



Exploration & Production

GENERAL SPECIFICATION

PIPING VALVES VESSELS

GS PVV 212

**Design and fabrication of pressure vessels
according to PD 5500**

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1. Scope

This General Specification covers the COMPANY practices and minimum requirements for the Engineering design, selection of materials, fabrication, inspection and testing of fusion welded unfired pressure vessels conforming in definition to the Code mentioned in section 2 of this specification.

For the purpose of this specification, the name “pressure vessels” includes all nozzles up to the flange facing of the first flange, blind flanges of manways, and blind flanges of any other nozzles which are part of the supply as shown on the relevant datasheet. It also includes vessel's supports (e.g., skirts with base rings, legs, saddles, etc.), as well as lifting lugs and trunnions.

In this specification, high-pressure vessels are those designed for a coincident pressure and temperature equal to or greater than class 600 rating as defined per [ASME B16.5](#).

Any vessel in H₂S service subject to the [NACE MR01.75](#) requirements shall be considered in “lethal service”.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Pressure vessels covered by this specification shall be designed, engineered, and built in accordance with the latest revisions issued at the date of the call for tender of the following documents listed hereafter.

Any divergence between any of the Contractual Reference Documents, or between this specification and any other Contractual Reference Document, shall be reported to the COMPANY Technology Division for decision. In such a case, and unless otherwise agreed or decided by the COMPANY Technology Division, it is understood that the more stringent requirement shall apply.

Exceptions to, or deviations from this specification are not permitted unless previously accepted in writing by the COMPANY Technology Division. For this purpose, Manufacturer's requests for substitution or change of any kind shall be complete with all pertinent information required for the COMPANY Technology Division assessment.

Manufacturer's responsibility

This specification together with the particular specifications shall not be construed as releasing the Manufacturer from his responsibility, fulfillment of his duties, guarantee and/or liabilities, nor does the COMPANY, by any acceptance or approval, assume any responsibility for the conformance of the vessels to the requirements of the Code and/or of the Governing Authority.

Standards

Reference	Title
MSS SP 6	Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings
EN 288-3	Specification and approval of welding procedures for metallic materials. Welding procedure tests for the arc welding of steels
EN 287-1	Approval testing of welders for fusion welding steels
BS 5996	Specification for acceptance levels for internal imperfection in steel plate, strip and wide flats based on ultrasonic testing
EN 10204	Metallic Products - Type of inspection documents
EN 584-1	Industrial radiographic film. Classification of film systems for industrial radiography

Professional Documents

Reference	Title
NACE MR 01.75	Standard Recommended Practice. Sulfide Stress Cracking. Resistant Metallic Materials for Oilfield Equipment
WRC 107 and 297	Welding Research Council: Bulletin 107 and 297

Regulations

If the country of installation has its own regulation, it must be applied wherever more stringent than the Code.

Any Construction Code or Government Regulations, which may be listed in the Project Specifications, in the requisition or in the Purchase Order, if any, shall have precedence except where this Specification is more stringent.

Reference	Title
Not applicable	

Codes

The basic code is the British Standard Institute Published Document **PD 5500**: Specification for unfired fusion welded pressure vessels. This code is referred to herein as "the Code".

Reference	Title
PD 5500	Specification for unfired fusion welded pressure vessels
ASCE 7-95	Minimum design loads for buildings and other structures
UBC	Uniform Building Code: Volume 2 Wind And Earthquake
AISC	Manual of Steel Construction

Reference	Title
ASME VIII div. 2	Boiler and Pressure Vessel Code
ASME B 1.1	Unified Inch Screw Threads
ASME B 16.5	Pipe Flanges and Flanged Fittings (NPS ½ through NPS 24)
ASME B 16.9	Factory-Made Wrought Steel Buttwelding Fittings
ASME B 16.11	Forged Fittings, Socket-Welding and Threaded
ASME B 16.20	Metallic Gaskets for Pipe Flanges – Ring-Joint, Spiral-Wound, and Jacketed
ASME B 16.21	Non metallic Flat Gaskets for Pipe Flanges
ASME B 16.25	Buttwelding Ends
ASME B 36.10M	Welded and Seamless Wrought Steel Pipe
ASME B 46.1	Surface Texture (Surface Roughness, Waviness, and Lay)
ASME B 16.30	Unfired pressure vessel flange dimensions

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS COR 350	External protection of off-shore and related structures and equipment by painting
GS COR 352	Internal protection of equipment by painting
GS ECP 103	Process sizing criteria
GS PVV 109	Allowable nozzle loads on static equipment
GS PVV 611	Welding of pressure containing piping and equipment
GS PVV 771	Thermal Insulation (hot service)
GS PVV 772	Thermal Insulation (cold service)
GS PVV 773	Thermal Insulation (cyclic service)
SD PVV 201	Tolerances of pressure vessels
SD PVV 202	Horizontal tanks, heads with large knuckle radius
SD PVV 203	Horizontal tanks, elliptical heads
SD PVV 204	Lifting lugs
SD PVV 205	Anchor lugs and base rings of vertical vessels
SD PVV 206	Saddles for horizontal containers, diameter 350 to 550 mm

Reference	Title
SD PVV 207	Saddles welded for horizontal tanks
SD PVV 208	Standard equipment of column skirts
SD PVV 209	Legs for small vessels
SD PVV 210	Nozzle designation
SD PVV 211	Minimum nozzle thicknesses
SD PVV 212	Nozzles less than 2" in diameter
SD PVV 213	Protruding length and boltholes of nozzles
SD PVV 214	Vertical manhole with davit (WN flange)
SD PVV 215	Vertical manhole with davit (SO flange)
SD PVV 216	Horizontal manhole with davit (WN flange)
SD PVV 217	Horizontal manhole with davit (SO flange)
SD PVV 218	Hinged manhole (WN flange)
SD PVV 219	Hinged manhole (SO flange)
SD PVV 220	Handles and rungs for manholes
SD PVV 221	Vortex Breaker
SD PVV 222	Deflector on steam inlet
SD PVV 223	Name plate for vessels
SD PVV 224	Earthing plate
SD PVV 225	Monorail davit
SD PVV 230	Insulation supports on vertical vessels
SD PVV 231	Insulation supports on horizontal vessels
SD PVV 232	Welding of clad vessels
SD PVV 233	Coating of nozzles
SD PVV 234	Weld deposits on RTJ flange facings

3. Manufacturer's responsibility

This specification together with the particular specifications shall not be construed as releasing the Manufacturer from his responsibility, fulfilment of his duties, guarantee and/or liabilities, nor does the COMPANY, by any acceptance or approval, assume any responsibility for the conformance of the vessels to the requirements of the Code and/or of the Governing Authority.

4. Design data

4.1 Pressures

4.1.1 General

Design pressures are shown on the relevant pressure vessel mechanical data sheets that shall be issued by the Engineering Company. These pressure values are meant at the top of the vessels in their final operating positions, unless otherwise specified in the data sheet.

4.1.2 Operation under partial vacuum

If the internal pressure is 0.35 bar or less (absolute pressure), the vessel shall be designed for full vacuum. In all other cases, the vessel shall be designed for the maximum external pressure plus a margin of 0.15 bar.

4.2 Temperatures

The Manufacturer shall check impact test requirements of the Code at the minimum design reference temperature. Unless otherwise specified, this temperature value shall be taken equal to the minimum design temperature as shown on the data sheet. A unique minimum design reference temperature shall be used for the complete vessel.

4.3 Thermal insulation

Thermal insulation must be provided either required by the process studies or for personnel protection (although protection by metal mesh shall be preferred whenever possible). Any required thermal insulation shall comply with the following COMPANY specifications, as appropriate: **GS PVV 771, GS PVV 772, GS PVV 773**. Surfaces shall be appropriately protected in accordance with **GS COR 350** before installation of thermal insulation.

4.3.1 Protection of personnel

Protection of the personnel by metal mesh must be provided on uninsulated equipment when the service temperature thereof is over 70°C. This protection shall also apply to cold equipment, which might be a danger to the operators.

4.4 Combination units

The partition between two independent chambers of a combination unit shall be designed to withstand the design pressure and temperature of any chamber whilst the adjacent chamber is under atmospheric pressure and temperature.

Unless otherwise authorised in writing by the COMPANY, design based on the differential pressure is not permitted.

4.5 Corrosion allowance

Additional thickness shall be provided for the corrosion allowance specified in the vessel data sheet.

Corrosion allowance for nozzles and manholes shall be at least equal to that specified for the vessel shell. No corrosion allowance is required on gasket face of flanges.

