21-44W	8, 10	A516-70	9	A633 D	
A516-70		G40.21-50W	8, 10	G40.21-44W	8, 9	A537 Class 1	
A662 B		E275 D		G40.21-50W	8, 9	A537 Class 2	12
G40.21-44W	8	E355 D				A678 A	
G40.21-50W	8	S275 J2	8			A678 B	12
E275 C	8	S355 (J2 or K2)	8			A737 B	
E355 C S275 J0 S355 J0	8 8 8					A841, Grade A, Class 1 A841, Grade B, Class 2	11, 12, 13 11, 12, 13
Grade 275	8						

NOTES

DIMENSION REQUIREMENT(NOZZLES) API 650 clause 5.7



KEY

14 ▌ RTR = Regular-Type Reinforced Opening (nozzle or manhole) with diamond or circular shape reinforcing plate, or insert plate, or thickened
15 ▌ insert plate, that does not extend to the bottom (see Figure 5.7A and Figure 5.8).

14 ▌ LTR = Low-Type Reinforced Opening (nozzle or manhole) using tombstone type reinforcing plate, insert plate, or thickened insert plate that
15 ▌ extends to the bottom [see Figure 5.8, Detail (a) and Detail (b)].

14 ▌ S-N = Shell openings with neither a reinforcing plate nor with a thickened insert plate (i.e. integrally reinforced shell openings; or openings not requiring reinforcing).

DIMENSION REQUIREMENT(NOZZLES) API 650 clause 5.7

Variables		Reference	Minimum Dimension Between Weld Toes or Weld Centerline (Notes 1, 2, 3, and 4)						
Shell *t*	Condition	Paragraph Number	A	B	C	D (5 only)	E	F (6)	G (6)
t ≤ 13 mm (*t* ≤ 1/2 in.)	As welded or PWHT	5.7.3.2 5.7.3.3 5.7.3.3 5.7.3.3 • 5.7.3.4 • 5.7.3.4	150 mm (6 in.)	75 mm (3 in.)	75 mm (3 in.)	Table 5.6a and Table 5.6b	75 mm (3 in.)	Lesser of 8*t* or 1/2 *r*	8*t*
t > 13 mm (*t* > 1/2 in.)	As Welded	5.7.3.1.a 5.7.3.1.b 5.7.3.3 5.7.3.3 5.7.3.3 • 5.7.3.4 • 5.7.3.4	8*W* or 250 mm (10 in.)	8*W* or 250 mm (10 in.)	8*W* or 250 mm (10 in.) 75 mm (3 in.) for S-N	Table 5.6a and Table 5.6b	8*W* or 150 mm (6 in.)	Lesser of 8*t* or 1/2 *r*	8*t*
t > 13 mm (*t* > 1/2 in.)	PWHT	5.7.3.2 5.7.3.3 5.7.3.3 5.7.3.3 • 5.7.3.4 • 5.7.3.4	150 mm (6 in.)	75 mm (3 in.) or 2 1/2*t*	75 mm (3 in.) or 2 1/2*t* 75 mm (3 in.) for S-N	Table 5.6a and Table 5.6b	75 mm (3 in.) or 2 1/2*t*	Lesser of 8*t* or 1/2 *r*	8*t*

NOTE 1 If two requirements are given, the minimum spacing is the greater value, unless otherwise noted.

NOTE 2 Weld spacings are measured to the toe of a fillet-weld, the centerline of an insert or thickened insert plate butt-weld, or the centerline of a shell butt-weld.

NOTE 3 *t* = shell nominal thickness.

NOTE 4 *W* = the largest weld size around the periphery of the fitting(s): for fillet welds the leg length along the tank shell, for butt welds the thickness of the insert plate at the weld joint.

NOTE 5 *D* = spacing distance established by minimum elevation for low-type reinforced openings from Table 5.6a and Table 5.6b, column 9.

NOTE 6 Purchaser option to allow shell openings to be located in horizontal or vertical shell butt-welds. See Figure 5.9.

Figure 5.6—Minimum Weld Requirements for Openings in Shells According to 5.7.3

PWHT Requirement for Shell Openings

5.7.4 Thermal Stress Relief

5.7.4.1 All flush-type cleanout fittings and flush-type shell connections shall be thermally stress-relieved as an assembly prior to installation in the tank shell or after installation into the tank shell if the entire tank is stress-relieved. The stress relief shall be carried out within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) (see 5.7.4.3 for quenched and tempered materials) for 1 hour per 25 mm (1 in.) of shell thickness. The assembly shall include the bottom reinforcing plate (or annular plate) and the flange-to-neck weld.

