

DEP SPECIFICATION

**VERTICAL STEEL STORAGE TANKS – SELECTION
DESIGN AND CONSTRUCTION
(AMENDMENTS/SUPPLEMENTS TO EN14015)**

DEP 34.51.01.31-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE

DEM1



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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies the minimum technical requirements for the selection, design, fabrication, construction, erection and testing of standard vertical steel storage tanks based on European Standard EN 14015:2004. It is intended to be used in conjunction with standard requisition sheets.

This DEP is written in the form of amendments and supplements to EN 14015. All clauses of EN 14015 not modified by this DEP remain valid as written.

Although EN 14015 gives design rules for very high pressure tanks [design pressure/vacuum +500/-20 mbar (ga)], this DEP is not intended to cover design rules for these tanks.

Site preparation and foundation aspects of the design are covered in DEP 34.11.00.11-Gen.

The design and construction of aboveground storage tanks in accordance with API 650 is covered in DEP 34.51.01.33-Gen.

Structural modifications undertaken during tank operation are not part of the new design/construction scope and are not covered in this DEP.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This DEP is a revision of the DEP of the same number and title dated September 2013; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.3 Abbreviations

Term	Definition
CFRT	Closed floating roof tank
EFRT	External floating roof tank
IFC	Internal floating cover
IFRT	Internal floating roof tank
TVP	True Vapour Pressure

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (Part IV).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated September 2013. The following are the main, non-editorial changes.

Section/Clause	Change
All	Restructured, clarified, and increased overall quality of DEP requirements.
Part II, 2.9.1, Item 5	Clarified further the DEM1 requirement
Part III, 6.1, Item 1	Removed "clause 6" from the DEM1 requirements since the salient reference is Table 9
Part III, 10.5	Clarified the DEM1 requirement further, as reflected in Item 4 and Item 5

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

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DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

PART II GENERAL REQUIREMENTS

2.1 GENERAL

1. Part III of this DEP is written as amendments and supplements to EN 14015:2004. Wherever reference is made to EN 14015, it shall be understood to mean EN 14015:2004, as amended/supplemented by this DEP.
2. For ease of reference, the clause numbering of EN 14015 has been used throughout Part III of this DEP. Clauses in EN 14015, which are not mentioned in this DEP, shall remain valid as written.

2.2 REQUISITION SHEETS

1. This DEP shall be used in conjunction with the standard requisition sheets available in DEPs Online. Refer to DEP 34.51.01.93-Gen.

2.3 FITTINGS AND ACCESSORIES

1. Unless otherwise specified in the requisition, tanks shall be provided with the standard range of fittings and accessories as listed in (Appendix C) of this DEP for fixed roof tanks and (Appendix D) of this DEP for floating roof tanks.
2. Fittings and accessories may be supplied in accordance with standard designs of the tank Manufacturer/Supplier subject to the approval of the Principal.

2.4 DRAWINGS AND CALCULATIONS

1. Contractor's drawings and calculations shall be based on EN 14015 and this DEP.
Shell Standard Drawings, group S 51, as listed in (Part IV), are available as a reference and guidance for details on standard tank calculations, fittings and features. However, it remains the Contractor's responsibility to satisfy the requirements outlined in this DEP.

2.5 MATERIAL CERTIFICATES

1. Materials used in the fabrication of tanks designed in accordance with this DEP shall be supplied with material certificates in accordance with EN 10204, type 3.1.B.
2. Material certificates shall be submitted to the Principal for review prior to commencement of fabrication.

2.6 LIQUID-LEVEL INDICATORS

1. Liquid-level indicators or automatic liquid-level gauges shall be fitted to all tanks.
2. Unless otherwise specified on the requisition, level indicators or automatic level gauges shall be supplied separately.
3. The tank Manufacturer/Supplier shall include the required nozzles, gauge poles, etc. to suit the level indicators to be fitted.
4. The construction of the gauge poles depends on the operational conditions and the required measurement accuracy of the level gauges. The deformation of the tank shell during filling/emptying shall be taken into account in the design of the gauge poles for tank contents subject to custody transfer.
5. If a gauge pole is intended for radar gauge installation, then the ID surface of gauge poles shall be smooth and free of burrs, with the ID of all circumferential welds ground flush on the ID surface.

Radar instruments are extremely sensitive and can detect the ID projection of the stilling well welds, if the welds have excessive penetration. These welds can be mistaken for liquid level. To avoid potential errors in the level measurement, it is useful to map the location of all echoes produced by stilling well flaws during installation and calibration of a radar level instrument.

