

DEP SPECIFICATION

**PRESSURE VESSELS; AMENDMENTS/SUPPLEMENTS TO  
PD 5500**

DEP 31.22.10.32-Gen.

February 2012

DESIGN AND ENGINEERING PRACTICE

**DEM1**



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## PART I INTRODUCTION

### 1.1 SCOPE

This DEP specifies requirements and gives recommendations for the construction of welded metallic pressure vessels designed according to BS PD 5500 for an internal gauge pressure of 0.5 bar or greater, or designed for external pressure, or if specified by the Principal. This DEP also applies to pressure vessels that are components of packaged equipment units.

This DEP, accompanied by a completed data sheet (and, where necessary, additional technical notes), is used for purchasing pressure vessels in accordance with PD 5500.

The following are excluded from the scope of this DEP:

- Pressure vessels fabricated by brazing;
- Pressure vessels or pressure vessel parts fabricated by casting;
- Pressure vessels constructed in accordance with other codes such as EN 13445, ASME VIII and GB150.

This DEP Specification is based on BS PD 5500:2009. Part III of this DEP amends, supplements and deletes various clauses of BS PD5500. Part III follows the clause numbering of BS PD5500 for easy reference.

All clauses of BS PD5500:2009 not modified by this DEP Specification remain valid as written.

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

This is a revision of the DEP of the same number dated February 2011; 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 authorisation 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.

### 1.3.2 Specific definitions

| Term                        | Definition                                                                                                                                                                           |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Hydrogen Service</b>     | Service in which the hydrogen partial pressure is greater than 7 bar (abs) at any temperature or any pressure at a temperature above 230 °C (446 °F). Refer to API RP 941, Figure 1. |
| <b>Very Toxic Substance</b> | Substances that are hazardous for the environment or human health, as specified in DEP 01.00.01.30-Gen. (which also references databases of "toxic" substances).                     |

### 1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section 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 February 2011. The following are the main, non-editorial changes.

| Old section | New section | Change                                                                                                                        |
|-------------|-------------|-------------------------------------------------------------------------------------------------------------------------------|
| Part I      | Part II     |                                                                                                                               |
| 2.2         | 2           | Revised SHALL [PS] to shall for Construction Category 1 and 2                                                                 |
| 2.3.3       | 3.3         | Revised SHALL [PS] to shall                                                                                                   |
| 2.5.1       | 5.1         | Revised SHALL [PS] to shall for materials and bolting materials                                                               |
| 2.5.2       | 5.2         | Added paragraphs on MDMT and design for vacuum conditions.                                                                    |
| 2.5.3       | 5.3         | Revised shall to SHALL [PS] for wind loading. Changed L/d ratio from 10 to 15. Added information on mass dampening parameter. |
| 2.5.4       | 5.4         | Revised SHALL [PS] to shall                                                                                                   |
| 2.5.5       | 5.5         | Revised SHALL [PS] to shall                                                                                                   |
| 2.5.6.2     | 5.6.2       | Revised SHALL [PS] to shall                                                                                                   |
| 2.5.7       | 5.7         | Revised SHALL [PS] to shall for nozzle external loading. Added SHALL [PS] for minimum nozzle thickness                        |
| 2.5.8       | 5.8         | Revised SHALL [PS] to shall for vessel temperature at concrete supports and for sphere legs                                   |
| 2.5.9       | 5.9         | Revised SHALL [PS] to shall for lifting lugs on equipment lifted from offshore barges                                         |
| 2.5.10      | 5.10        | Revised SHALL [PS] to shall                                                                                                   |