5.7.4.2 When the shell material is Group I, II, III, or IIIA, all opening connections NPS 12 or larger in nominal diameter in a shell plate or thickened insert plate more than 25 mm (1 in.) thick shall be prefabricated into the shell plate or thickened insert plate, and the prefabricated assembly shall be thermally stress-relieved within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) for 1 hour per 25 mm (1 in.) of thickness prior to installation. The stress-relieving requirements need not include the flange-to-neck welds or other nozzle-neck and manhole-neck attachments, provided the following conditions are fulfilled.

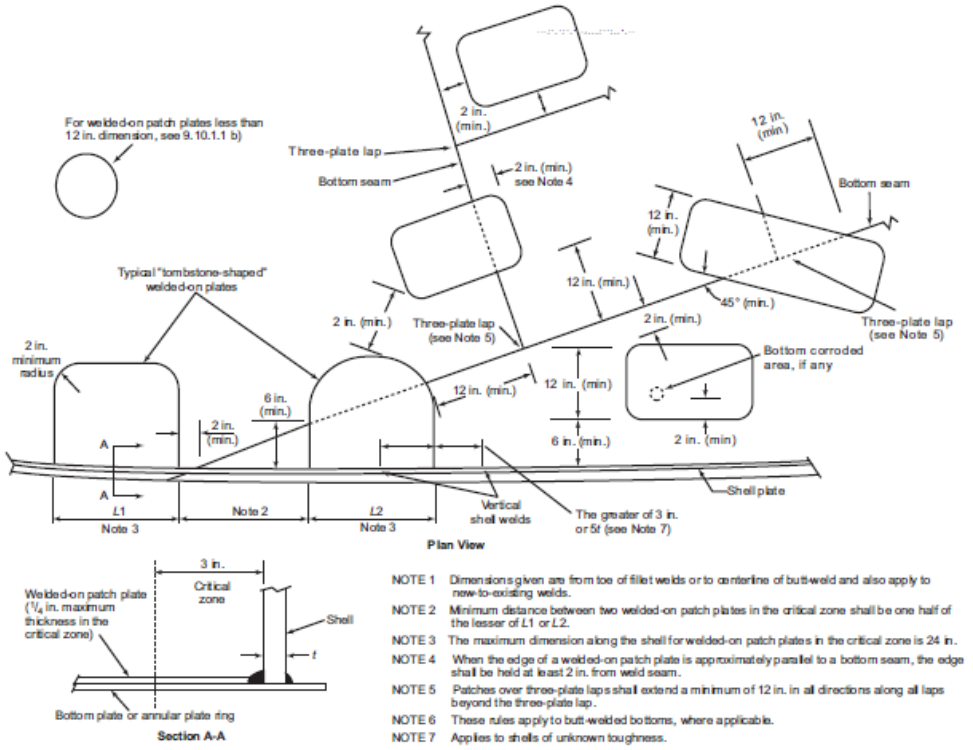
a) The welds are outside the reinforcement (see 5.7.2.4).

b) The throat dimension of a fillet weld in a slip-on flange does not exceed 16 mm ($^5/_8$ in.), or the butt joint of a welding-neck flange does not exceed 19 mm ($^3/_4$ in.). If the material is preheated to a minimum temperature of 90 °C (200 °F) during welding, the weld limits of 16 mm ($^5/_8$ in.) and 19 mm ($^3/_4$ in.) may be increased to 32 mm and 40 mm ($1^1/_4$ in. and $1^1/_2$ in.), respectively.

5.7.4.3 When the shell material is Group IV, IVA, V, or VI, all opening connections requiring reinforcement in a shell plate or thickened insert plate more than 13 mm ($^1/_2$ in.) thick shall be prefabricated into the shell plate or thickened insert plate, and the prefabricated assembly shall be thermally stress relieved within a temperature range of 600 °C to 650 °C (1100 °F to 1200 °F) for 1 hour per 25 mm (1 in.) of thickness prior to installation.

When connections are installed in quenched and tempered material, the maximum thermal stress-relieving temperature shall not exceed the tempering temperature for the materials in the prefabricated stress-relieving assembly. The stress-relieving requirements do not apply to the weld to the bottom annular plate, but they do apply to flush-type cleanout openings when the bottom reinforcing plate is an annular-plate section. The stress-relieving requirements need not include the flange-to-neck welds or other nozzle-neck and manhole-neck attachments, provided the conditions of 5.7.4.2 are fulfilled.

BOTTOM PATCH PLATE DIMENSIONAL REQUIREMENT



NOTE 1 Dimensions given are from toe of fillet welds or to centerline of butt-weld and also apply to new-to-existing welds.

NOTE 2 Minimum distance between two welded-on patch plates in the critical zone shall be one half of the lesser of *L*1 or *L*2.

NOTE 3 The maximum dimension along the shell for welded-on patch plates in the critical zone is 24 in.

NOTE 4 When the edge of a welded-on patch plate is approximately parallel to a bottom seam, the edge shall be held at least 2 in. from weld seam.

NOTE 5 Patches over three-plate laps shall extend a minimum of 12 in. in all directions along all laps beyond the three-plate lap.