Corrosion allowance for internals shall be as specified in section 5.7.2 and table 5.7 of this specification.

In the particular case of nozzle protrusion inside vessels, the corrosion allowance applies to both sides of the nozzle.

4.6 Wind

4.6.1 Applicable code

The applicable code is **ASCE 7-95**: "Minimum design loads for buildings and other structures", which must be applied as design method. Alternatively, the code **UBC** (Uniform Building Code) volume 2 (wind and earthquake) may be used.

In addition to the static calculations, calculations taking account dynamic effects must be carried out for all vertical vessels, such as vertical drums, columns, stacks, etc. when the slenderness ratio is greater than 5.

However, in the case of very slender or special vessels, the COMPANY and/or the Engineering Company may require that the Manufacturer furnish calculations under dynamic conditions based on the references of the Code or on other approved methods.

4.6.2 Design data

All data required for wind calculation shall be specified by the Engineering Company in the vessel requisition.

4.7 Earthquake

The stability of vessels shall be checked for the operating conditions as defined in table 5.2.

4.7.1 Applicable code

The applicable code is **ASCE 7-95** "Minimum design loads for buildings and other structures". It must be applied as design method. Alternatively, the code **UBC** (Uniform Building Code) volume 2 (wind and earthquake) may be used.

4.7.2 Design data

All data required for earthquake calculation shall be specified by the Engineering Company in the vessel requisition.

4.8 Transport

Design data (acceleration values) shall be specified by the Engineering Company in the vessel requisition. Except otherwise specified in the requisition, the following shall apply:

- The acceleration force shall be 0.8 g in any direction during sea transportation. Where the equipment is not adequate, brackets for attaching sea fastenings shall be provided
- All equipment shall be capable of withstanding loads during road transport of 0.3 g longitudinally and 0.1 g in the vertical and transverse directions.

5. Design rules

5.1 General

High-pressure vessels or vessels in lethal service shall be category 1 vessels. All other vessels may be either category 1 or 2. Category 3 shall not be used.

Cases and features not fully covered by the Code shall be the subject of agreement in writing between the Manufacturer and the COMPANY Technology Division.

5.2 Combinations of loads

All vessels and their supports, including anchor bolts, shall be designed for the most adverse condition to which they may be subjected.

For that purpose, in addition to sizing the various components for the most severe condition of coincident design pressure and temperature, the Manufacturer shall determine the stress level in the shell and support resulting from all the combinations of static and dynamic loads which may occur at any time during the vessel life.

The extent and methods of that investigation and the appropriate data to be used in calculations shall be agreed as early as possible (and preferably before contract award) between the COMPANY Technology Division and the Manufacturer.

As a minimum, the Manufacturer shall analyse the structural stability of the vessel and its support for the combinations of loading and conditions given in table 5.2.

Table 5.2 - Combination of loadings

Loading	Condition		
	As installed	Operating	Hydrostatic testing (1)
Dead load	(2)	(3)	(3)
Live load	-	(4)	(5)
Internal and external pressure	Atmospheric	(6)	(7)
Temperature	Atmospheric	(8)	Atmospheric
Wind	(9)	(9)	(11)
Earthquake	(10)	(10)	-

Notes:

- (1) In operating position, in corroded condition.
- (2) "Lifting weight" of the vessel, empty, new (non-corroded), including all fixed attachments, excluding loose internals and appurtenances, excluding insulation.
- (3) "Operating weight" of the vessel, corroded, including any permanent equipment attached to the vessel, e.g. internals, platforms, ladders, piping, rotating equipment and drive, insulation, fireproofing.
- (4) Weight of normal liquid content.
- (5) Weight of water.
- (6) Design pressure + static head of the maximum operating liquid level as specified in the data sheet of the vessel (including liquid specific gravity).
- (7) Test pressure, including static head, vessel full of water.

- (8) Design temperature.
- (9) Shall not be combined with seismic load.
- (10) As specified in the particular specifications. Shall not be combined with wind load.
- (11) 30 % of the nominal wind load used in the calculations for the operating case.

5.3 Hull movements shall be taken into account for vessel on floating facilities (accelerations and hull distortion). Local loads

The Manufacturer shall check the localized stresses and deformations in the vessel wall due to concentrated loads caused by external and/or internal structural attachment, piping reactions, supported equipment, platform, davit, etc.

For this purpose, the Engineering Company shall issue detailed loading data to the Manufacturer for piping supports reactions, platform supports, and any other external loadings.

Piping loads on nozzles as detailed in Appendix 1 shall be used when no other data are available.

The methods for computing such stresses shall comply with PD 5500 appendix G. Allowable stress combination for this purpose shall comply with appendix A of the Code.

5.4 Maximum allowable stresses

The Manufacturer shall verify that, in any combination of loadings, except the testing condition, and in any part of the vessel and support, the computed stresses do not exceed the values prescribed in the Code.

Under the condition of the hydrostatic test, the stress shall not exceed 90 % of the minimum specified yield strength of the material at testing temperature. The efficiency of full penetration butt-weld joints shall be taken as 1. This verification shall be made on shell components only, except if the shell components thickness is governed by the test condition (in this case, nozzle reinforcements shall also be checked in the testing condition).

5.5 Clad vessels

The thickness and the strength of the clad part of clad vessels shall not be taken into account in the mechanical calculations.

5.6 Deflection

Lateral deflection of vertical vessels under the effect of dynamic loading shall not exceed the following:

- Columns with internal trays: $\frac{H}{300}$
- Other vessels: $\frac{H}{200}$

Where H = Total height of the vessel and support.

5.7 Minimum thicknesses

5.7.1 Shell and heads

The minimum thickness of shell and heads shall not be less than: $t = \frac{D}{800} + 3 + C$

Where:

t = Minimum thickness in mm (rounded up to next higher mm)

D = Outside diameter in mm

C = Corrosion allowance in mm

This requirement applies to:

- Walls consisting of a single material (i.e. carbon, low alloy, or stainless steel, etc.)
- Clad vessels made of carbon steel (or low alloy steel) with stainless steel clad. In this case, the thickness of stainless steel shall not be included in the minimum thickness.

5.7.2 Internals

The “A” columns of table 5.7 hereafter give the minimum thicknesses for internals, including the corrosion allowance, as a function of the corrosion allowance specified for the vessel.

The “B” columns give the corrosion margin in mm included in the column A, applied as indicated by note (1) to only one side or to both sides, and according to whether or not the item is removable.

How to read table 5.7:

- Select the column according to the corrosion allowance required for the shell
- If the component is not subjected to loads requiring larger dimensions, its minimum dimensions will be selected from column A.
- Otherwise, these dimensions shall be calculated, and the corrosion allowance indicated in column B shall be added to one or both sides according to the indication of note (1) of the table.

Table 5.7 - Internals

Corrosion allowance required on the main wall of the vessel (mm)		0		1.5		3		5		6	
		A	B	A	B	A	B	A	B	A	B
Carbon-steel trays (weirs) Stainless-steel downcomers (11/13 Cr)		3	0	3	-	3.5	-	6	-	6	-
		2	0	2	-	2	-	2.7	-	3.5	-
		US gauge=14		US gauge=14		US gauge=14		US gauge=12		US gauge=10	
Removable partitions, baffles, basins (carbon steel, etc.)		3	0	4	1.5 (1)	6	3 (1)	7	5 (1)	8	6 (1)
Permanent partitions, baffles, stacks, basins, etc. or compartment separators (carbon steel)		5	0	6	1.5	8	3	12	5	14	6
Gratings and grids (carbon steel) Minimum thickness of rods		3	0	4	1.5 (1)	6	3 (1)	7	5 (1)	8	6 (1)
Internal bolts, diameter in mm (carbon or stainless steel)		10	-	10	-	10	-	10	-	12	-
Un-pressurised internal tubes (carbon steel)	Diameter ≤ 2"	STD	0	STD	1.5 (1)	XS	3 (1)	XXS	5 (1)	XXS	6 (1)
	Diameter > 2"	STD	0	STD	1.5 (1)	STD	3 (1)	XS	5 (1)	XS	6 (1)
Support beams (carbon steel)	Main	-	0	-	1.5	-	3	-	5	-	6
	Secondary	-	0	-	1.5 (1)	-	3 (1)	-	5 (1)	-	6 (1)
Support rings of trays, downcomers, demisters, etc.											
Carbon steel		10	0	10	1.5	10	3	13	5	14	6
Stainless steel		6		6		7		7		8	

Note (1): Corrosion allowance on only one side.

Column A: Minimum dimension is thickness or diameter as appropriate.

