International Association of Oil & Gas Producers

SPECIFICATION
IOGP S-619

April 2022
Version 2.0

REDLINE
Version 2.0 to Version 1.0

# Specification for Unfired, Fusion Welded Pressure Vessels



JIP33
JOINT INDUSTRY PROGRAMME

**Revision history**

| VERSION | DATE | PURPOSE |
|---|---|---|
| 2.0 | April 2022 | Second Edition |
| 1.0 | December 2018 | First Edition |



## Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

### Disclaimer



### Copyright notice

# Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2020).

This second edition cancels and replaces the first edition published in December 2018.

Due to technical writing requirements leading to extensive changes, this second edition should be treated as a new document.

**ABOUT THE REDLINE VERSION**

**This Redline version aims at comparing Version 2.0 to Version 1.0 but may not capture all changes.**

**The Redline version is not a specification document. It is a mark-up copy provided for information only. The user must refer to the official published version.**

# Table of Contents



## List of Tables

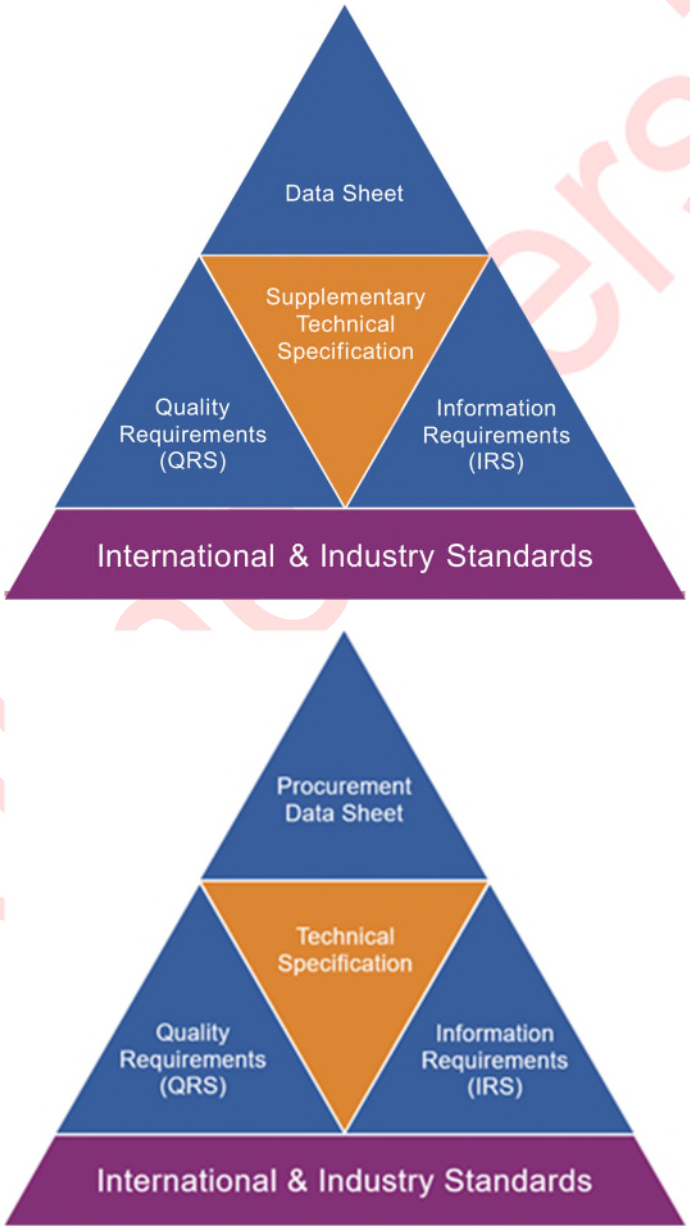


## List of Figures

# Introduction

The purpose of this specification is to define a minimum common set of ~~specification~~ requirements for the procurement of unfired, fusion welded pressure vessels for application in the petroleum and natural gas industries.

~~This JIP33 standardized procurement~~This specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.




**JIP33 Specification for Procurement Documents**
**~~Supplementary~~ Technical Specification**

~~It~~This specification is ~~required~~ to ~~use all of these documents~~be applied in conjunction with ~~each other when applying this specification,~~the supporting procurement data sheet, information requirements specification (IRS) and quality requirements specification (QRS) as follows~~:~~.