NOTE 6 These rules apply to butt-welded bottoms, where applicable.

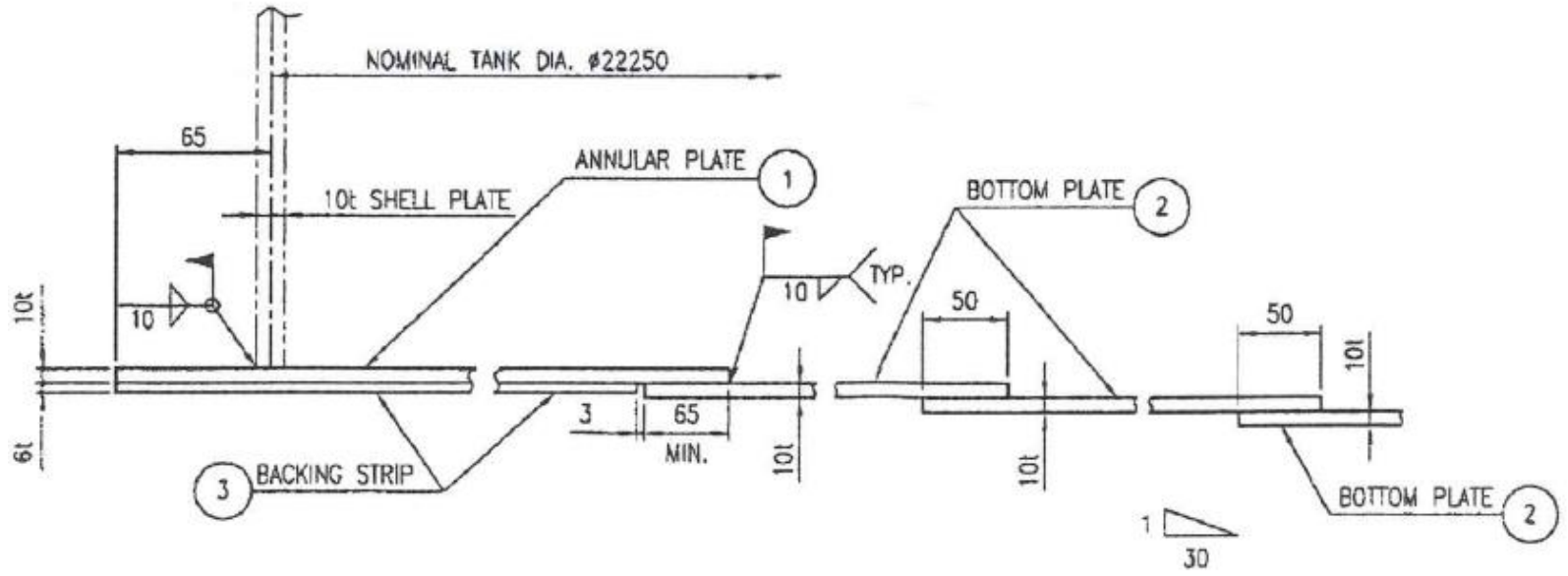
NOTE 7 Applies to shells of unknown toughness.