2.7 DIP PLATES

1. A 6 mm (1/4 in) thick dip plate shall be provided and welded to the tank bottom or lowest shell course directly under the dip fittings (i.e., dip hatches, slotted dipping devices and combined vent and dip hatches).

2.8 DIP HATCHES

1. Tanks shall be supplied with one dip hatch, unless otherwise specified in the requisition:
 - a. additional dip hatches shall be provided if required by local regulations.

2.9 LEVEL ALARMS/INDICATION SYSTEM

2.9.1 General

1. For fixed roof tanks, the critical high liquid level shall be the overall height of the shell excluding the rim angle or top angle.
2. Where an overflow or surface foam nozzle is installed, the critical high liquid level shall be measured to the underside (invert) of the overflow or surface foam nozzle.
3. For fixed roof tanks with an internal floating roof, the critical high liquid level shall be the overall height of the shell measured up to the side overflows or to the underside of the circulation vents or the bottom edge of rafter members (whichever is lowest), minus the dimensional clearance required for the internal floating roof seal system above liquid level.

For internal floating roof tanks, the dimensional clearance for the seal system above the liquid level is dependent on the seal configuration. This dimension is provided by the floating roof seal Manufacturer/Supplier and is a critical parameter allowed in the height of the tank shell to ensure the seal system does not collide with the underside of the rafter members or ride over the circulation vents if the tank is filled to critical high liquid level.

4. For external floating roof tanks, the critical high liquid level shall be the overall height of the tank shell excluding the rim angle or top angle minus the clearance required for the external floating roof inclusive of seal system.

5. Tanks SHALL [PS] be provided with independent sensor and transmitter assemblies for each for the following:

- a. normal operating level, including any high level or low level alerts to aid operations;
- b. high-high, critical high, and low-low level alarms.

Prevention of storage tank overfills is an important safety and environmental concern. The safe operation of a storage tank is dependent on the receipt of product into the intended storage tank within its defined capacity. Tank overfills can be effectively prevented via use of reliable instrumentation, implementing an overflow prevention management system (including operating procedures), performing preventative maintenance, and employee training. The hardware selected for tank overflow prevention should be based on a detailed risk assessment, considering the hazards associated with each specific tank installation.

6. The level alarm settings shall be at least as defined in Figure 1:

- a. the Principal shall be consulted to establish the required operator response time to prevent a tank overflow;

The selected response time is normally based on a detailed estimate of the time needed to respond to an alarm, considering the estimated time required for operations to diagnose a high-level alarm, and the time required to complete the response actions, including a factor of safety.

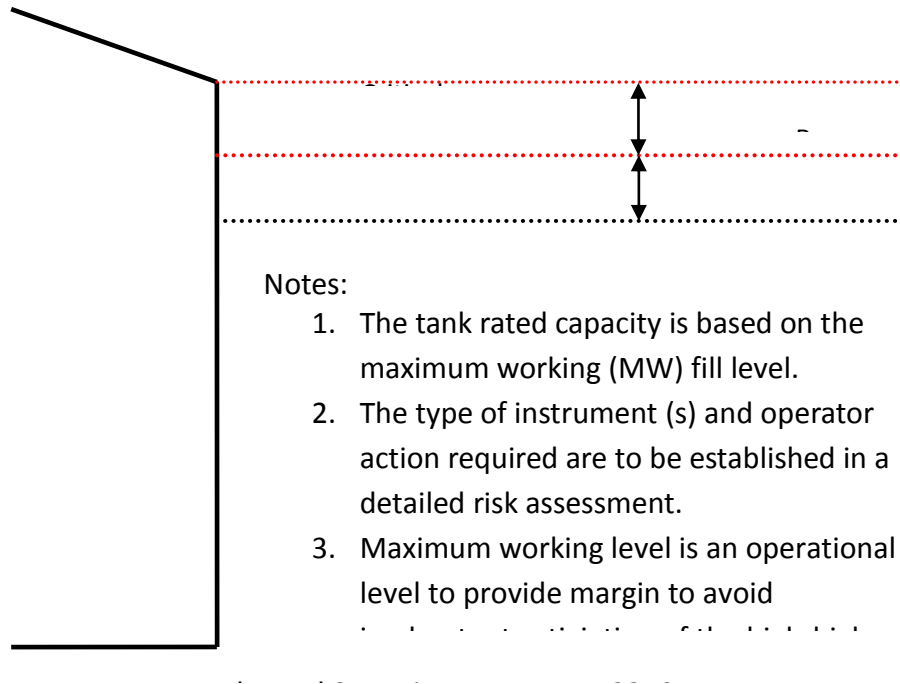
See API 2350 for additional guidance regarding selection of an appropriate response time.