| Old section   | New section   | Change                                                      |
|---------------|---------------|-------------------------------------------------------------|
| 2.5.10        | 5.10          | Added SHALL[PS] on limitation of non-metallic sheet gaskets |
| 2.5.12        | 5.12          | Revised SHALL [PS] to shall                                 |
|               | 5.13          | Added new section on seismic loads                          |
|               | 5.14          | Added new section on overpressure protection                |
| Part II       | Part III      |                                                             |
| 2.1.1.1       | 2.1.1.1       | Revised SHALL [PS] to shall                                 |
| 2.1.1.1.1     | 2.1.1.1.1     | Revised shall to SHALL[PS]                                  |
| 3.2.7         | 3.2.7         | Revised SHALL [PS] to shall                                 |
| 3.5.4.1       | 3.5.4.1       | Revised SHALL [PS] to shall in Notes 1 and 2.               |
| 3.5.4.5       | 3.5.4.5       | Revised SHALL [PS] to shall                                 |
| 5.6.4         | 5.6.4         | Revised SHALL [PS] to shall                                 |
| 5.6.4.1.2     | 5.6.4.1.2     | Revised SHALL [PS] to shall                                 |
| 5.6.4.3       | 5.6.4.3       | Revised SHALL [PS] to shall                                 |
| 5.6.5.1       | 5.6.5.1       | Revised two (2) SHALL [PS] to shall                         |
| 5.8.2.12      | 5.8.2.12      | Revised SHALL [PS] to shall                                 |
| Ann. E        | Ann. E        | Revised SHALL [PS] to shall                                 |
| Ann. AA 2.3   | Ann. AA 2.3   | Revised SHALL [PS] to shall                                 |
| Ann. AA 2.3.3 | Ann. AA 2.3.3 | Revised SHALL [PS] to shall                                 |
| Appendices    |               |                                                             |
| App. 1        | App. 1        | Revised five (5) SHALL [PS] to shall                        |
| App. 3        | App. 3        | Revised three (3) SHALL [PS] to shall                       |
| App. 6        | App. 6        | Revised SHALL [PS] to shall for final PWHT temperature.     |

#### 1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at [standards@shell.com](mailto:standards@shell.com), using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

#### 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.

## PART II GENERAL INFORMATION AND REQUIREMENTS

### 1 GENERAL

Part III of this DEP Specification amends, supplements and deletes various clauses of BS PD 5500:2009.

Wherever reference is made to BS PD 5500, it shall be understood to mean BS PD 5500:2009 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of BS PD 5500 has been used throughout Part III of this DEP.

The clauses of BS PD 5500 not mentioned in this DEP shall apply as written.

In the event of conflict between documents relating to the enquiry or order, the following hierarchy of documents shall apply:

|               |                                                                                                                                                                                                                                                                                                                                          |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First Level:  | Purchase order and variations thereto;                                                                                                                                                                                                                                                                                                   |
| Second Level: | Data/requisition sheets and drawings referred to where explicit deviations from this DEP are indicated. In all other cases, any discrepancy between the data/requisition sheets and this DEP shall be brought to the attention of the Principal;<br><br>NOTE: The data/requisition sheet(s) for pressure vessels is DEP 31.22.00.94-Gen. |
| Third Level:  | This DEP.                                                                                                                                                                                                                                                                                                                                |

### 2 CONSTRUCTION CATEGORIES

In addition to the definition of the construction categories in PD 5500, (Section 3, Chapter 3.4.1), the following additional requirements determine the appropriate category. See also amendment (Part III, 3.4.1):

**Construction category 1** shall be selected if one or more of the following conditions apply:

- a) hydrogen service (Part I, 1.3.2);
- b) very toxic substances (Part I, 1.3.2);
- c) liquefied gas;
- d) Cr-Mo steels and other ferritic alloy steels, and carbon steels having a tensile strength greater than 510 N/mm<sup>2</sup> (74,000 psi);
- e) vessels operating in cyclic service;
- f) vessels which operate in the creep range of the materials of construction;

**Construction category 3** SHALL [PS] only be selected for:

- utilities which are non-flammable and non-toxic;

**Construction category 2** shall be selected for conditions not covered by category 1 or category 3.

### **3 QUALITY ASSURANCE**

#### **3.1 GENERAL**

Pressure vessels shall be purchased only from Manufacturers/Suppliers accepted by the Principal.

#### **3.2 SURVEILLANCE**

Surveillance requirements shall be established for each pressure vessel constructed in accordance with this DEP. The requirements shall be established by the Principal, or by the Contractor with the approval of the Principal.

The Manufacturer/Supplier shall submit the Inspection and Test Plan (ITP) to the Contractor for review and acceptance/approval. Surveillance requirements identified by the Principal or the Contractor shall be incorporated into the Manufacturer's/Supplier's ITP. The ITP shall include review, monitoring, witness and hold points as identified by the Inspecting Authority and Notified Body.

ITPs for Construction category 1 pressure vessels shall be reviewed and approved by the Principal.

