

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

**PRESSURE VESSELS
(AMENDMENTS/SUPPLEMENTS TO PD 5500)**

PTS 31.22.10.32

JANUARY 2010



PTS Circular

2009 - 1



PTS No:	PTS 31.22.10.32
Publication Title:	PRESSURE VESSEL (AMENDMENTS/SUPPLEMENTS TO PD 5500)

This revision of PTS 31.22.10.32, Release 13: March 2001 for PRESSURE VESSEL (AMENDMENTS/SUPPLEMENTS TO PD 5500) has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document if any are highlighted in *italic* font.

The custodian of this PTS is:

Name: MK Shrivastava

Tel. No: 03-2783 6508

Please direct any questions regarding this PTS to the above-named

Document Approval

	Name	Designation	Date	Signature
Prepared/ Reviewed	Ir. Zaini Bin Minin	Staff Engineer (Static Unfired Equipment), GTS	4/1/2010	
Approved	M.K Shrivastava	TP (Technical Authority)	4/1/2010	
Verified	Zuraimi M Idris	Senior Manager, Plant Engineering - GTS	8/01/2010	
Verified	Pau Kiew Huai	General Manager, Engineering - GTS	15.1.10	
Endorsed	Pau Kiew Huai	Acting Senior General Manager, GTS	15.1.10	

Revision History

Revision No	Reviewed by	Approved by	Date
0	Ir Zaini Bin Minin	MK Shrivastava	Jan 2010

PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

The right to use PTS rests with three categories of users:

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorised to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, PETRONAS disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any PTS, combination of PTS or any part thereof. The benefit of this disclaimer shall inure in all respects to PETRONAS and/or any company affiliated to PETRONAS that may issue PTS or require the use of PTS.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, PTS shall not, without the prior written consent of PETRONAS, be disclosed by users to any company or person whomsoever and the PTS shall be used exclusively for the purpose they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of PETRONAS.

The copyright of PTS vests in PETRONAS. Users shall arrange for PTS to be held in safe custody and PETRONAS may at any time require information satisfactory to PETRONAS in order to ascertain how users implement this requirement.

TABLE OF CONTENTS

PART I	INTRODUCTION	4
1.1	SCOPE.....	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	4
1.4	CROSS-REFERENCES	4
PART II	GENERAL INFORMATION AND PETRONAS DESIGN REQUIREMENTS	5
1.	GENERAL	5
2.	CONSTRUCTION CATEGORIES	5
3.	SHELL DESIGN REQUIREMENTS.....	5
PART III	AMENDMENTS/SUPPLEMENTS TO PD 5500	10
SECTION 1	GENERAL	10
SECTION 2	MATERIALS	12
SECTION 3	DESIGN	13
SECTION 4	MANUFACTURE AND WORKMANSHIP	16
SECTION 5	INSPECTION AND TESTING	17
ANNEX E	RECOMMENDATIONS FOR WELDED CONNECTIONS OF PRESSURE VESSELS.....	20
ANNEX AA	ALUMINIUM SUPPLEMENT	21
PART IV	REFERENCES	22

APPENDICES

APPENDIX 1	REQUIREMENTS FOR WELDED PRESSURE VESSELS CONSTRUCTED OF MATERIAL WITH CORROSION RESISTANT INTEGRAL CLADDING, WELD METAL OVERLAY CLADDING OR APPLIED LININGS	27
APPENDIX 2	VESSEL TOLERANCES NOT COVERED IN PD 5500	29
APPENDIX 3	HARDNESS REQUIREMENTS FOR CARBON AND FERRITIC ALLOY STEEL PRESSURE VESSELS	32
APPENDIX 4	CARBON STEEL PRESSURE VESSELS IN WET H ₂ S SERVICE/SOUR SERVICE	33
APPENDIX 5	PREPARATION AND INSTALLATION OF TEST BLOCKS.....	42
APPENDIX 6	REQUIREMENTS FOR EQUIPMENT BUILT FROM Cr-Mo STEELS.....	43

PART I INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for unfired fusion welded pressure vessels, in the form of amendments and supplements to PD 5500 (2006 edition).

NOTE BSI changed the name of the code from BS 5500 into PD 5500 when the European Pressure Equipment Directive became operative.

This PTS is a revision of the PTS with the same number dated December 1996.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS 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 with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which 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 which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. 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 word **should** indicates a recommendation.