Column B: Corrosion allowances (included in column A).

5.7.3 Skirts of vertical vessels

Skirt thickness shall be a minimum of one third of the main shell thickness. In case of pressure vessels made of several sections, the skirt minimum thickness shall be taken as one third of the largest shell thickness value. (However, larger values of skirt thickness may still be required as a result of Code calculations).

5.7.4 Nozzles

Nozzle necks shall conform to paragraph 3.5.4.7 of [PD 5500](#).

No flange connections shall be located inside the skirt of a vertical vessel.

6. Calculation notes

The calculation note shall be one complete set of calculation, covering all pressure vessels parts, including lifting devices, supports, nozzle loading, etc.

The calculation note shall have a clear document number with revision index and date of revision.

Each page shall be numbered. There must be a table of content with cross-reference to page numbers for each particular section.

All design data shall be listed on a summary table at the beginning of the calculation note document. The format in Appendix 2 should be used for that purpose.

Name, version number and date of the software used for the calculation shall be shown on the front page, and, if feasible, on each individual calculation note page. The name of the design engineer and the date of the calculations shall also be shown on the front page.

The following items shall be part of the calculation note and shall be shown on the table of content with reference to their page number:

- Design data
- Materials used and allowable stresses determination
- Shell(s) thickness
- Head(s) thickness
- Cone(s) thickness
- Vessel sketch
- Detailed calculation of the test pressures
- Stress verification under hydrostatic test conditions
- Nozzle(s) thickness and reinforcement
- Multiple openings reinforcement verification
- Nozzles loading
- Weight calculation
- Wind/Seismic analysis
- Supports calculation (including anchor bolts, even if not part of the supply)
- Lifting devices (lugs, trunnions, etc.) calculation.

The test pressures calculation shall detail all necessary information required by section 5.8.5.1 of the Code: Pth, Ptl, and test pressure(s). The calculation of the test pressure(s) shall be carried-out for shop test as well as site test.

7. Materials

7.1 Selection of materials

The materials shall be selected from those listed in the Code according to the design data and geometrical characteristics of the vessels. The use of enhanced materials with higher allowable stresses than those given by the Code is not permitted.

The selection of materials as a function of the design data must be made in conformity with Table 7.1. The COMPANY and/or the Engineering Company specifies the materials for each vessel which may be different from the materials of Table 7.1 in certain special cases arising from the nature of the fluids or from corrosion.

The Manufacturer must request a waiver for any different selection.

Material for vessels supports (skirts, saddles, legs, etc., including their weir plates if applicable) shall be of the same material grade as for the shell/head components to which they are welded, particularly with regards to impact test requirements.

In case of vessels subject to PWHT, materials shall be ordered with guaranteed properties on the basis of simulated post weld heat treatment according to the intended heat treatment of the vessel and provisions for repairs.

For vessels subject to autorefrigeration, all materials shall be impact tested. In this case, and wherever the Code requirements are less restrictive, the difference of the final autorefrigeration temperature with the impact test temperature of the materials shall not exceed 30°C.

Table 7.1 - Selection of materials in relation to design temperatures

Design Temperature	+ 380°C to - 196°C (2)	+ 380°C to - 101°C	+ 380°C to - 46°C	+ 380°C to - 29°C	+ 380°C to + 21°C	Max. 468°C
Type of Steel	18/8 stainless steel (1)	3.5 % Ni	Normalized carbon steel	Carbon steel	Carbon steel	1.25 Cr-0.5 Mo

Notes to Table 7.1:

- (1) 18/8 stainless steels shall be either of the low carbon or of the stabilised grade if used in welded applications.
- (2) Stabilized grades of 18/8 stainless steels are limited in temperature to a minimum of -145°C in welded applications.

7.2 Equivalent materials

Whenever the Manufacturer cannot use the materials specified in paragraph 7.1, equivalent materials may be proposed to the COMPANY Technology Division for approval; his choice should be in full accordance with the Code requirements, including enquiry cases.

7.3 Weldability of C-Mn steels

Carbon-manganese steels shall have a maximum carbon content of 0.23 %.

The carbon-equivalent of these materials (based on ladle analysis), calculated using the formula (IIW):

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

shall be less than 0.420.

7.4 Clad vessels

Unless otherwise specified the thickness of the cladding shall be 3mm minimum.

7.5 Flange gaskets and gasket contact faces

The gaskets are specified in the particular specifications and must comply with the following standards:

- **ASME B 16.20**: Ring joint gaskets and grooves for steel pipe flanges.
- **ASME B 16.21**: Non-metallic gaskets for pipe flanges

Except otherwise specified, the following rule shall apply:

Table 7.5 - Flange gaskets and gasket contact faces

Type of gasket	Surface condition of flanges (contact faces) as per MSS SP 6	Mean roughness (maximum value)
Flat gasket (series 150 & 300)	1/16 raised concentric serrated or "stock finish"	150 microns approx. 50 microns
Spiral wound (series 150, 300 & 600)	1/16 raised or 1/4 raised "smooth finish"	250 AARH (or 6.3 microns)
Ring joint (series 900 and above)	smooth (grooved)	63 AARH (or 1.5 microns)

Gasket contact faces for metal joints such as ring joints must be at least 20 Brinell harder than the joints.

7.6 Bolting

7.6.1 External bolting

The external bolting of vessels for the assembly of the flanges of manholes, handholes, nozzles with blind flanges, etc., must always consist of threaded studs and nuts. They shall have a protection, against corrosion in accordance with **GS COR 350**. Threading shall be as per **ASME B 1.1** (diameter in inches):

- UNC for threaded studs up to 1" in diameter
- 8N for diameters over 1".

7.6.2 Internal bolting

The internal bolting must comply with **ASME B 1.1** threading as defined for external bolting. It may consist either of threaded studs and nuts, or of bolts and nuts.

7.7 Suborders of materials

Suborders for materials or components shall include all applicable requirements from the relevant specifications and requisition of the pressure vessel. Unpriced copies of all suborders including requisitions and any further change orders shall be issued to the COMPANY for information.

8. Rules of construction

8.1 Shell and heads welded joints number

The number of shell and heads welded joints shall be minimised.

Shell rings 2800 mm or less in outside diameter shall have not more than one longitudinal welded joint.

The maximum number of circumferential joints, exclusive of head-to-shell joints, shall be determined as a function of the total length "L" of the cylindrical shell between tangent lines as follows:

Table 9.1 - Shell circumferential welded joints number

L (mm)	Number of circumferential joints
≤ 2400	0
≤ 4800	1
≤ 7200	2
≤ 9500	3
> 9500	(See note below)

Note: beyond these length values, one additional joint every 2500-mm of L.

8.2 Welded joint layout

Welded joints shall be so arranged that:

- Visual inspection can be made with all internals in place
- No openings intersect with a weld seam
- No saddle bearing plates, nozzle-reinforcing pads, or wear plate cover longitudinal or girth joints
- No nozzle or other attachment weld edge shall be closer to the nearest weld edge than 1.5 times the related shell or head wall thickness, with a minimum distance of 50 mm
- Centres of the longitudinal joints of two adjacent courses shall be staggered 30° minimum apart and preferably be off-centre relative to the vessel main centrelines. For horizontal

vessels, they shall be located above the horizontal plane through the centreline of the vessel.

8.3 Type of welded joints

All longitudinal and circumferential joints, and in as much as possible, all pressure retaining joints, shall be double-sided butt-welds.

Welds inaccessible for double-sided welding (e.g. circumferential closing joint of small diameter vessels, piping and fitting butt welds) shall be single butt welds equivalent to a double butt-welded type (which means in particular full access for visual inspection at the back side of the weld).

8.4 Heads

Heads shall be semi-ellipsoidal, in one piece for carbon, low alloy and clad steel vessels up to 2300 mm in diameter, with an integral straight flange of 50 mm minimum length.

Hemispherical heads shall be used preferably for High Pressure Vessels even if not already specified in the vessel data sheet.

Other types of formed heads are not permitted.

8.5 Transitions

Conical shell-reducer sections shall have a half-apex angle not greater than 30°. Any reinforcement for internal pressure shall be provided by increased plate thickness; a stiffening ring may be used to satisfy external pressure requirements only.

8.6 Body flanges

Full diameter body flanges may be of the slip-on type for pressure class 150 only. Over class 150, the welding neck type is required. All flanges must be of the raised face type (flat face is not permitted).