#### **3.3 POSITIVE MATERIAL IDENTIFICATION (PMI)**

The Manufacturer/Supplier shall perform PMI in accordance with DEP 31.10.00.10-Gen.

### **4 DRAWINGS AND FINAL DATA**

#### **4.1 GENERAL DRAWINGS**

The general arrangement, assembly or outline drawing(s) shall contain the following information:

- a) Code of Construction Division, edition year, addenda year
- b) Hazard category, where applicable
- c) References to supplementary drawings, standards and specifications
- d) Nozzle reference/markings, size, rating, reinforcing pads and locations, reference datum for dimensions, fixed end/point of supports
- e) Operating and design pressures and temperatures of all services for which the vessel is designed including number of cycles if designed for fatigue
- f) Allowable nozzle loads
- g) Environmental data:
  - Wind speed
  - Earthquake data
  - Blast loadings
- h) Corrosion allowances for shell, heads, nozzles, manways, and all supports and other accessories
- i) PWHT requirements
- j) Minimum Design Metal Temperature(s) (MDMT) with coincident Pressure(s)
- k) Field pressure test pressure at top of vessel
- l) Shop pressure test pressure and orientation of vessel
- m) Weights; shipping, operating, water full with all internals, centre of gravity

## 4.2 FABRICATION DRAWING(S)

The detailed fabrication drawing(s) shall contain the following information:

- a) Full dimensions of all parts and sub-assemblies shown including necessary tolerances and any finishing requirements
- b) Complete identification of materials, including gaskets
- c) Complete identification of internal materials supplied by fabricator, including gaskets.
- d) Location of all circumferential and longitudinal joints
- e) Details of weld preparations and welding procedure numbers
- f) Heat treatment details, including temperature of PWHT, time at temperature.
- g) General remarks on fabrication, assembly and testing as appropriate
- h) Extent and location of all nondestructive examination (NDE)
- i) Cleaning, surface preparation, painting and marking requirements
- j) Nozzle schedule including the mark number, quantity, size, rating, facing, and type. Nozzle orientation and elevation shall be provided. The mark number shall match that shown on equipment data sheet.

## 5 SHELL DESIGN REQUIREMENTS

The Contractor (or Principal) normally specifies the requirements and choices made from this section on the data/requisition sheets.

The Manufacturer/Supplier can then refer to Part IV for the detailed technical specification.

### 5.1 MATERIALS

Materials shall be in accordance with DEP 30.10.02.11-Gen., including the additional requirements specified in the Notes therein. The selected materials standard (and the aforementioned Notes) shall be indicated on the data/requisition sheets.

For low temperature services DEP 30.10.02.31-Gen. SHALL [PS] apply, to prevent brittle fracture.

Material selection and fabrication (e.g., postweld heat treatment) for pressure vessels in sour service or wet H<sub>2</sub>S service shall be in accordance with one of the following, as applicable:

- DEP 30.10.02.15-Gen.
- DEP 30.10.02.17-Gen.

Materials with tensile properties enhanced through quench and tempering or micro-alloyed steels shall not be used without approval of the Principal.

Materials selection for hydrogen service (Part I, 1.3.2) SHALL [PS] be in accordance with API RP 941. The maximum operating conditions (temperature and hydrogen partial pressure) SHALL [PS] be at least 15 °C (59 °F) below and 170 kPa (25 psi) to the left of the applicable material curve of API RP 941, Figure 1. This requirement also applies to the carbon and low alloy pressure boundary material of vessels built with a stainless steel corrosion resistant cladding or overlay.

Bolting materials shall be selected from DEP 30.10.02.11-Gen. or DEP 30.10.02.31-Gen. (as applicable), unless otherwise approved by the Principal.

### 5.2 DESIGN PRESSURE AND TEMPERATURE

The definition and determination of temperature and pressure levels, including design pressure and design temperature shall be in accordance with DEP 01.00.01.30-Gen.

The minimum design metal temperature (MDMT) shall be specified as the minimum metal temperature (MMT) as defined by DEP 01.00.01.30-Gen.

Repressurization requirements shall be considered when specifying this temperature as MDMT. A temperature warmer than the minimum temperature reached during depressurization may be specified if approved by the Principal.

In addition, consideration for the prevention of brittle fracture shall be made in accordance with the requirement of DEP 30.10.02.31-Gen.