Figure 9.13—Typical Welded-on Patch Plates on Tank Bottom Plates

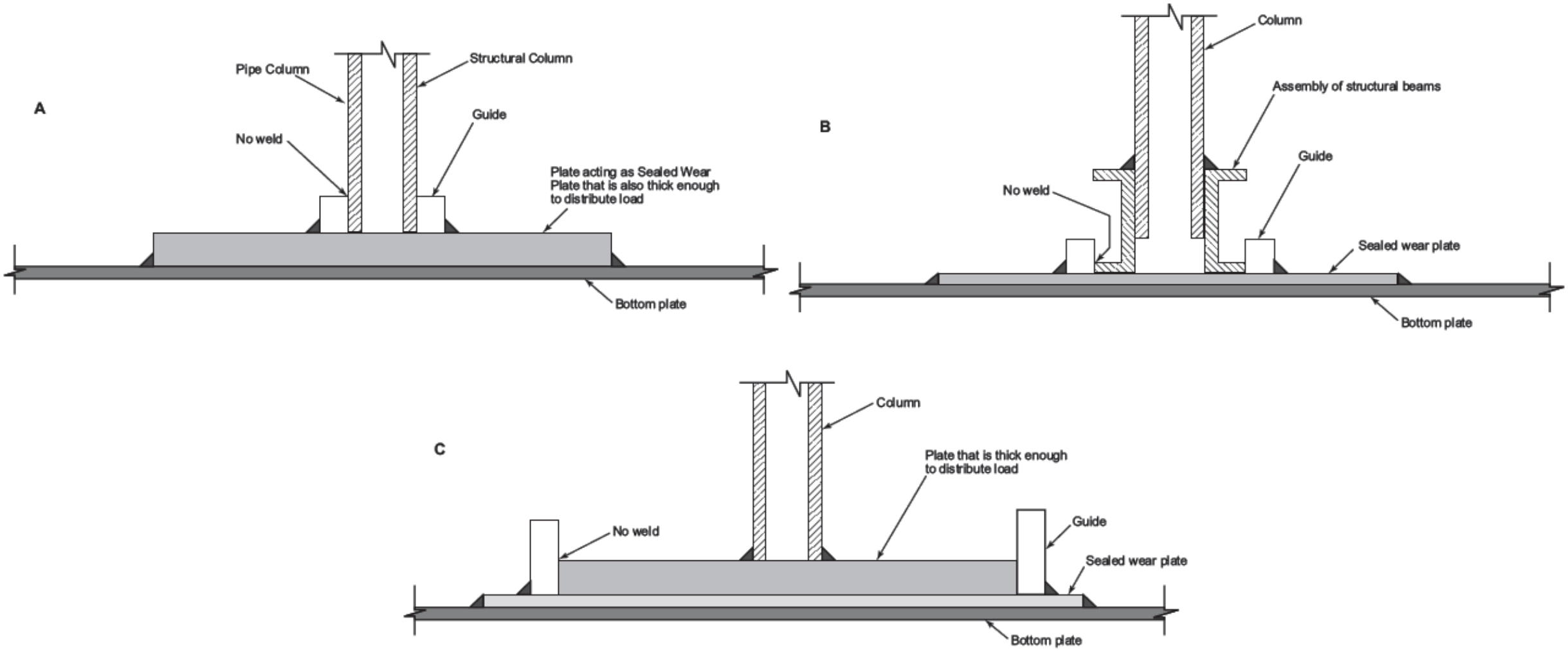
Typical Patch Plate

EXTERNAL ANNULAR PLATE PROJECTION OUTSIDE REQUIREMENT

5.4.2 Bottom plates of sufficient size shall be ordered so that, when trimmed, at least a 50 mm (2 in.) width will project outside the shell or meet requirements given in 5.1.5.7 d whichever is greater.



SUPPORTED CONE ROOF –WEAR PLATE REQUIREMENT



SUPPORTED CONE ROOF –WEAR PLATE REQUIREMENT

b) ***Corrosion and Abrasion Protection***: At each column a wear plate with a nominal thickness of not less than 6 mm (1/4 in.) shall be welded to the tank bottom with a 6 mm (1/4 in.) minimum fillet weld. A single adequate thickness plate may be designed for the dual functions of load distribution and corrosion/abrasion protection.

c) ***Vertical Movement***: The design shall allow the columns to move vertically relative to the tank bottom without restraint in the event of tank overpressure or bottom settlement.

d) ***Lateral Movement***: The columns shall be effectively guided at their bases to prevent lateral movement. The guides shall remain effective in the event of vertical movement of columns relative to tank bottom of up to 75 mm (3 in.). The guides shall be located such that they are not welded directly to the tank bottom plates.