- b. the tank maximum working level shall be the maximum normal liquid operating height, i.e., the maximum level to which the tank is filled during routine operations;
- c. the tank High-High level shall be set to provide a minimum of twenty minutes (20) operator response time between the High-High level and critical high liquid level, where product diversion is operated manually;
- d. the tank High-High level shall be set at 95% of the tank critical high level where automatic controls are in place.

7. The operator response time shall be based on the maximum flow rates at which product will be introduced into the tank with no liquid outlet:

- a. a lower operator response time may be assumed where automatic inbound pipeline shutdowns are available together with automatic tank gauging or monitoring systems; subject to Principal approval.

Figure 1 Level alarms for a fixed roof tank



8. High-High level alarms shall be triggered at the tank High-High level.
9. For fixed roof tanks the High-High level alarm shall be set so that the maximum filling height is a minimum of 200 mm (8 in) below the top of the shell, or lower as required by the response time to stop inflow.

2.9.2 Fixed roof tanks with an internal floating cover (IFC):

1. The High-High level shall be set to provide a minimum of 200 mm (8 in) clearance between any moving part of the IFC and any obstruction fixed to the shell, including the roof supporting structure.
2. The Low-level alarm shall be set so that the IFC still remains floating with its supports at least 100 mm (4 in) above the tank bottom.
3. The Low-Low alarm shall guarantee a clearance of at least 100 mm (4 in) between the IFC (including moving parts) and any internal structure (e.g., mixer) or piping in the lower part of the tank.

2.9.3 Floating roof tanks:

1. With the roof in its High-High position, a minimum free clearance of 50 mm (2 in) shall still remain between moving parts of roof and seal, and any of the parts fixed to the shell.
2. The shunts of the roof seal shall be in contact with the shell with the roof in its High-High position.
3. The Low-level alarm shall be set so that the roof still remains floating with its supports at least 100 mm (4 in) above the tank bottom.
4. The Low-Low level alarm shall guarantee a clearance of at least 100 mm (4 in) between the roof (including moving parts) and any internal structure (e.g., mixer) or piping in the lower part of the tank.
5. The Low-Low level alarm should be set at a lower position than the Low-level alarm.

2.9.4 Tanks with a mixer and a floating roof (IFRT, EFRT or CFRT):

1. The mixer should be provided with a trip function to avoid mixer or floating roof damage when landing the floating roof.

2.9.5 Tanks operating at elevated temperature with heating coils:

1. The minimum fluid level in the tank shall be set to ensure that heating coils are always submerged in the product during normal operation.

The Low-Low level alarm settings for tanks equipped with heating coils depend on many factors, such as coil layout, tank dimensions, heat capacity, product stored, etc., and are normally evaluated on a case-by-case basis.

2. During the Define phase, the operational and safety engineers shall specify the final Low-Low level alarm settings.
3. A temperature or a level trip function of the heating coil system should be considered.

2.10 SPECIAL FITTINGS FOR FIXED ROOF TANKS STORING CLASS I AND CLASS II PRODUCTS

1. Slotted dipping devices shall be fitted on all tanks operating under pressure, so that dips and samples can be taken without excessive pressure loss.
2. When specified in the requisition, manometers or pressure/vacuum gauges shall be supplied for pressurised tanks:
 - a. the manometers or pressure gauges should normally be mounted at ground level for ease of operator access.

These devices are used to verify proper function of the breather valves.

3. A floating suction (a form of swing pipe fitted with floats to the outlet) may be provided on tanks used for storing fluids like aviation fuels:

The main purpose of this fitting is to minimize the risk of extracting water-contaminated product.

- a. a floating suction head assembly shall never be connected to the inlet connection.

2.11 SPECIAL FITTINGS FOR FLOATING ROOF TANKS

Refer to Annex D of EN 14015 for special fittings for floating roof tanks in addition to those indicated in this DEP.

2.12 SELECTION OF ABOVE GROUND STORAGE TANK TYPE

1. Unless otherwise stated within project documentation, the selection of the tank type shall be in accordance with Table 1 and (2.12.1).

The selection of the most suitable storage tank(s) is influenced by a variety of parameters.

The main parameters are the TVP (True Vapour Pressure) and the flash point of the liquid stored.