The pressure vessel SHALL [PS] be designed for Full Vacuum if any of the following conditions apply:

- a) If the process is such that vacuum conditions can occur.
- b) If the vessel normally operates under vacuum. Vessels that operate at less than full vacuum [i.e., absolute pressure between 0 kPa and 100 kPa (0 psi and 14.7 psi)] shall be evaluated for design at full vacuum.
- c) Vessels in steam or steam condensate systems that are not open to the atmosphere.

For flanges and bolts, the design temperature shall be in accordance with the following table:

| Design temperature             | % of vessel design temperature |           |
|--------------------------------|--------------------------------|-----------|
| Flanges                        | Uninsulated                    | Insulated |
| • All flanges except lap-joint | 90                             | 100       |
| • Lap-joint flanges            | 85                             | 100       |
| Bolts for Flanges              | 80                             | 100       |

### 5.3 WIND LOAD

Wind loads shall be determined in accordance with local codes or EN 1991-1-4, refer to DEP 34.00.01.30-Gen. The wind pressure either at the top of the equipment or, for equipment with an overall height over 30 m (100 ft) and/or having a length to diameter ratio larger than 15, at different specific elevations shall be stated on the data/requisition sheets. The calculation of the stated wind pressure shall take into account the applicable correction factor for the aspect ratio of the equipment.

The fabricator SHALL [PS] provide a proposal for mitigation against vortex shedding effects for towers that meet the following conditions:

- a) H/D ratio of 15 or greater, and
- b) Mass damping parameter (MDP) less than 0.8 under operating conditions, or MDP less than 1.1 when the vessel is under erection or on standby.

Where

$$MDP = \frac{m \cdot \beta}{\phi \cdot d^2}$$

$m$  = mass per unit length of the top third of the tower, in the condition considered

$\beta$  = structural damping ratio, 0.004 for empty, unlined steel vessel

$\phi$  = density of air

$d$  = mean diameter over the top third of the tower

$D$  = nominal diameter of tower

H = height of tower

NOTE: The term MDP is dimensionless. Consistent units shall be used for the above equation to be valid, and MKS (meter, kilogram, second) units are preferred.

The following shall be considered:

- Piping and platforms shall be distributed around the circumference of the equipment, especially within the top third part of the equipment, to prevent vortices being formed;
- If the above is not possible (e.g., only one overhead line and only rest platforms every 6 m (20 ft)), and if the eddy shedding frequency is within 70% of the natural frequency of the equipment, three wind deflectors shall be installed with a width of  $\frac{1}{10}$  of the equipment diameter, evenly spaced in circumference and having a pitch of 5 times the diameter of the equipment, within the top third part of the equipment.

Alternatively, dynamic damping devices may be considered.

#### 5.4 FATIGUE ANALYSIS

The Principal shall specify on the data/requisition sheets whether the Manufacturer/ Supplier shall perform a detailed fatigue analysis. (To decide whether such an analysis is required, the Principal may use PD 5500, Annex C, Section C.2).

If a detailed fatigue analysis is specified, the Principal shall specify the required fatigue service lifetime and all operating data necessary for the Manufacturer/ Supplier to perform the analysis. If a vessel is intended to be used in a service where more than one set of operating parameters (pressure and temperature) is envisaged (e.g., catalyst regeneration, batch processes, etc.), the data shall include this information and shall state the duration of each envisaged operating mode.

#### 5.5 CREEP ANALYSIS

If a vessel is operating above the temperatures given in Table 1, where time dependent properties are a consideration, a creep analysis shall be performed in accordance with API RP 579-1/ASME FFS-1 or EN 13445.

**Table 1** Temperatures above which creep analysis is required

| Material                    | Temperature      |
|-----------------------------|------------------|
| Carbon steel                | 400 °C (750 °F)  |
| Nickel steel                | 400 °C (750 °F)  |
| 1 Cr–0.5 Mo                 | 470 °C (875 °F)  |
| 1¼ Cr–0.5 Mo                | 440 °C (825 °F)  |
| 2¼ Cr–1 Mo                  | 440 °C (825 °F)  |
| Austenitic stainless steels | 540 °C (1000 °F) |

The temperatures in Table 1 are not valid if the vessel is also subject to fatigue. If cyclic service is a consideration along with operation in the time dependent temperature range, API RP 579-1/ASME FFS-1 shall be used for analysis method.