1.3.2 Specific definitions

hydrogen service service in which the hydrogen partial pressure is greater than 7 bar (abs).

very toxic substance See PTS 01.00.01.30

1.4 CROSS-REFERENCES

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

PART II GENERAL INFORMATION AND PETRONAS DESIGN REQUIREMENTS

1. GENERAL

This PTS is written in four parts. Part III is written in the form of amendments and supplements to PD 5500.

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 PTS are indicated. In all other cases any discrepancy between the data/requisition sheets and this PTS shall be brought to the attention of the Principal; |
| | NOTE: The data/requisition sheet(s) for pressure vessels is
PTS 31.22.00.94 |
| third level: | this PTS. |

For easy reference, the clause numbering of PD 5500 has been used in Part III of this PTS. PD 5500 clauses not mentioned in this PTS shall apply as written.

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 to 3.4.1):

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

- hydrogen service (Part I, 1.3.2);
- very toxic substances (Part I, 1.3.2);
- liquefied gas;
- Cr-Mo steels and other ferritic alloy steels, and carbon steels having a tensile strength greater than 485 N/mm²;
- vessels operating in cyclic service;
- vessels which operate in the creep range of the materials of construction;

Construction category 3 shall be selected for:

- utilities (e.g. low pressure steam, air, water, inert gas).

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

3. PETRONAS DESIGN REQUIREMENTS

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

The Manufacturer can then refer to Part III for the detailed technical specification.

3.1 Materials

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

For low temperature services PTS 30.10.02.31 shall apply, to prevent brittle fracture.

A materials/corrosion engineer shall judge whether additional requirements shall be specified for the metallic materials of equipment containing process streams with hydrogen

sulphide (H_2S) in concentrations which could cause any of the wet H_2S cracking mechanisms described in Appendix 4 of this PTS.

Materials selection for hydrogen service (Part 1, 1.3.2) above 230 °C shall be in accordance with API RP 941. The maximum operating conditions (temperature and hydrogen partial pressure) shall be at least 15 °C and 1.5 bar below the applicable material line 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 PTS 30.10.02.11 or PTS 30.10.02.31 (as applicable), otherwise the approval of the Principal is required.

3.2 Design pressure and temperature

For the definition and determination of temperature and pressure levels, including design pressure and design temperature, see PTS 01.00.01.30.

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

Design temperature	% of vessel design temperature	
Flanges	Uninsulated	Insulated
• Lap-joint flanges	85	100
• Other type flanges	90	100
Bolts for Flanges	80	100

3.3 Wind load

Wind loads shall be determined in accordance with Appendix 1 of PTS 34.00.01.30, unless deviation is necessary to comply with national and/or local regulations. The wind pressure either at the top of the equipment or, for equipment with an overall height over 30 metres and/or having a length to diameter ratio larger than 10, 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 (K) of the equipment.

Equipment having an overall height to diameter ratio larger than 10 may be prone to vortex shedding, and 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 metres), 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.

3.4 Fatigue analysis

The Principal shall specify on the data/requisition sheets whether a detailed fatigue analysis is required, to be performed by the Manufacturer. (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 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.

3.5 Creep analysis

If the vessel is operating in the creep range of the intended construction material, usually above 500 °C, a creep analysis shall be performed.

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.

3.6 Corrosion allowance and cladding/lining

3.6.1 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
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
Service in which the operating temperature is always below 0 °C	fine grain carbon steel, 3.5% Ni steel and 9% Ni steel	1 mm
	aluminium and stainless 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

3.6.2 Cladding/lining

The effective thickness of a cladding/lining will depend on the corrosion rate expected, and shall be subject to the approval of the Principal. Generally, no additional corrosion allowance is needed unless specified. See also Appendix 1 of this PTS.

Loose linings shall not be applied.

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

3.7 Nozzles, openings and branch connections

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 shall 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.

External nozzle loadings shall be specified on the data/requisition sheets.

3.8 Vessel supports

Supports shall be designed so that the metal temperature of the part of the support resting on concrete will not exceed 100 °C. 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 condensate collecting areas.

If full skirts are specified they shall be constructed in accordance with Standard Drawing S 20.001. There shall not be any flanged connection inside full skirts.

If half skirts are specified they shall be constructed in accordance with Standard Drawing S 22.005. Half skirts shall not be used for vessels with fire proofing or for vessels connected to piping that is prone to vibration.

Legs may be used as supporting structures in proven applications.

If saddles are specified they shall be constructed in accordance with Standard Drawings S 22.001 or S 22.002.