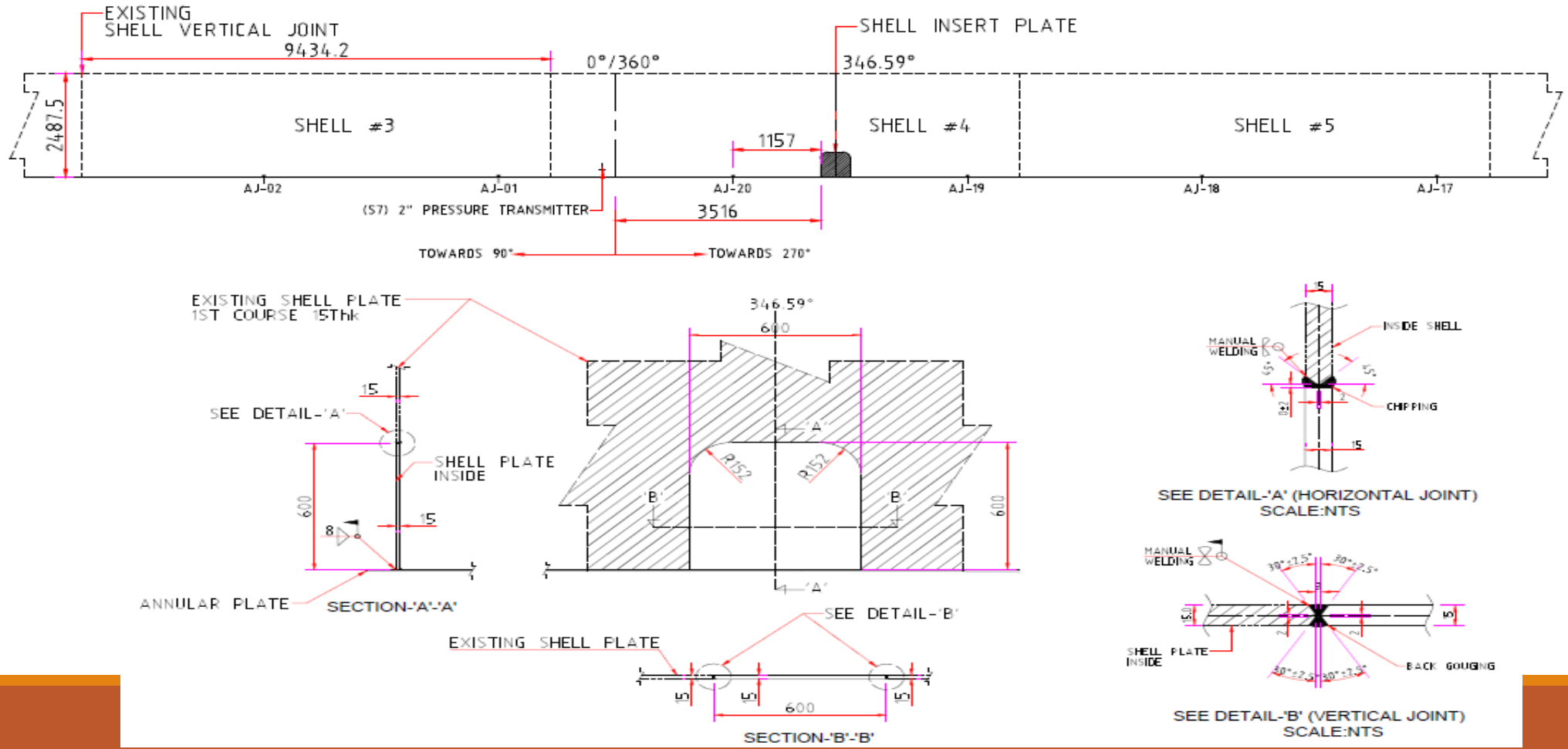
FFS

FFS Means

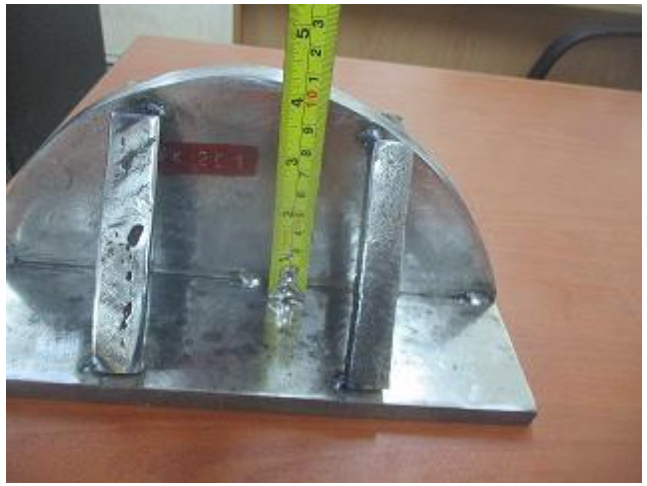
Why Required

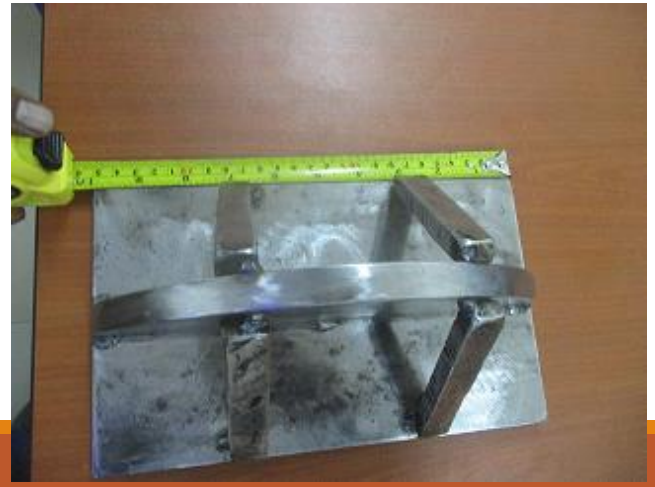
Type of Test

Fitness for Service(Hydro test Exemption) API 653 clause 12.3.2



Fitness for Service(Hydro test Exemption) API 653 clause 12.3.2





Fitness for Service(Hydro test Exemption) API 653 clause 12.3.2

Fitness for Service(Hydro test Exemption) API 653 clause 12.3.2

Finite Element Analysis – Perform to identify the peak stresses in the new welds for the tank under hydro static conditions

Material Properties – Tensile, Yield and Crack Tip Opening displacement(CTOD)

Fracture Mechanics Analysis – Critical flaw sized for a surface flaws in New welds