- **If the diameter of the vessel is a standardised dimension**

The flanges shall comply with one of the following standards:

- **ASME B 16.5** up to a diameter of 24" inclusive
- Alternatively: **ASME B 16.30** for the class 150 (slip-on flanges, regardless of diameter)
- Outside the limits of the above standards, body flanges shall be designed according to the Code.

- **If the diameter of the vessel is not standardised.**

The flanges shall be designed in accordance with the Code.

8.7 Supports

8.7.1 Vertical vessels

All vertical vessels shall be designed to be freestanding and self-supporting on a cylindrical or conical skirt in accordance with **SD PVV 208** and **SD PVV 205**. The cylindrical skirt plate centreline shall coincide with the shell wall centreline. The base ring shall always be of the double base ring type as shown on **SD PVV 205**.

Vessels 1000 mm OD or less and weighing 1200 kg or less (empty weight) may be supported on structural legs in accordance with [SD PVV 209](#).

No brackets, lugs, ring girder nor other type of supports shall be used.

Tailing lugs, when required, must be located on the skirt and not on the vessel wall; they shall be attached to the skirt base ring without interference with the attachment bolts of the vessel. Skirt reinforcement, if needed (e.g. for lifting purpose), must be located outside the skirt envelope. No temporary reinforcements are permitted, whether inside or outside the skirt envelop.

8.7.2 Horizontal vessels

These vessels are generally supported by two saddles (standard No [SD PVV 206](#) or [SD PVV 207](#)), located as close as possible to the heads. The Manufacturer must calculate the stresses and deformations resulting from these supports and decide whether or not it is necessary to reinforce the vessel. The contact angle of the saddle support shall be a minimum of 120°.

8.8 Connections - Nozzles and Manholes

Threaded fittings or couplings shall not be utilised.

Self reinforced type nozzles shall mandatorily be used on high pressure vessels and H₂S service.

8.8.1 Reference standards

Connection components shall conform to the following standards:

8.8.1.1 Flanges

Flanges shall be of welding neck type and shall comply with the [ASME B 16.5](#) standard for diameters up to NPS 24. For larger diameters, flanges shall be calculated according to the Code.

8.8.1.2 Nozzles

Nozzles shall comply with the standard [ASME B 36.10.M](#) Carbon and low alloy steel pipes 16 inches and smaller in diameter shall be seamless.

8.8.1.3 Welding fittings

Welding fittings shall comply with the standard [ASME B 16.9](#).

8.8.2 Sizes

Minimum nozzle size shall be 2" NPS. However, when a connection must be smaller, a reducing flange matching a 2" nozzle neck may be used. Alternatively, a concentric reducer may be inserted between a 2" pipe neck and the required smaller flange. See [SD PVV 212](#).

Sizes 2"½, 3"½ and 5" NPS shall not be used.

When specified in the particular specifications, the inside diameter of nozzles shall be maintained, particularly for connections that must receive equipment or manholes through which internals shall be installed.

8.8.3 Reinforcement

Nozzle reinforcement calculation shall be made according to section 3 of PD 5500 (the use of appendix F of the Code is not permitted).

Added reinforcement plate, when provided, shall have a minimum width of 50 mm and shall be in one piece. Welded reinforcement should also be avoided when the temperature of the vessel exceeds 400°C, regardless of pressure. In this case, integral reinforcement, tapered for butt-welding to the shell, should be used.

Self-reinforcing forged nozzles shall also be used for High Pressure Vessels or vessels in Hydrogen or H₂S service.

8.8.4 Nozzles for sloping horizontal vessels

When the horizontal centreline of the vessel slopes, the nozzles must be vertical and horizontal and not perpendicular and parallel to the vessel.

8.8.5 Nozzles for stainless steel vessels

(Walls made of solid stainless steel or covered with stainless steel by cladding, or weld deposit).

The nozzles shall be built up as follows:

8.8.5.1 Tubular portion

- For a solid stainless-steel wall:
Pipe made of the same grade of stainless steel, welded or seamless, according to fabrication possibilities.
- For a carbon or low-alloy steel wall with stainless steel cladding:
Seamless carbon or low-alloy steel pipe with stainless steel weld overlay.

8.8.5.2 Flanges

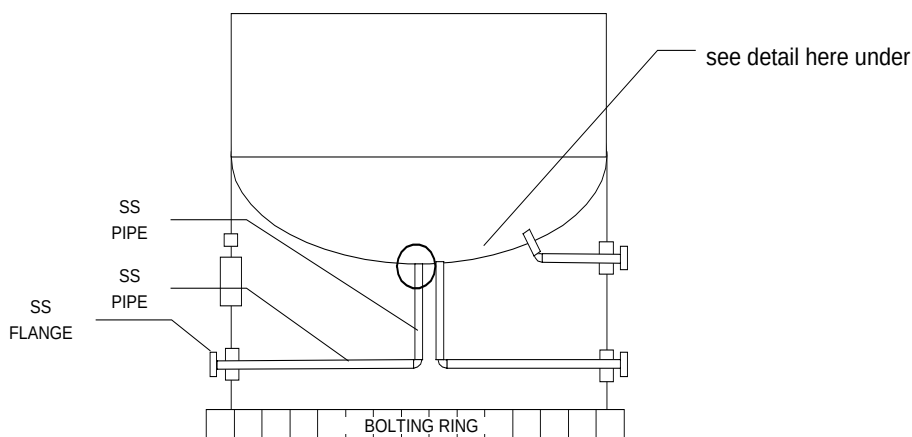
Flanges in carbon steel must be weld overlaid with stainless steel.

8.8.5.3 Thickness of the stainless steel weld overlay

The effective thickness of weld deposit must be at least equal to that of the cladding of the shell of the vessel, with the understanding that the effective thickness means the thickness of the stainless steel coating having the same structure and composition as the stainless steel specified, not counting the dilution zone. In all cases, this weld deposit must be applied in a minimum of two passes.

8.8.5.4 Long nozzle connections within the skirt of clad vessels

- Flanged connections within the skirt are prohibited
- Typical weld details for long nozzle connections for 2" and 3" nozzle diameters are given on figure 8.8.5.4 hereafter.



SS SHALL BE 321 OR 316 L depending of pressure and temperature design conditions

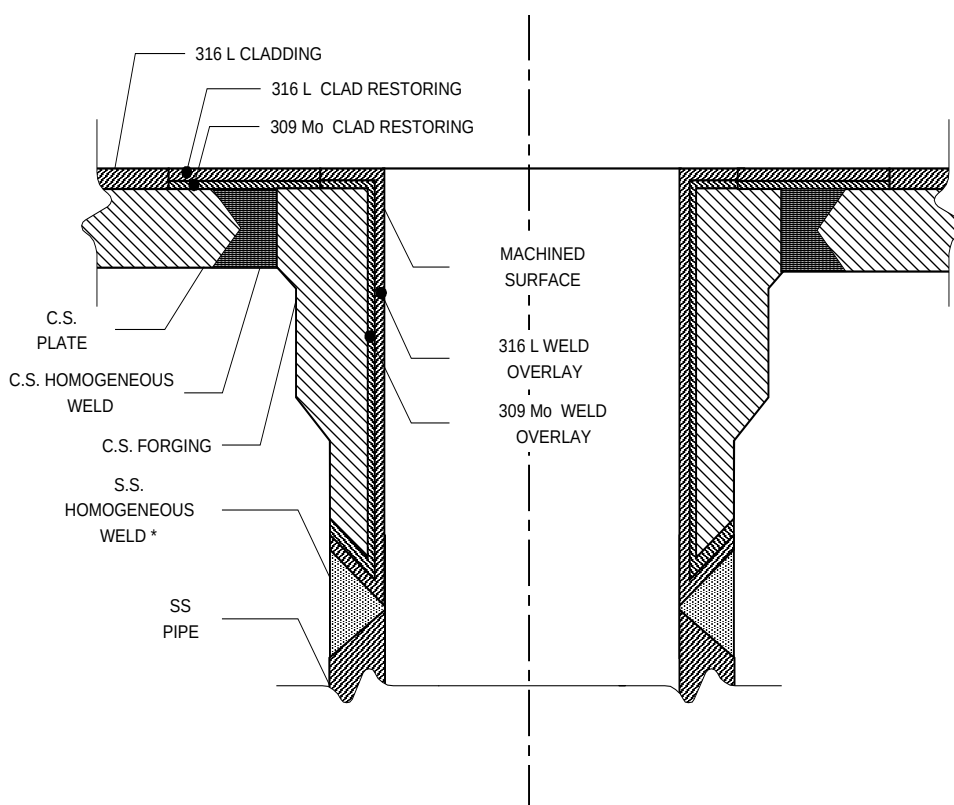


Figure 8.8.5.4 - Long nozzle connections within the skirt of clad vessels

The stainless steel pipe and the flange shall be welded after post weld heat treatment. All welds made after PWHT shall be 100 % radiographed.