The Principal shall specify the required service lifetime and all operating data, necessary to perform the analysis. If a vessel is intended to be used in a service where more than one set of operating parameters (pressure and temperature) is envisaged, the data shall include this information and shall state the duration of each envisaged operating mode.

## 5.6 CORROSION ALLOWANCE AND CLADDING/LINING

### 5.6.1 Corrosion allowance

The corrosion allowance for vessels shall be as follows, unless otherwise specified by the Principal:

| Service                                                                                               | Material                                               | Corrosion allowance |
|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------|---------------------|
| General process                                                                                       | Carbon steel and low-alloy steel                       | 3 mm (1/8 in)       |
| Non-corrosive or very mildly corrosive (e.g. steam, dry compressed air, LPG, LNG and dry natural gas) | Carbon steel and fine grain carbon steel               | 1 mm (0.04 in)      |
| Service in which the operating temperature is always below 0° C (32 °F)                               | Fine grain carbon steel, 3.5% Ni steel and 9% Ni steel | 1 mm (0.04 in)      |
|                                                                                                       | Aluminium and stainless (duplex) steel                 | none                |

The corrosion allowance for removable internals shall be as follows:

| Item                                                                                                       | Corrosion allowance                                                                                      |
|------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Stainless steel internals                                                                                  | none                                                                                                     |
| Heavily-loaded components (catalyst grids, etc.) in non-clad equipment made from carbon or low-alloy steel | 50% of the corrosion allowance specified for the vessel shall be applied to each surface of the internal |

### 5.6.2 Cladding/lining

A chemical analysis of the welded overlay material shall be made at one of the following depths:

- 2.5 mm (0.10 in) for cladding applied as corrosion protection, or
- 1.5 mm (0.06 in) for cladding applied only for product purity.

The chemical composition shall comply with the specification for the material alloy of the cladding.

Loose linings shall not be used.

For the requirements for process equipment with internal chemical-resistant brick lining, see DEP 30.48.60.13-Gen. For dense refractory concrete linings, see DEP 64.24.32.30-Gen. For the requirements for glass-lined process equipment, see DEP 30.48.70.30-Gen.

## 5.7 SHELLS, NOZZLES, OPENINGS AND BRANCH CONNECTIONS

If shell courses have different thicknesses, the inside diameter shall be constant unless otherwise specified by the Principal.

The minimum distance between the weld toe of two longitudinal seams in one course shall be 200 mm (8 in) or five times the wall thickness, whichever is the larger. The minimum distance between the weld toe of staggered longitudinal seams of two adjacent courses shall be 200 mm (8 in) or five times the wall thickness, whichever is the greater. However,

where this cannot be achieved, the last 300 mm (12 in) of the adjacent longitudinal seams shall be subjected to 100% examination.

Continuous liquid outlets on columns and vessels shall each be provided with a vortex breaker, see Standard Drawing S 10.010, and in the following cases internally extended vortex breakers may be used:

- in fouling service;
- for the hydrocarbon liquid outlets of separators where the liquid is separated from water or aqueous solutions, except where this would give rise to corrosion problems in the bottom.

Vortex breakers should not be used if exposed to rapid thermal loading.

External nozzle loadings shall be specified on the data/requisition sheets. If nozzle loadings are not known or stated in the specification, the interface loadings in (Appendix 7) shall be assumed.

Electric Resistance Welded (ERW) pipe or tube shall not be used for pressure retaining parts such as shells or nozzle necks.

Nozzle necks SHALL [PS] be a minimum thickness of Schedule Standard Pipe plus corrosion allowance with the following exceptions:

- a) Insulated carbon steel or low alloy nozzles DN 80 (NPS 3) or less SHALL [PS] be minimum schedule 160 when the operating temperature of the vessel is between 0 °C (32 °F) and 175 °C (350 °F).
- b) Austenitic stainless steel or other high alloy nozzles DN 80 (NPS 3) or less shall be minimum schedule 80S.

## 5.8 VESSEL SUPPORTS

Supports shall be designed so that the metal temperature of the part of the support resting on concrete will not exceed 70 °C (160 °F). For vessels with operating temperatures below ambient, this temperature shall be such that no condensation will occur under normal operating conditions. The mechanical design shall provide for insulation sealing, adequate surface protection and prevention of liquid collecting areas.