BASIS OF TANKS - OPERATIONS

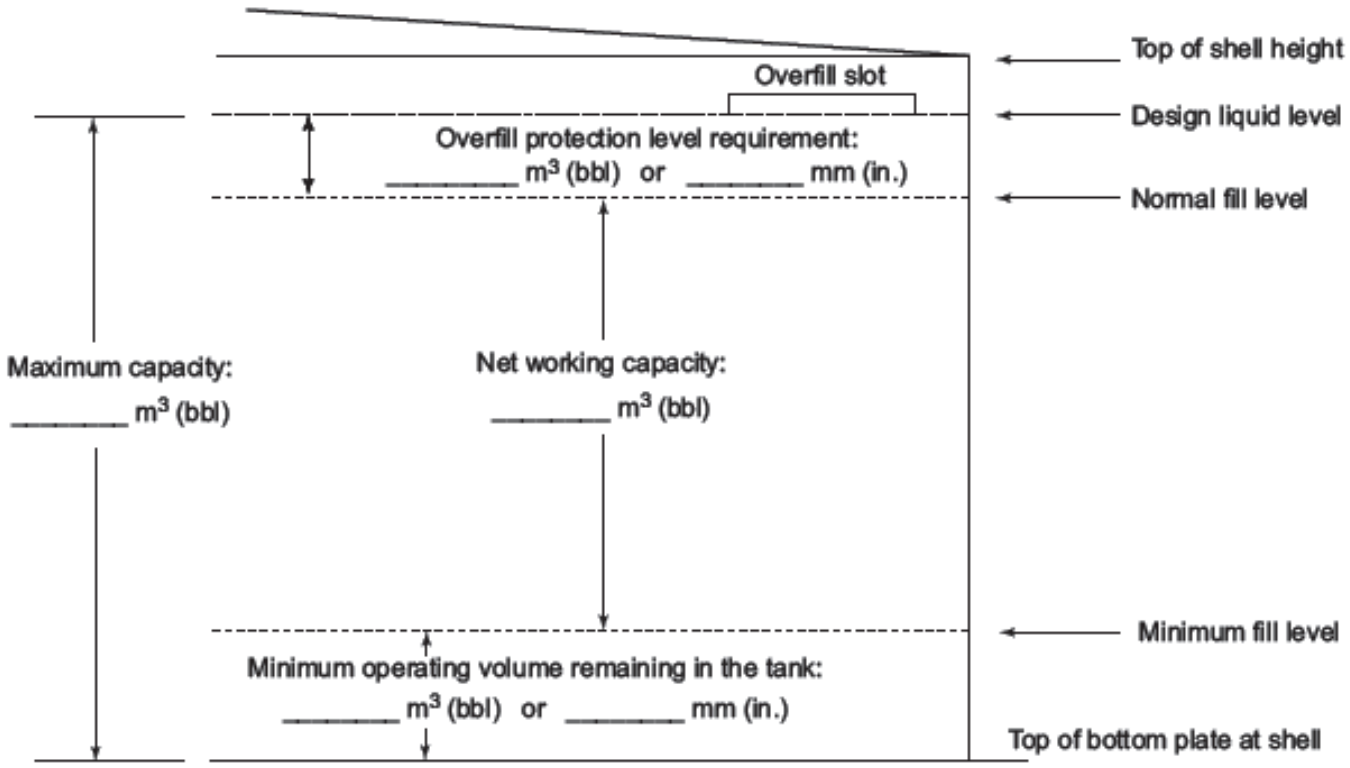


Figure 5.4—Storage Tank

CODE AWARENESS

API 650/653

MODULE – III OUT OF SERVICE CALCULATIONS

Inspections frequency Considerations

1. Nature of product stored
2. Results of visual maintenance checks
3. Corrosion allowance and corrosion rates
4. Corrosion prevention systems
5. Conditions at previous inspections
6. Methods and material of construction and repair
7. Locations of tanks
8. Potential risk of water pollution
9. Leak Detection systems
10. Change in operating mode
11. Jurisdiction requirements
12. Changes in Service

Basis of Internal Inspection

1. Ensure the bottom is not severely corroded and or leaking
2. Gather the necessary data for the minimum bottom and shell thickness assessments
3. Identify and evaluate bottom settlement

Initial Inspection Interval

Table 6.1—Tank Safeguard

Tank Safeguard	Add to Initial Interval
i. Fiberglass-reinforced lining of the product-side of the tank bottom installed per API RP 652.	5 yrs
i Installation of an internal thin-film coating as installed per API RP 652.	2 yrs
iii. Cathodic protection of the soil-side of the tank bottom installed, maintained, and inspected per API RP 651.	5 yrs
iv. Release prevention barrier installed per API Std 650, Annex I.	10 yrs
v. Bottom corrosion allowance greater than 0.150 in.	(Actual corrosion allowance -150 mils)/corrosion rate*
vi. Bottom constructed from stainless steel material that meets requirements of API 650, Annex SC, and either Annex S or Annex X; and internal and external environments have been determined by a qualified corrosion specialist to present very low risk of cracking or corrosion failure.	10 yrs
* Corrosion rate to be 15 mpy, or as determined from Appendix H, Similar Service	