8.8.6 Manholes

Except when provided with a bolted full diameter end closure, all vessels 800-mm O.D. and larger shall have at least one manhole for inspection, maintenance and operation requirements.

Several manholes may be necessary to ease the access inside the vessels and removal of internals. In any case for vessels having a length higher than 9m, two manholes are required.

Manholes shall conform to **SD PVV 214**, **SD PVV 216** and **SD PVV 218**.

24" diameter manholes are preferred. Inside diameter of smaller manholes shall not be less than 20 inches (500 mm).

8.8.7 Connection attachment to shell

Typical details are shown in [SD PVV 213](#).

Nozzle connections shall be of the set-in type. Set-on attachment type is not permitted.

Nozzle and manhole necks shall be attached to the vessel wall and to the separate reinforcement, when added, by full penetration groove welds, preferably double-welded.

Except when a piping extension into the vessel is provided, the inner edge of the connection neck shall be flush with the inside contour of the shell and shall have inside corners rounded to 3-mm radius.

Connections shall project from the vessel as required for easy access to, and removal of flange studs and nuts, accounting for insulation as appropriate.

Bolt holes in flanges of connections located in heads shall straddle the principal centrelines of the vessel, or lines parallel thereto. Bolt holes in flanges of connections located in shell shall straddle the vertical centreline of the vessel.

8.8.8 Stand pipes

Standpipes shall be avoided. The related vessel nozzles shall be 3" minimum diameter. The distance between the standpipe and the nozzles shall be minimised. The actual loads induced by the standpipe shall not exceed the maximum allowable loads as per [GS PVV 109](#). The design of the nozzles shall be verified for these maximum allowable loads. If necessary, nozzles shall be of the self-reinforced type; opening reinforcement pads are not allowed whichever the rating.

8.9 Other attachments to vessel walls

Appurtenances welded to the outside surface of the vessel may include stiffeners, lifting lugs, rings, clips and miscellaneous supports for platforms, ladders, davit, piping, insulation, fireproofing or other equipment.

Fixed internals may include rings, bars, brackets and clips to support trays and downcomers, piping, gratings and mesh, distributors, etc., as well as baffles, weirs, impingement and wear plates, ladder rungs, etc.

Typical details are shown in the following COMPANY standards:

- [SD PVV 220](#): Ladder rungs
- [SD PVV 221](#): Vortex breaker
- [SD PVV 222](#): Impingement plates
- [SD PVV 225](#): Davit
- [SD PVV 230](#): Insulation supports - Vertical vessels
- [SD PVV 231](#): Insulation supports - Horizontal vessels

These supports, except as otherwise indicated in the particular specifications, must be made of the same grades of material as the walls to which they are welded.

Any interference between these supports and the shell welds or between the supports themselves must be reported by the Manufacturer to the Engineering Company before the supports in question are set in place.

Corners of doubling plates shall be rounded off to a radius of not less than 25 mm.

Welds:

- Attachment welds to the vessel wall shall be designed to the same allowable stress limits required for pressure retaining parts
- Attachments shall be continuously welded to the vessel
- All doubler plate pads welded to the vessel shall have at least one 6-mm telltale hole in lower position of pad
- Lifting lugs and trunnions attachment welds shall be full penetration welds.

8.10 Lifting devices

Vessels shall have lifting lugs or trunnions that shall be designed with a dynamic factor of 1.5. This verification shall take into account the shackle and sling specific characteristics, and shall be based on the actual lifting procedure related to each lifting operation of the vessel. Allowable stresses must be limited to the following:

- Allowable shear stress : $0.40 \times F_y$
- Allowable bending stress : $0.66 \times F_y$
- Allowable tension stress : $0.60 \times F_y$
- Allowable bearing stress : $0.90 \times F_y$

Where F_y is the Yield stress of the material used.

The stress combination must be done according to the [AISC](#) manual of steel construction.

Local loads during lifting shall also be checked using appendix G of [PD 5500](#).

8.11 Internals

Removable internals shall be designed to pass through the vessel manhole(s) and shall allow easy installation and removal.

Internal piping 6" NPS and larger shall be flanged for ease of removal.

9. Fabrication

9.1 General

Fabrication shall not commence until the Manufacturer has received written authorisation from the COMPANY.

The Manufacturer shall not subcontract any work without previous written acceptance by the COMPANY. This acceptance may require from the COMPANY an audit at the Sub-Contractor premises.

Machined faces and edges shall be protected against damage during fabrication and against oxidation during heat treatment.

All fabrication shall be carried-out in-door, in a dedicated workshop-out-door or under-shelter fabrication is not authorised.

9.2 Cutting

Shear cutting shall not be utilised for pressure retaining plate material. Machining flame cutting, or plasma cutting shall be used exclusively.

9.3 Forming

Plate forming shall normally be parallel to the final direction of mill rolling.

Forming above 150°C shall not be made unless the relevant Manufacturer 's detailed procedure is previously accepted in writing by the COMPANY Technology Division. In this case, forming shall be followed by a normalising or quench and tempering treatment, as appropriate, and mechanical properties of the material shall be checked on production coupons having been subject to the same heat treatment, at the same time, and in the same furnace as the related plate (simulated heat treatment is not authorised for that purpose). In addition, and wherever possible, these production coupons shall be taken directly from each related plate after forming.

Forming at temperatures below 450°C by "step rolling" or bending of steels having a Yield Strength over Ultimate Tensile Strength ratio larger than 0.75 is not permitted. This process is also not permitted on Quenched and Tempered steels below the same temperature (i.e. 450°C).

9.4 Welding

Welding shall comply with the COMPANY General Specification **GS PVV 611**, with the following additional requirements:

9.4.1 Welding technique

Whenever practicable, welding shall be done in the flat position.

Welds made of only one pass are not acceptable on pressure containment welds.

Gas metal arc welding (GMAW) is not acceptable, even on root passes.

Flux Cored Arc Welding (FCAW) process is acceptable only on nozzles to vessel connection welds and if used with shielding gas. It may also be used on non-pressure parts welds.

All double-sided butt-welds shall be back-gouged by arc-air followed by grinding down to sound metal prior to back welding. However, for vessel wall thickness 12 mm and below, back gouging may be performed by grinding only, provided all relevant welds are 100 % radiographed.

9.4.2 Welding documents

Before starting any fabrication work, the Manufacturer must submit one set of welding documents per vessel, including at least the following items of information, to the Engineering Company and the Inspection Agency for approval:

9.4.2.1 Reference

Order number of COMPANY or Engineering Company.

Name and identification of the vessel.

Place of fabrication.

9.4.2.2 Weld map

A sketch of the vessel showing the types of joint and seam locations for the vessel and such welded fittings as supports, gussets, reinforcements, internals, etc.

Each weld of this weld map must be cross-referenced to a WPS number.

9.4.2.3 Welding Procedure Specification (WPS) according to the European standard [EN 288-3](#), including:

- The identification number of the qualification test record supporting each welding procedure specification (record to be attached)
- Type of preparation (oxy-gas cutting, grinding, machining, etc.)
- Welding process
- Welding position
- Identification of welder(s) or operator(s)
- Filler material (wires, electrodes) and diameters
- Protecting flux
- Refractory (tungsten) electrode (diameter)
- Characteristics of electric current
- Speed of execution of each pass
- Preheating, post-heating
- Welding equipment
- Gouging (type)
- Post weld heat treatment.

9.4.3 Approval of welders

Welders and welding operators shall be qualified according to the European standard [EN 287-1](#).

The Manufacturer must issue a list of approved welders. This list shall specify, in particular:

- The identification number of each welder
- The number and date of the certificate of qualification (certificate to be attached)
- The term of validity.

This list must be certified by the Inspection Agency.

9.5 Post-Weld Heat Treatment

9.5.1 General

Post Weld Heat Treatment shall be carried out only after all welding operations (including insulation or fireproofing support attachments) as been achieved.

The heat treatment record chart must be submitted by the Manufacturer to the Inspection Agency's approval.

9.5.2 Specific requirements

In addition to the Code requirements, a post-weld heat treatment must also be applied in the following cases:

- Vessels made of Carbon Steel materials and operating in a "sour wet" condition, as defined by **NACE MR 01-75** ("Sulfide stress cracking resistant metallic materials for oil field equipment").
- Vessels containing alkaline solutions must undergo post weld heat treatment when the design temperatures are higher than the following temperatures:

$$T = 73 - \frac{25}{46}N$$

Where:

T = limiting temperature without treatment (°C)

N = content in percent (by weight) of caustic soda in the solution.