All vessel supports shall be provided with at least 2 earthing bosses in accordance with Standard Drawing S 68.004.

3.9 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 tonnes shall be provided with a tailing lug (or lugs).

Lifting lugs and trunnions shall be designed for a total load of 1.5 times the lifted weight of the equipment to allow for dynamic effects, etc., except lifting lugs and trunnions on vessels liable to be lifted from an offshore barge, etc., which 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.

See for lifting trunnions for vertical vessels Standard Drawing S 10.115. To avoid corrosion, heat loss and thermal stress, lifting trunnions shall be removed 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.

3.10 Bolted flanged connections

The Principal may specify the use of standard flanges other than ASME B16.5 or ASME B16.47, e.g. if the site is standardised on these other types, in which case the ratings and design requirements shall be checked against code requirements.

Spiral wound gaskets are the preferred type of gaskets for flange sizes up to DN 600 (24"), preferably graphite filled and provided with a compression stop via inner and outer rings. These rings shall be specified for this purpose, except in cases where the flange geometry provides such a compression stop (e.g. confined gaskets for heat exchangers). Tongue and groove jointing shall not be used. For larger flange sizes metal grooved ring (cam-profile) gaskets have proven to be reliable, especially with heat exchangers.

Bolting and threads shall comply with ISO metric standards if this is standard practice for the location (which shall be stated on the data/requisition sheets). See also Standard Drawings S 10.035 and S 10.116.

For bolt tensioning applications see PTS 31.38.01.11. and for bolt tensioning equipment see PTS 70.08.10.11. Bolt pitch and flange hub details shall allow for the use of bolt tensioning equipment where specified.

3.11 Manholes and inspection openings

Manholes shall have a minimum clear inside diameter of 460 mm; however, nominal pipe sizes DN 500 (20"), DN 600 (24") and DN 750 (30") are preferred. The nominal minimum diameter for inspection openings (hand holes) is DN 150 (6").

For the required sizes of access openings in columns with removable trays, see PTS 31.20.20.31.

Davits shall be provided for all openings DN 300 (12") nominal up to and including DN 750 (30"). Typical details are shown in Standard Drawing S 10.070, except for vessels in low-temperature service, for which the covers shall be hinged.

Hand hole covers shall be provided with a grip, see Standard Drawings S 10.039, S 10.053 and S 10.054.

If davits are to be provided for servicing components having a mass greater than 25 kg, mounted at the top or attached to the sides of columns taller than 20 m, this shall be specified on the data/requisition sheets. If required, davits shall be provided in accordance with Standard Drawing S 28.015.

3.12 Surface protection

The external surface of pressure vessels shall be prepared and painted in accordance with PTS 30.48.00.31-P. Internal surfaces shall not be painted unless so specified by the Principal, in which case a paint system selected from PTS 30.48.00.31 shall be indicated on the data/requisition sheets.

PART III AMENDMENTS/SUPPLEMENTS TO PD 5500

SECTION 1 GENERAL

1.1.1 Add to this clause:

The following types of pressure vessels and components are not allowed for construction categories 1 and 2 vessels:

- pressure vessels constructed by brazing;
- pressure vessels or parts fabricated by casting;
- layered pressure vessels, unless authorised by the Principal;
- forged pressure vessels, unless authorised by the Principal;
- threaded, expanded and flued openings;
- screwed connections/constructions are not allowed on the primary pressure boundary.

NOTE: The above amendment is applicable to all further clauses in PD 5500 related to these subjects.

1.5.1 Add to this clause:

- g) The year of issue of any additional standards or codes being used and, where applicable, the published amendments thereto.

1.5.2.2 Add to this clause:

- h) Items 1, 2, 7 and 9 from Annex S.
- i) The contents of the manufacturing report shall be in accordance with PTS 31.22.10.35. The format of the manufacturing report shall be in accordance with the Manufacturer's standard or PTS 31.22.10.35.