Mandatory Inspection checks

1. Shell Minimum Thickness Calculation
2. Shell remaining life calculation
3. Nozzle remaining life calculation
4. Bottom Annular Plate Thickness Evaluation
5. Shell Settlement Evaluation
6. Tank Verticality (Plumbness)
7. Tank Roundness
8. External and Internal Visual Inspection

Shell Minimum Thickness Calculations

SHELL MINIMUM THICKNESS CALCULATIONS

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

where

t_{min} is the minimum acceptable thickness, in inches for each course as calculated from the above equation; however, t_{min} shall not be less than 0.1 in. for any tank course;

D is the nominal diameter of tank, in feet (ft);

H is the height from the bottom of the shell course under consideration to the maximum liquid level when evaluating an entire shell course, in feet (ft); or

is the height from the bottom of the length L (see 4.3.2.1) from the lowest point of the bottom of L of the locally thinned area to the maximum liquid level, in feet (ft); or

is the height from the lowest point within any location of interest to the maximum liquid level, in feet (ft);

G is the highest specific gravity of the contents;

S is the maximum allowable stress in pound force per square inch (lbf/in.^{2}); use the smaller of $0.80Y$ or $0.429T$ for bottom and second course; use the smaller of $0.88Y$ or $0.472T$ for all other courses. Allowable shell stresses are shown Table 4.1 for materials listed in the current and previous editions of API 12C and API 650;

Shell Remaining Life Calculations

SHELL REMAINING LIFE CALCULATIONS

Ca = tact-tmin = Remaining Corrosion Allowance (mm)

Cr = tprev-tact / Y = Corrosion Rate (mm per year)

RL = Ca / Cr = Remaining Life (years)

Y = 9 **= Tank age (years)**

Where:

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

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

FHc *= Calculated fill Height = (SEtact/2.6DG+1)+ (product height below course of interest), in meters.*

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

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

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

Tank Verticality Plumbness

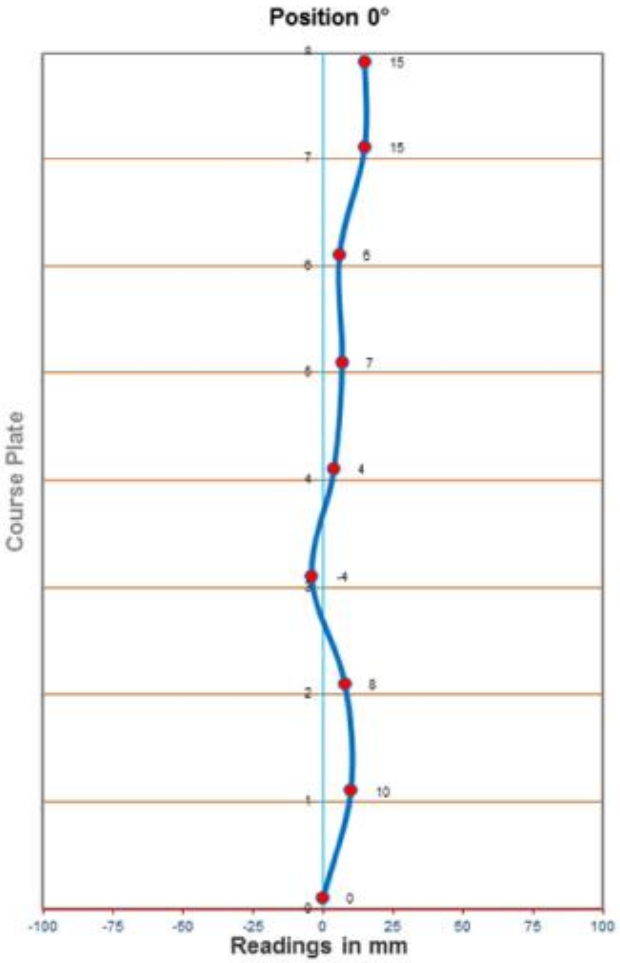
Acceptance Criteria (as per API 653, Clause 10.5.2 – Plumpness)

Clause 10.5.2.1-The maximum out-of-plumpness of the top of the shell relative to the bottom of the shell shall not exceed **1/100** of the total tank height with a maximum of 5 inch. The 1/100 criteria with a maximum of 5 inch shall also apply to fixed roof columns. For tanks with internal floating roof, apply the criteria of this section or API 650, Appendix H, whichever is more stringent.