The treatment is not necessary for solutions:

- of which the concentration by weight is less than 1.5 %
- at ambient temperature, regardless of concentration.
- Vessels containing solutions of potassium carbonate at concentrations over 2 % (by weight) must be post-weld heat treated when the design temperatures are over 90°C or when the vessels are equipped with reheaters without temperature alarms
- Vessels containing solutions of monoethanolamine must undergo post-weld heat treatment
- The Manufacturer is authorised to propose a heat treatment when he deems it necessary, even if neither the Code nor Local Regulations require it
- Other cases may require heat treatment; this is then stipulated in the vessel data sheet or requisitions.

9.5.3 Post Weld Heat Treatment procedure

A post-weld heat treatment procedure shall be submitted to the COMPANY for approval prior to fabrication. This procedure shall include a layout and elevation map showing the installation of the vessel inside the furnace together with the location and number of thermocouples. The location of fabrication coupons in the furnace together with appropriate number of thermocouples shall also be shown on the same sketch.

The PWHT procedure shall also include a detailed description of the furnace (dimensions, means of loading, heating sources, number and location of burners, temperature recording devices). This procedure shall also detail in advance the full-proposed thermal cycle.

9.5.4 Post-Weld Heat Treatment process

As far as feasible, the PWHT shall be done on the vessel as a completed unit, and not in section.

Thermocouples shall be evenly spread on the vessel surface, including top, bottom, sides, and heads parts, they must also be located at any major change in wall thickness. In case of wall

thickness exceeding 75 mm a minimum of two thermocouples shall be located inside the vessel, and located close to main nozzles like manways or large inlet/outlet nozzles.

Minimum number of thermocouples: a minimum of six thermocouples is required on outer surface of the vessel, disregarding the thermocouples which might be eventually required inside the vessel and those required on fabrication coupons.

Heating process: heat treatment using internal flame process inside the vessel is not permitted.

9.6 Production test pieces

In addition to the Code requirements production test pieces shall be provided for any vessel subject to PWHT.

Fabrication coupons include two test pieces using the same welding procedures as those used for the assembly of the main seams of the vessel and the same materials (basic metal and filler metals), at the same time. There must be one set of two fabrication coupons for each WPS used either on circular or longitudinal welds. The thicknesses of the test pieces must match the thickness of the thickest wall, not including any reinforcements. These test pieces must furthermore undergo the same heat treatments as the vessel itself, in the same furnace and at the same time.

The mechanical tests to be carried out on these test pieces shall be those required for type approval of the corresponding weld procedures, and their results must satisfy the same criteria.

Mechanical tests shall be carried-out on only one of the two test pieces, the second one being kept for any necessary investigation or re-test in the future. This second coupon shall not be cut or touched in any way without the prior acceptance of the COMPANY Technology Division.

The results must be certified by the Inspection Agency and reported to the Engineering Company.

10. Pressure tests

10.1 Shop tests

Without exception, the shop tests are hydraulic tests.

Vessels are tested in the shop, in a position compatible with their dimensions. However, for vertical vessels, which are shop-tested in the horizontal position, the shop test pressure must be increased by the hydrostatic head corresponding to the vessel field tested full of water in the vertical position, in compliance with the calculation note.

10.2 Testing procedure

A fully detailed testing procedure shall be submitted to the COMPANY for approval prior to fabrication.

This procedure shall include a sketch of the vessel showing details and number of temporary supports during the test, location of pressure gauges, the position of the vessel, pressure gauges range, location of vents and drains, etc.

- The vessels shall be tested in the presence of the Inspection Agency, before being painted
- Prior to testing, the vessels shall be thoroughly cleaned and free from dirt, debris, loose scale and slag, pieces of metal, weld spatter, oil and grease, etc.

- Tightness of welded attachments with telltale hole shall preliminarily be air and soapsuds tested
- Service bolting shall be used for pressure testing; bolts and nuts shall be thoroughly inspected after testing and replaced whenever damaged. This inspection shall be witnessed by the Inspection Agency
- Gaskets shall be the same as for the service type, dry or coated with graphite. Use of compounds, glue, lead, is not permitted. Metallic "O"-rings gaskets shall be replaced after testing if damaged. All other gaskets shall be replaced with new ones after testing
- All air shall be vented from the vessel before the pressure is applied
- Test pressure shall be held at least one hour during visual examination of the vessel by the Inspection Agency
- Immediately after draining, vessel shall be dried and cleaned thoroughly.

10.3 Temperature and quality of the test water

Testing medium shall be clean, fresh water. When testing stainless steel vessels, the water shall have a maximum chloride content of 15 ppm and shall be inhibited; the inhibitor shall be constituted of 3 ppm of sodium nitrate (Na NO₃) per ppm of chloride in water, and of 12 ppm of oxygen scavenger per ppm of oxygen in water.

If vessel envelope materials (other than austenitic stainless steels) are not impact tested, both the test water and the envelope metal temperatures shall be a minimum of + 16°C. In all other cases, these temperatures shall be at least 10°C above the impact test temperature of envelope materials, with a minimum of + 10°C.

11. Inspection and quality assurance

11.1 General

Materials, design, fabrication and preparation for shipment of each vessel shall be subject to inspection by the COMPANY and/or the Inspection Agency designated in the contract and, if applicable, by the certification authority. However, the acceptance of any work and/or release of the vessels by the COMPANY and/or the Inspection Agency shall in no way relieve the Manufacturer of any responsibility for carrying out all the provisions of the Code and this specification.

Unless otherwise stated in the contract, all qualifications, examinations, tests or inspections shall be made at the place of fabrication.

The Manufacturer shall notify the COMPANY and the Inspection Agency, at least ten working days in advance, of the date of tests or inspections to be witnessed.

11.2 Quality Assurance system

For prior evaluation and audit, the COMPANY and/or the Inspection Agency may require the written description of the Manufacturer's Quality Assurance System.

11.3 Quality plan

Within six weeks from the effective date of contract, the Manufacturer shall set out a step by step inspection program for the COMPANY and the Inspection Agency approval.

This program shall be in accordance with the provisions of the Code and shall itemise all required stages of design, procurement, fabrication and inspection with hold points.

11.4 Material verification, inspection and testing

11.4.1 General

Plates 30 mm and thicker shall be ultrasonically examined in accordance with [BS 5996](#) (Material body and edge). Acceptance criteria levels shall be B6 for material body and E3 for edges.

Clad plates shall be ultrasonically examined in accordance with [BS 5996](#) (material body). Acceptance criteria level shall be B6. This is also applicable to any part of the vessel subject to clad restoration by weld overlay (in this case, the surface subject to testing shall include a minimum of 50 mm width of clad metal each side in addition to the weld deposit surface).

Other suitable supplementary testing or examination may include, but are not limited to:

- Chemical analysis (product analysis)
- Grain size
- Etching test
- Mechanical testing:
 - After simulated post-weld heat treatment (if applicable)
 - Additional tensile tests:
 - . At design temperature
 - . On the opposite end of each plate-as-rolled
 - Reduction of area
 - Bend test
 - Flattening test
 - Hardness test
 - Impact test
- Corrosion test
- Ultrasonic testing, magnetic particle, liquid penetrant examinations.

11.4.2 Repairs

No repairs shall be made unless previously accepted in writing by the COMPANY Technology Division.

11.4.3 Material test reports

For all pressure parts (plates, heads, nozzles, flanges, etc.) as well as for supports (skirt, saddles, legs), the Manufacturer shall provide material test reports showing the results of the required tests and inspection, including supplementary requirements if any. Material certificates shall conform to [EN 10204 3.1.B](#).

Material certificates for non-pressure parts shall conform to [EN 10204 2.2](#).

11.4.4 Material identification sketch

For each vessel, the Manufacturer shall prepare a material identification sketch showing the marking on every piece and referencing the related material test report or certificate.

11.4.5 Transfer of markings

Transfer of markings shall be made by the Manufacturer prior to cutting and shall be witnessed by the Inspection Agency.