Table 1.5 Add to this table:

Purchaser option or feature requiring approval by purchaser (Part, Section)	Classification (see 1.5.2.2 (e))
Any departure from this PTS to meet national and/or local regulations (Part I, 1.2)	Basic requirement
Use of grade M1 steel above 485 N/mm ² (Part III, 2.1.1.1)	Basic requirement
Corrective actions for hardness (Part III, 2.3.2.12)	Basic requirement
Flanges other than raised-face, WN (Part III, 3.8.1)	Variation
Accepted gasket suppliers (Part III, 3.8.1)	Basic requirement
Sheet gasket thickness if not 1.5 mm (Part III, 3.8.1)	Variation
Accepted weld details (Part III, 3.10.1)	Basic requirement
Use of Contractor's own despatch forms (Part III, 4.1.1)	Variation
Alternative joint details (Annex E)	Variation
Ultrasonic examination (Annex AA, 5.6.5.1)	Basic requirement
Alternative lining methods (Appendix 1, item 1)	Basic requirement
Calibration of ferrite scope (Appendix 1, item 7-2)	Basic requirement
Use of single-layer overlay (Appendix 1, item 9)	Basic requirement
Crack detection method and testing intensity for weld overlay deposits (Appendix 1, item 17)	Basic requirement
Alternative portable hardness tester (Appendix 3, 2.1) (Appendix 4, 3.7.2)	Variation
Use of hot-finished material (Appendix 4, 3.2)	Variation
Intentional addition of micro-alloying elements (Appendix 4, 3.2) (Appendix 4, 4.2.3)	Variation
Alternative heat treatments (Appendix 4, 4.1)	Variation
Use of ASTM 841 TMCP steel (Appendix 4, 4.2.1)	Variation
Alternative methods of inclusion shape control (Appendix 4, 4.2.2)	Variation
Witnessing party for inspection certificates type 3.1.C (Appendix 4, 5.1.1)	Basic requirement

SECTION 2 MATERIALS

2.1.1.1 Add to this clause:

Materials of Grade M1 with specified minimum tensile strength (R_m) exceeding 485 N/mm^2 may be used if the Manufacturer can prove that satisfactory welding results have been achieved (with either test plates or previous vessels); this shall be subject to the approval of the Principal.

Plates for equipment in hydrogen service shall be ultrasonically examined in accordance with EN 10160, grade S₂E₂. For clad materials in this service, see Appendix 1 of this PTS.

Add new clause:

2.1.1.1.1 Cr-Mo equipment

For equipment built from 1Cr-0.5Mo, 1.25Cr-0.5Mo, 2.25Cr-1Mo and 3Cr-1Mo steels, the requirements of Appendix 6 of this PTS shall apply.

2.1.1.2 Add to this clause:

Material inspection certificates shall be in accordance with ISO 10474 type 3.1.B for construction category 1 and 2 vessels. Material test reports shall be in accordance with ISO 10474 type 2.2 for construction category 3 vessels.

2.1.2.4 Add to this clause:

Bolts coated with zinc or cadmium shall not be used. Aluminium coatings or suitable non-metallic coatings are permitted.

2.3.2.12 Add new clause:

If hardness results exceed the maximum specified values, appropriate corrective actions shall be proposed for the approval of the Principal. For hardness requirements and extent of hardness checks, see Appendix 3 of this PTS.

SECTION 3 DESIGN

3.1.1 Add to this clause:

Unless other precautions are taken to prevent deformation or damage during transport and handling, no vessel shall have a wall thickness less than:

- 3 mm for high-alloy steel vessels;
- $t_{\min}$ (including the corrosion allowance) for carbon and low-alloy steel vessels transported as one unit or in cylindrical parts. $t_{\min}$ shall be derived from the following equation, with a minimum of 6 mm:

$$t_{\min} = \frac{D}{650} + 1.8 \quad (\text{mm})$$

where D = mean vessel diameter in mm.

3.2.7 Add to this clause:

The Manufacturer shall check the static deflection and stresses induced by wind pressure during operation and the stress during shutdown. The deflection at the top of the equipment is restricted to $1/500$ of the overall height for brick-lined equipment and to $1/200$ for all other equipment. The calculation of the deflection during operational conditions shall take into account insulation, steel structures and piping that are guided or supported by the equipment.

The shape factors (Cf) shall be as follows:

ITEM		SHAPE FACTOR, Cf
Equipment (if cylindrical)		0.7
Steel structures (platforms, ladders etc)		1.0
Piping supported or Guided by the equipment	if the distance between the pipe and the equipment is more than 20 percent of the average diameter*	0.7
	if the distance between the pipe and the equipment is not more than 20 percent of the average diameter*	1.5

NOTE Average diameter = (diameter of equipment + diameter of pipe) / 2

The area to be taken into account for steel structures shall be:

ITEM	DETAIL	AREA (m ²)
Circular platform	full circumference	1.1
Square platform	full circumference	1.7
Cage ladder	per metre length	0.33
Flush ladder	per metre length	0.11

The above shall be used for calculations in accordance with Annex B of PD 5500.