Table 1 Selection of tanks based on flash point and tank diameter

Class of product	TANK DIAMETER, METERS (FEET)																							
	3 (10)	4 (13)	6 (20)	8 (26)	10 (33)	12.5 (41)	15 (49)	17.5 (57.5)	20 (65.6)	22.5 (74)	25 (82)	27.5 (90)	30 (98.5)	33 (108)	36 (118)	39 (128)	42 (138)	45 (148)	48 (157)	54 (177)	60 (197)	66 (217)	72 (236)	78 (256)
Class I, flash point less than 21°C (70°F) and Class II ⁽¹⁾ flash point between 21°C (70°F) and 55°C (131°F) handled <u>above</u> flash point	FRT (L,H) IFRT (N,L,H)						FRT (L,H) IFRT (N,L,H) EFRT (double deck) CFRT			FRT (L) EFRT (preferred) IFRT (N) CFRT						EFRT CFRT								
Class II, flash point 21°C (70°F) and higher but less than 55°C (131°F) handled <u>below</u> the flash point and Class III ⁽¹⁾ flash point above 55°C (131°F) but handled <u>above</u> flash point	FRT (L) IFRT(N)						FRT(L) IFRT(N) EFRT CFRT			FRT(L) EFRT (preferred) IFRT(N) CFRT						EFRT CFRT								
Class III + unclassified, flash point 55°C (131°F) and higher handled below flashpoint	FRT(N)						FRT(N)			FRT(N)						EFRT CFRT								

NOTES: 1. Tanks up to 39 m (128 ft) incl., storing certain class I and II products, may be connected to a vapour recovery system, or a fixed roof with floating cover may be used (especially as an alternative to the BOF type) where rain water penetrating between shell and seal may have an adverse effect on the quality of the product stored.

Some typical product examples;

Class I

Crude, Gasoline, Tops (light gas oil), Untreated Kero, Mogas, Slops

Class II

Kero, Kerosine, Cut Back bitumen, Cut back drum filling

Class III

Light gas oil, Heavy gas oil, Automotive gas oil (AGO),

Unclassified

Residue, Bitumen, Refinery fuel

2. The above selections are recommended, but other selections may be made subject to approval by the Principal.

3. (N)=Non Pressure, (L)= Low Pressure, (H)= High Pressure fixed roof tanks with either a cone or dome roof (see 3.1).

2.12.1 Selection of storage tanks based on emissions

1. To minimize volatile emissions to the atmosphere, the following apply for the selection of tanks for the storage of hydrocarbon products:
 - a. the true vapour pressure (TVP) for hydrocarbons stored in fixed roof tanks without an internal floating roof, shall not be greater than 100 mbar (10.34 kPa or 1.5 psia);
 - b. floating roof tanks shall be used for the storage of volatile hydrocarbons with vapour pressures greater than 100 mbar (10.0 kPa or 1.5 psia), or any products that require storage in this type of tank for environmental or health reasons;
 - c. TVP for hydrocarbons in conventional storage tanks with internal or external floating roofs shall not exceed 860mbar (86.0 kPa or 12.5 psia);
 - d. hydrocarbon products with a TVP greater than 860mbar (86.0 kPa or 12.5 psia) shall be stored in low-pressure refrigerated storage tanks, or in pressurised storage vessels;
 - e. for tanks with a diameter <15 m (49 ft) or >50 m (164 ft), either a double deck floating roof or a CFRT tank roof shall be provided;

The lower limit is introduced because a single deck roof has an increased chance of getting stuck in a smaller diameter tank. The upper limit is related to the increased risk of fatigue cracking to a single deck floating roof in areas with strong wind conditions (>32 m/s [105 ft/s]).
 - f. for tanks used for the storage of a hydrocarbon with a TVP greater than 625 mbar (62,5 kPa or 9 psia), a double deck floating roof or a Combi Tank shall be used.

2.13 HEATING COILS

1. In tanks where a water layer may be present on the bottom (e.g., crude oil tanks), the heating coils shall be at a height sufficiently above the tank bottom (at least above the product/water interface) to prevent direct heating of the water.

PART III AMENDMENTS/SUPPLEMENTS TO EN 14015

3 TERMS, DEFINITIONS, SYMBOLS AND ABBREVIATIONS

3.1 Terms and definitions

Add the following new clause:

3.1.46

The various types of standard tanks used within Shell, are designated by a reference code, which consists of a three-letter prefix indicating the tank type, followed by a numerical group indicating the dimensions of the tank (diameter and height in meters).

The following letter prefixes are used to identify the standard tanks described in this specification. The initial letter B of the prefix indicates that the shell is butt-welded.