11.5 Welding inspection

11.5.1 Visual and non-destructive examinations

Visual and nondestructive examinations of weld preparation and welded joints shall conform to the requirements of the Code, the COMPANY General Specification **GS PVV 611** and the following:

- Nondestructive examination procedures shall be submitted for approval to the COMPANY and the Inspection Agency before fabrication starts
- For category 1 vessels, all butt welds shall be 100 % radiographed, regardless of welded joint category as defined by the Code
- For category 2 vessels, spot radiography shall include all butt-weld intersections and not less than 10 % of each longitudinal and circumferential joint length in the shell and heads. Butt-weld intersection radiographic examination includes one film in each direction of both circular and longitudinal welds
- The Inspection Agency shall select in advance the locations at which spot radiographs will be taken
- Nozzle attachment welds to vessel walls shall be 100 % inspected by ultrasonic examination
- In addition to the requirements of the General Specification **GS PVV 611**, attachments to pressure parts including intermediate heads, lifting lugs and skirt-to-shell weldments shall be subject to magnetic particle or liquid penetrant examination

Fillet and butt welds that cannot be radiographed or ultrasonically examined shall be checked by magnetic particle or dye penetrant examination in accordance with the method specified by the Code

This requirement applies to all welds, including the welded zones of temporary fabrication attachments

- All butt-welds of High Pressure Vessels shall be 100 % radiographed **and** 100 % Ultrasonically tested
- All NDT including radiographic, ultrasonic, magnetic particle or liquid penetrant examinations shall be performed before and after Post Weld Heat Treatment of the Vessel
- Radiographic inspection must be done by X-rays using the European standard **EN 584-1** category C3 (or better) quality films (INDUSTREX MX125 or equivalent). However, and subject to prior written approval of the COMPANY Technology Division, radiography may be performed using gamma rays provided **CEN 584-1** category 2 (or better) quality films are used (INDUSTREX M or equivalent).

Other standards for film quality (like [ISO 5579](#), [ASTM E 1815](#), or others) shall not be used for this purpose as they are in general less accurate in film classification than [CEN 584-1](#). Equivalence of films recognised by the COMPANY Technology Division is given on table 11.5.1 hereafter.

Table 11.5.1 - Equivalence of films recognised by the COMPANY Technology Division

Film type	EN 584-1 category recognised by the COMPANY	Type of radiographic examination related
INDUSTREX MX125	C3	X-rays only
AGFA D5	C3	X-rays only
FUJI IX80	C3	X-rays only
INDUSTREX M	C2	Gamma rays or X-rays
AGFA D4	C2	Gamma rays or X-rays
FUJI IX50	C2	Gamma rays or X-rays

- Qualification of NDT personnel:
 - All operators, including for Dye Penetrant or Magnetic Particle Inspection, must be qualified to SNT-TC-1A level I, as a minimum
 - Interpretation must be carried-out by inspectors holding at least a valid certificate to SNT-TC-1A level II or CSWIP.

11.5.2 Dimensional check

The final dimensional check and visual inspection shall be performed after the hydrostatic test. Tolerances shall be as shown in the COMPANY standard no. [SD PVV 201](#) and in the Code, whichever is more stringent.

If so required in the requisition, removable internals shall be trial fitted inside the vessel.

12. Nameplate

Each complete vessel shall be provided with a nameplate as shown in the COMPANY standard [SD PVV 223](#), securely attached and so located that it is easily accessible after the vessel installation. The nameplate shall be on a bracket welded to the shell. Insulated vessels shall have bracket to provide 25-mm clearance between nameplate and the outside surface of insulation.

13. Preparation for shipment

13.1 General

Cleaning, packing, shipping and storage requirements shall be subject to the COMPANY approval

No vessel or vessel section shall be released for shipment without the COMPANY prior written authorisation.

13.2 Particular requirements

After completion of fabrication and testing, the vessels shall be thoroughly drained of water and dried.

After drying out, the vessels or sections shall be cleaned externally and internally of weld spatter, weld slag, flux deposits, burrs and splinters, loose mill scale and all foreign matter.

Internal surfaces of stainless steel vessels shall be pickled and passivated.

External surfaces of vessels shall be blasted and painted as prescribed in **GS COR 350** and in the requisition.

Internal surfaces of carbon steel vessels shall be blasted and painted as prescribed in **GS COR 352** when required in the requisition.

Orientation of vertical vessels shall be clearly marked with white paint on the top and bottom portions of the shell (axes 0°, 90°, 180° and 270° respectively).

All machined surfaces shall be cleaned with a suitable solvent and immediately be protected with an easily removable rust preventive coating or plastic film.

Surfaces adjacent to gasket faces shall be protected in the same manner for a distance of 100 mm.

All connection openings shall be sealed with one-piece plywood covers or heavy plastic caps taped to the nozzle.

Permanent blind flanges or covers included in the Manufacturer 's supply shall be bolted with gaskets, stud bolts and nuts in place, ready for service.

Telltale holes shall be fitted with wooden plugs or may be packed with sealant grease.

Internals installed prior to shipment when required shall be properly secured and protected.

Removable internals, davit, anchor bolts, spares and all other loose items as required in the particular specifications, shall be adequately marked or tagged for identification and packed in fully waterproof and moisture proof lined wooden crates, items being separately wrapped in a plastic sheet, if appropriate.

Copy of the packing list shall be fixed inside the crates.

13.3 Packing

The package and protection of equipment shall be suitable for inland and/or sea transportation and for a storage period as defined in the project specification. Supply shall include complete export boxing packing in compliance with this requirement.

All equipment and piping likely to vibrate during transportation shall be properly braced to prevent damage.

Dessicant bags shall be located in all capacities to prevent built-up of condensation and warning notices shall be attached

14. Fittings and spare parts

14.1 Fittings

All fittings mentioned in the particular specifications are included in the supply. These include, in particular:

- Manhole covers with their handling apparatus (davit)
- Major supports (saddles, skirts, and legs)
- Other supports (for insulation, structures, platforms, piping, etc.)
- Blind flanges for tests and the corresponding studs and gaskets
- All internals together with their attachment bolts and other fittings.

14.2 Spare parts

The spare parts shall include at least:

- Two sets of gaskets (including manholes gaskets)
- 5 % of studs, bolts, nuts, washers, etc., of each type (with a minimum of two units)
- Other parts, such as internals, if required in the particular specifications.

15. Documentation

15.1 Language and format of documents:

The Manufacturer 's documentation shall be:

- Identified as required in the contract
- In English language
- In S.I. units (except diameter of nozzles and flanges which shall be in nominal inch size).

Sizes of drawings shall be A1 or A2. Other documents shall be A4 or A3 size, as appropriate.

15.2 Detail of documents to be submitted for review

For each vessel, the Manufacturer shall submit for the COMPANY review printed and/or reproducible copies of design and fabrication documents and subsequent revisions. These documents include at least the following:

15.2.1 Outline and assembly drawings

These documents shall show all design basis and vessel data as listed hereafter:

- Applicable Code, including edition and addenda
- Applicable COMPANY specifications
- Maximum Service Pressure (M/S/P/.)
- Maximum and minimum Service Temperatures (M/S/T/. and m/S/T/.)
- Design pressure(s)

- Design temperature(s)
- Other loadings
- Corrosion allowance
- Insulation
- Materials specifications
- Post Weld Heat Treatment (PWHT) (Procedure no. ... date...)
- Hydrostatic test pressures (shop and site tests)
- Lifting weight
- Operating weight
- Hydrostatic test weight.

15.2.2 Detail drawings

These documents shall include as a minimum:

- Nozzles
- Supports
- Internals
- Welding details
- Nameplate.

15.2.3 Welding documents

These documents shall include as a minimum:

- Weld map
- Welding Procedures Specifications (WPS)
- Procedures Qualification Records (PQR).

15.2.4 Fabrication procedures

These documents shall include as a minimum:

- Forming procedures for shell plates and heads
- Postweld heat treatment procedure
- NDT procedures
- Pressure test procedures.

15.3 Manufacturer data report

On completion of the vessel, the Manufacturer shall issue a form "X" conforming to the Code in order to certify that the vessel has been designed, constructed, and tested in every respect in accordance with the Code. This form "X" shall be countersigned by the Inspection Authority.

Appendix 1 Nozzle loads

1. General

The criteria specified shall apply to process nozzles DN50 (NPS 2) and larger.

Nozzles shall be designed to withstand forces and moments from the thermal expansion and dead weight of piping. Piping reactions shall be within the limiting criteria set by this standard.

The forces and moments contained in this specification are considered as minimum criteria in order to allow for an economical design of the connecting piping.

Nozzles shall be suitable for a total number of 7000 full temperature cycles over expected life times.

2. External forces and moments on nozzles

Each nozzle shall be capable of withstanding forces and moments from external piping under design conditions and considered to be acting at the intersection of nozzle and shell in corroded condition.