Clause 10.5.2.2- The out-of-plumpness in one shell course shall not exceed the values specified for mill tolerances in ASTM A6 or ASTM A20, whichever is applicable

2.3.1. Method of Inspection:

The total number of stations to be carried out was not specified in API 650;



Tank Roundness

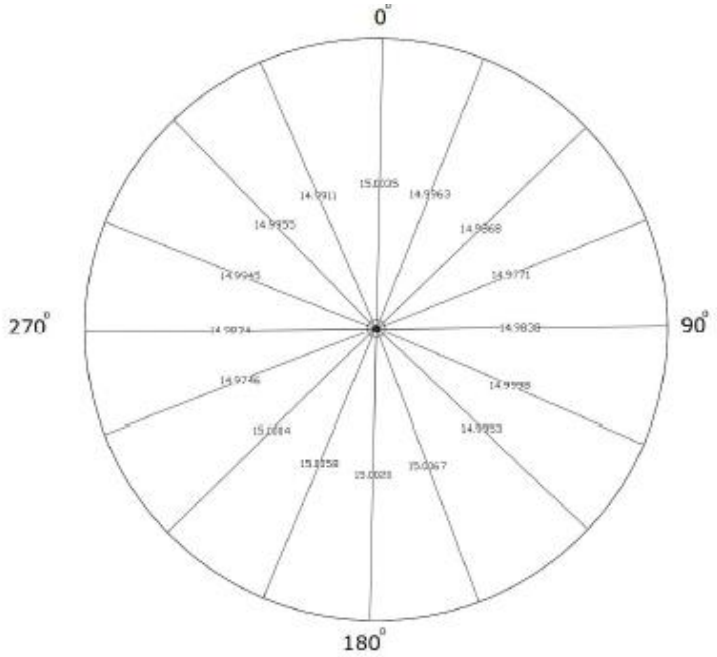
10.5.3 Roundness

Radii measured at 1 ft above the shell-to-bottom weld shall not exceed the tolerances shown in Table 10.2.

Radius tolerances measured higher than one foot above the shell-to-bottom weld shall not exceed three times the tolerances given in Table 10.2.

Table 10.2—Radii Tolerances

Tank Diameter (ft)	Radius Tolerances (in.)
< 40	±1/2
40 to < 150	±3/4
150 to < 250	±1
≥ 250	±1 1/4



INSPECTION MANDATORY CHECK POINTS

Refer API 653 Annexure F

Out of Service inspection Check list

Tank Out-of-service Inspection Checklist			
	Item	Completed	Comments
	OVERVIEW		
a.	Check that tank has been cleaned, is gas free, and safe for entry.	√	Satisfactory.
b.	Check that the tank is completely isolated from product lines, all electrical power, and steam lines.	√	Satisfactory.
c.	Check that roof is adequately supported, including fixed roof structure and floating roof legs.	√	Satisfactory.
d.	Check for presence of falling object hazards, such as corroded-through roof rafters, asphalt stalactites, and trapped hydrocarbons in unopened or plugged equipment or appurtenances, ledges, etc.	√	Satisfactory.
e.	Inspect for slipping hazards on the bottom and roof decks.	√	Satisfactory.
f.	Inspect structural welds on access ways and clips.	√	Satisfactory.
g.	Check surface needing inspection for a heavy-scale build up and check weld seams and oily surfaces where welding is to be done. Note areas needing more cleaning, including blasting.	√	Satisfactory.
h.	Review cathodic protection potential readings	NA	
	TANK EXTERIOR		
a.	Inspect appurtenances opened during cleaning such as lower floating swing sheave assemblies, nozzle interiors (after removal of valves).	√	Rust and scales noted inside nozzle's bore.
b.	Hammer test or ultrasonically test the roof.	N/A	
c.	Enter and inspect the floating roof pontoon compartments.	N/A	
BOTTOM INTERIOR SURFACE			
a.	Using a flashlight held close to and parallel to the bottom plates, and using the bottom plate layout as a guide, visually inspect and hammer test the entire bottom.	√	Product side corrosion noted
b.	Measure the depth of pitting and describe the pitting appearance (sharp edged, lake type, dense, scattered, etc).	√	corrosion noted at many locations. Deep holes observed at initial inspection.
c.	Mark areas requiring patching or further inspection.	√	
d.	Mark locations for turning coupons for inspection.	√	200X200 coupen was taken
e.	Inspect all welds for corrosion and leaks, particularly the shell-to-bottom weld.	√	
f.	Inspect sketch plates for corrosion.	√	corrosion noted at many locations.
g.	Check condition of internal sump, if applicable. Standing liquid should be removed from the sump to allow for complete inspection and vacuum testing of weld seams as appropriate. Sump bottom and sidewall plate and seams need to be evaluated for both product-side and soil-side corrosion.	√	Satisfactory.
h.	Locate and mark voids under the bottom.	√	See MFL report
i.	Record bottom data on a layout sketch using the existing bottom plates as a grid. List the number and sizes of patches required.	N/A	Patches were marked.