BHC	=	High-pressure Cone roof tank
BLC	=	Low-pressure Cone roof tank
BNC	=	Non-pressure Cone roof tank (atmospheric tank)
BHD	=	High-pressure Dome roof tank
BLD	=	Low-pressure Dome roof tank
BND	=	Non-pressure Dome roof tank (atmospheric tank)
BOT	=	Open Top tank (only for fire water/cooling water)
BOF	=	Open top tank with Floating roof

Examples of the use of the code are as follows:

- BHC 15/12 means High-pressure cone roof tank, 15 m (49 ft) diameter and 12 m (39 ft) high;
- BND 36/18 means Non-pressure dome roof tank, 36 m (118 ft) diameter and 18 m (59 ft) high.

The abbreviations in Table 3.1 are used in this DEP to identify a specific type of tank.

Table 3.1 Abbreviations applicable for different types of tank

International abbreviation	Description	Standard tank
FRT	Fixed Roof Tank	BNC / BND BLC / BLD BHC / BHD
IFRT	Fixed Roof Tank with Internal Floating Cover (IFC)	BNC / BND + IFC BLC / BLD + IFC BHC / BHD + IFC
EFRT	External Floating Roof Tank	BOF
CFRT	Covered Floating Roof Tank	BOF + Geodesic dome roof

5 DESIGN

Add to this clause:

1. A tank requisition sheet shall be completed for the design of the aboveground storage tank.
2. The structural and functional integrity of the tank shall be based on the most severe possible combination of the load conditions as specified in the EN 14015:2004 Clause 7.

6 MATERIALS

Add to this clause:

1. Structural bolts shall have metric threads to ISO 898, grade 8.8.
2. Structural bolts shall be hot dip galvanized.
3. The allowable design stress of structural bolts shall not exceed the lower of one-half of the yield strength or one-third of the tensile strength.

6.1 CARBON AND CARBON MANGANESE STEELS

Add to this clause:

1. Notch ductility SHALL [PS] be in accordance with EN 14015 Table 9.

7 DESIGN LOADS

7.2

7.2.10 WIND

Add to this clause:

Refer to (Appendix A) for a world map marked with local maximum 3-s wind gust velocities, (up to 10 m [33 ft] height). The values are approximate and provide a rough indication of the winds gusts that could be encountered.

7.2.12 LOADS RESULTING FROM CONNECTED PIPING AND ATTACHMENTS

Add to this clause:

1. The settlement of the tank, the outward movement of the shell and the inclination of the nozzle under full hydrostatic load shall be taken into account.
2. For nozzles DN 500 (NPS 20) and larger in diameter, the use of bellows and balanced supports should be considered to minimize the piping loads on the tank nozzles.

7.2.13 FOUNDATION SETTLEMENT LOADS

Add to this clause:

Refer to DEP 34.11.00.11-Gen. for the minimum tank foundation design requirements.

8 Tank bottoms

8.2 General

Add to this clause:

Irrespective of tank diameter, a ring of annular plates shall be applied.

8.2 Materials

8.2.3

Add the following to this clause:

1. Tank bottoms shall be designed with the following minimum plate thickness:
 - a. tanks up to and including 12.5 m (41 ft) diameter;
 - i. bottom plates at least 6 mm (1/4 in) thick;
 - ii. bottom annular plates at least 8 mm (5/16) thick excluding any specified corrosion allowance.
 - b. tanks exceeding 12.5 m (41 ft) diameter;
 - i. bottom plates at least 6 mm (1/4 in) thick excluding any specified corrosion allowance;
 - ii. the minimum thickness of bottom annular plates as shown in Table 8.1.

Thickness depends on the thickness of the lowest shell course

8.3 Annular plates

Replace sub clause 8.3.1 by the following:

8.3.1

1. The minimum thickness of annular plates shall be as specified in Table 8.1.

Table 8.1 Minimum thickness of annular plates

Thickness of first (lowest) shell course (t_w) in mm (inch), excluding corrosion allowance	Minimum thickness of annular plate (t_a) in mm (inch), excluding corrosion allowance
< 15 (19/32)	8 (5/16)
15 (19/32) < t_w < 19 (3/4)	10 (3/8)
19 (3/4) < t_w < 28.5 (1-1/8)	12.5 (1/2)
> 28.5 (1-1/8)	$t_a = 3 + t_w/3$ (for max. t_w 40mm [1-9/16 in] $t_a = 16$ mm [5/8 in])

2. Irrespective of the corrosion allowance applied to the bottom plates, the corrosion allowance on the annular plates shall not be more than 3 mm (1/8 in).

8.3.3

Add the following to this clause:

1. Annular plates shall have a minimum width of 600 mm (24 in) at any point measured from the inside of the shell.
2. Backing strips, if used, shall be of the same material and heat treatment as the annular plates.