In the formulas "D" is the nominal diameter in inches. The "B" value in the formulas depends on the rating of the nozzle flanges as follows:

ASME Flange Rating	"B" value of Heat Exchangers	"B" value of Columns and Drums
Class 150	0.75	0.6
Class 300	0.75	0.7
Class 600	1.25	0.8
Class 900	3.0	1.8
Class 1500	4.0	3.0
Class 2500	5.6	3.3

2.1 Nozzles to shells or channels

- Longitudinal bending moment $ML = B.130.D^2$ Nm
- Circumferential bending moment $M\phi = B.100.D^2$ Nm
- Resultant bending moment $M_b = \sqrt{(ML^2 + M\phi^2)} = B.164.D^2$ Nm
- Torsional moment $M_t = B.150.D^2$ Nm
- Axial force in plane of flange $FL = B.2000.D$ N
- Tangential force in plane of flange $F\phi = B.1500.DN$
- Resultant shear force $Fr = \sqrt{(FL^2 + F\phi^2)} = B.2500.D$ N
- Radial tension or compression force $FA = B.2000.D$ N

2.2 Nozzles to formed heads

- Resultant bending moment $M_b = B.164.D^2$ Nm
Where M_b is the resultant of the components M_x and M_z
- Torsional moment $M_t = B.150.D^2$ Nm
- Resultant shear force $F_r = B.2500.D$ N
Where F_r is the resultant of the components F_x and F_z
- Radial tension or compression force $F_A = B.2000.D$ N

For orientation of the directions of forces and moments on shell/channel and heads, see Sketch No. 1

The above-mentioned loading shall criteria as being caused by 67 % thermal - and 33 % dead weight load

Calculation method and design criteria for the basic stress intensity limits shall be based as follows:

- Calculation method:
WRC 107/297 (cylindrical shells)
WRC 107 (heads)
- Design criteria:
[ASME VIII Div 2 Appendix 4](#), or
[PD 5500 Appendix A](#).

Documents and codes shall be the latest edition.

The effect of design pressure loading together with an appropriate stress concentration factor (SCF) shall be taken into account according to [PD 5500 App. G/code case 5500/19](#). An equivalent method to determine the SCF shall be subjected to the COMPANY approval.

The stresses shall be checked in two locations:

- Shell/head to nozzle junction
- At the outer edge of the reinforcing ring or insert plate (insert plate: a local increase of shell/head thickness around the nozzle).

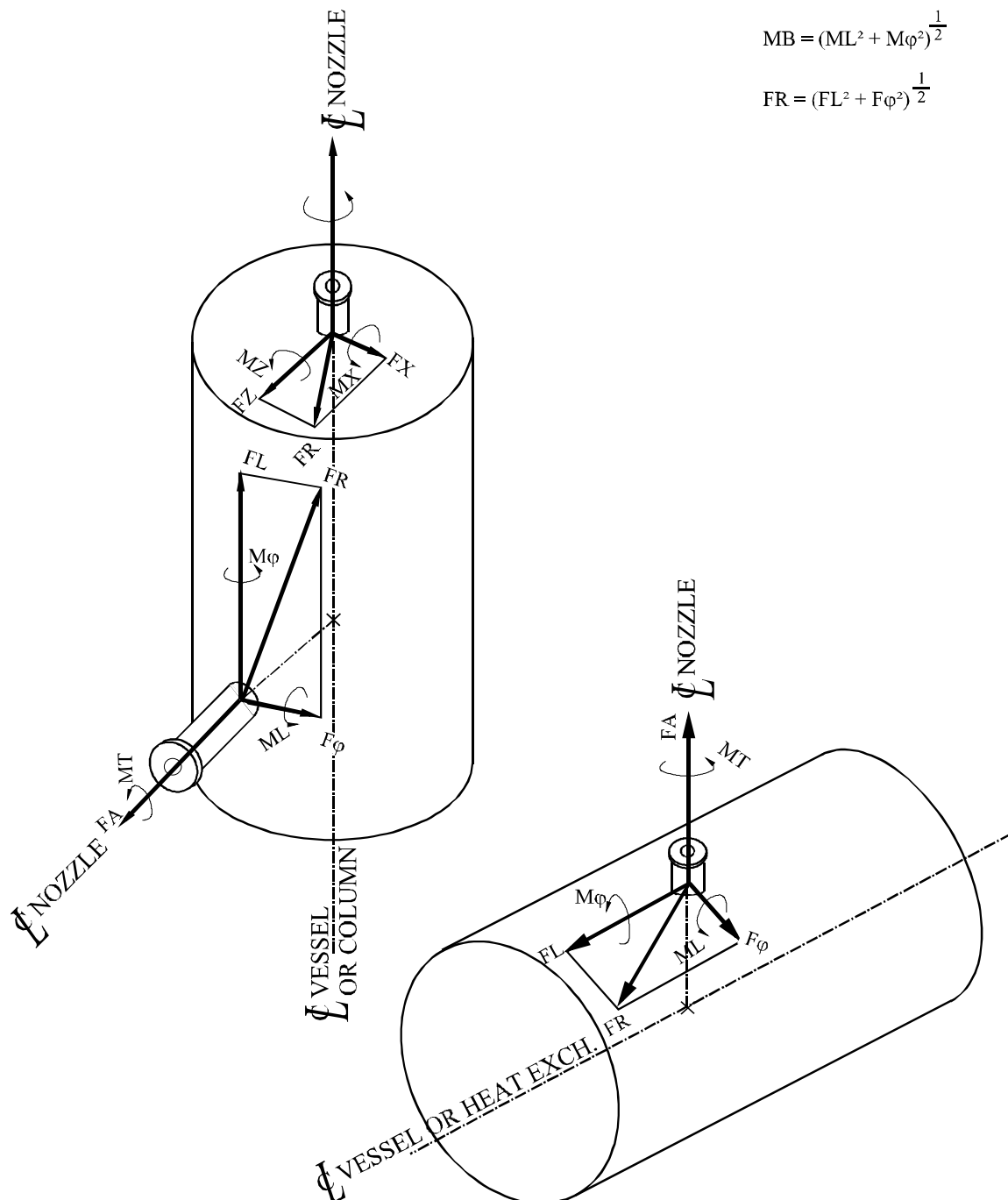
3. Additional reinforcement

Whenever stresses based on loadings calculated according to the above requirements exceed the allowable stresses, the Manufacturer shall apply additional reinforcing above the reinforcing required for pressure loading as follows:

- A reinforcing ring when not before required for pressure loading
- A larger reinforcing ring than already required for pressure loading
- A thicker/larger insert plate than already required for pressure loading.

In case the calculated stresses are still too high, the Manufacturer shall inform the COMPANY on the multiplication factor (< 1) applied simultaneously on all loadings for which the allowable stresses can be met.

The COMPANY may submit to the Manufacturer actual nozzle loadings from connected piping when these loadings exceed those set forth in paragraphs 2.1 and 2.2 of this Appendix.



ALL NOMENCLATURE ARE WITH RESPECT TO EQUIPMENT CENTERLINE.

Sketch No. 1 - Orientation of the directions of forces and moments



Appendix 2 Manufacturer Design Report Summary

Item number:

Designation:

Dimensions (m) ($\varnothing$, TL/TL Length):

Capacity (m^3):

Position (vertical or horizontal):

Design Code:

Software used for calculation (name version and date):

Internal design pressure (barg):

External design pressure (barg):

Maximum allowable working pressure (barg):

Static head (m) and fluid specific gravity:

Design temperature ($^{\circ}C$):

Minimum design reference temperature ($^{\circ}C$):

Impact test Code requirement:

Radiography testing:

Corrosion allowance (mm):

P.W.H.T.:

Maximum allowable flange rating pressure at maximum design temperature (barg):

Nozzle loading (user reference specification):

External supports loading (Engineering Company reference specification) :

Wind loading:

Seismic loading:

Operating weight (kg):

Lifting weight (kg):

Hydrostatic test weight (kg):

Detail of test pressure calculation (section 5.8.5.1. of PD 5500)

1. Shop Test Pressure

P_{tl} =

P_{th} =

1.35 P =

Applicable shop test pressure at top of the vessel =



2. Site Test Pressure

P_{tl} =

P_{th} =

$1.35 P$ =

Applicable site test pressure at top of the vessel =

Note: Allowable stress during hydrostatic testing is limited to a maximum of 90 % of the yield stress.

Material specification

- Shell/heads/cone:
- Pipe:
- Forging:

Materials	Allow. Stress amb. (MPa)	Allow. Stress design Temp (MPa)	Allow. Stress testing Temp (MPa)