All vessels shall be provided with at least 2 earthing bosses in accordance with Standard Drawing S 68.004 located on diagonal opposite sides.

Cylindrical, vertical vessels shall be supported by a skirt in accordance with Standard Drawing S 20.001, and shall meet the following requirements:

- a) The skirt shall be continuously welded to the shell of the vessel, in accordance with either Standard Drawing S20.001 or other appropriate design, subject to the approval of the Principal.
- b) For vessels of stainless steel or high alloy material and with a design temperature of 230 °C (450 °F) or more and low temperature carbon steel, the skirt material attached to the vessel shall be of the same material group and similar coefficient of thermal expansion. The length of this section of the skirt shall be no less than  $2\sqrt{Rt}$  where R is skirt radius and t is skirt thickness. The remainder of the skirt may be carbon steel.
- c) Flanges SHALL [PS] not be installed inside skirt areas.
- d) The Manufacturer/Supplier shall supply a template of the base plate bolt holes when so specified by the Principal. Template shall be clearly marked with 0° orientation and stating which way is up.

If specified or approved by the Principal, vessels normally supported by skirts may be supported by lugs if:

- The vessel is not in cryogenic service; and

- The lugs are attached to pads that are of the of the same material group as the pressure plate.

Spherical vessels shall be supported by legs.

Small, cylindrical, vertical vessels ( $D \leq 1500$  mm (5 ft)) can be supported by legs, generally four (4) in number or half skirts according to standard drawing S 22.005, if:

- i. The design temperature is not greater than 230 °C (450 °F); and,
- ii. The h/D ratio is no greater than 5, where h is the distance from the base of the support to the top tangent line of the vessel; and,
- iii. The vessel is not in cyclic service; and,
- iv. The legs are attached to pads that are of the same of the same material group as the pressure plate (see (3.1.1a)); and,
- v. Vessel is not subject to blast loading.

Horizontal vessels shall be supported by two saddle-type supports unless analysis indicates otherwise, with the agreement of the Principal. The supports shall be continuously welded and shall comply with Standard Drawing S 22.001 or S 22.002. If a sliding saddle is required, it shall comply with Standard Drawing S 22.003.

## 5.9 LIFTING TRUNNIONS AND OTHER ATTACHMENTS

All vertical vessels shall be provided with lifting trunnions, attached by full penetration welds, or lifting lugs as specified on the data/requisition sheets. The tail end of vertical vessels that have a mass greater than 20 t (44,100 lb) shall be provided with a tailing lug (or lugs).

Lifting lugs and trunnions for on-shore equipment SHALL [PS] be designed for a total load as follows:

- For vessels  $\leq 100$  t (220,500 lb), 1.5 times the lifted weight of the equipment.
- For vessels  $> 100$  t (220,500 lb), 1.35 times the lifted weight of the equipment.

Lifting lugs and trunnions on vessels liable to be lifted from an offshore barge shall be designed for a total load of 3 times the lifted weight. If vessels are dressed up, all lifting attachments shall be designed for the dressed weight. When tail lugs are fitted, the base ring and internal strengthening members shall be designed for the most severe lifting condition. All lifting lugs shall be NDT'ed before lift.

For lifting trunnions for vertical vessels see Standard Drawing S 10.115. Lifting trunnions shall be removed from insulated vessels after erection.

Cleats for ladders and platforms, insulation support rings and clips for steam tracing shall be fabricated in trapezium form to avoid corrosion under insulation. See Standard Drawings S 20.003, S 28.012, S 28.013 and S 28.014.

When specified by the Principal, hand and step rungs shall be installed in accordance with Standard Drawing S 10.119.

Stiffening rings as required for external pressure or when necessary at the junction of a cone to a cylinder shall be continuously welded on both sides. Stiffening rings shall be located so as to not intersect with nozzles, manways, reinforcing pads, platform supports, etc.

The structural shape of the stiffening rings SHALL [PS] be of a type that does not hold water or other liquids.

Insulation supports shall be in accordance with Standard Drawings S 10.056 and S 20.003.

Cleats for ladders and platforms, insulation support rings and clips for steam tracing shall be fabricated in trapezium form to avoid corrosion under insulation. See Standard Drawings S 20.003, S 28.012, S 28.013 and S 28.014.