**IOGP S-619: Specification for Unfired, Fusion Welded Pressure Vessels**

~~This specification is written as a set of minimum requirements for design, materials, fabrication, inspection, testing and preparation for shipment of unfired, fusion welded pressure vessels. The terminology used within this specification is in accordance with ISO/IEC Directives, Part 2.~~

~~**S-619D: Datasheet for unfired, fusion welded pressure vessels**~~

~~This document provides project specific requirements where~~ This specification ~~requires the purchaser to define an~~ defines the technical requirements for the supply of the equipment.

**IOGP S-619D: Procurement Data Sheet for Unfired, Fusion Welded Pressure Vessels**

The procurement data sheet defines application specific ~~requirement. It also includes information required by the purchaser for~~ requirements, attributes and options specified by the purchaser for the supply of equipment to the technical specification. The procurement data sheet may also include fields for supplier provided information attributes subject to purchaser's technical evaluation. Additional purchaser supplied documents ~~are~~may also ~~listed~~be incorporated or referenced in the ~~datasheet,~~procurement data sheet to define scope and technical requirements for enquiry and purchase of the equipment.

**IOGP S-619L: Information Requirements for Unfired, Fusion Welded Pressure Vessels**

~~This document~~The IRS defines the information requirements, including contents, format, timing and purpose~~, for information~~ to be provided by the ~~vendor~~supplier. It may also ~~defines the~~define specific conditions which ~~must be met for conditional information requirements to become mandatory. The~~ invoke information requirements ~~listed in the IRS have references to the source of the requirement.~~.

**IOGP S-619Q: Quality Requirements for Unfired, Fusion Welded Pressure Vessels**

~~This document includes a conformity assessment system (CAS) which specifies standardized user interventions against~~The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities ~~at~~for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four ~~different~~ generic conformity assessment system (CAS) levels~~.~~ on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the ~~datasheet~~data sheet or in the purchase order.

~~The datasheet~~The terminology used within this specification and the supporting procurement data sheet, IRS and QRS is in accordance with ISO/IEC Directives, Part 2.

The procurement data sheet and IRS are published as editable documents for the purchaser to specify application specific requirements. The ~~supplementary~~ specification and QRS are fixed documents.

~~Unless defined otherwise in the purchase order,~~ The order of precedence (highest authority listed first) of the documents shall be:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser defined requirements (~~datasheet~~procurement data sheet, IRS, QRS);

d) this specification.

# 1 Scope

## ~~1.1 General~~

This specification defines the minimum ~~set of~~ requirements for the design, materials, fabrication, inspection, testing and preparation for shipment of unfired, fusion welded pressure vessels.

## ~~1.2 Materials~~

Vessels fabricated in accordance with this specification ~~includes~~are intended for use in the typical services associated with oil and gas production facilities, mid-stream or pipeline facilities, gas plants, LNG facilities, oil refineries or petrochemical facilities.

The requirements ~~for the supply of vessels~~in this specification are selected based upon the following boundary conditions.

a) The vessel is manufactured from~~:~~ one of the following materials:

   ~~a.~~1) carbon steel;

   ~~b.~~2) austenitic stainless steel;

   ~~c.~~3) 22 Cr Duplex, 25 Cr Super Duplex; or

   ~~d.~~4) carbon steel base integrally clad or weld overlaid with austenitic stainless steel, alloy 276, alloy 625 and alloy 825.

b) The design temperature is less than or equal to 425 °C (800 °F).

c) The design pressure is less than or equal to 20 MPag (3000 psig).

d) The nominal thickness of the vessel shell or heads is less than or equal to 100 mm (4 in).

e) The vessel is designed, fabricated, inspected and tested in accordance with a recognized industry standard (e.g. ASME *BPVC*, Section VIII, Division 1, ASME *BPVC,* Section VIII, Division 2, EN 13445 and PD 5500).

The use of this specification for fabrication of vessels with one or more parameters that are outside the boundary conditions defined above may be an acceptable practice. However, as is provided by the base requirements in this specification, it is the purchaser responsibility to:

— determine which requirements, if any, need to be modified;

— specify additional requirements as necessary to ensure an equivalent level of safety and reliability.

Requirements under Section 2 to Section 10, Annex E, Annex F and Annex J are common for all pressure vessels.

For a typical facility covered by the scope of this specification, it is expected that approximately 60 % to 80 % of the vessels required for an average project can be purchased using this specification. This is one of the key premises against which requirements were tested when deciding whether a requirement is or is not to be included in this specification. In addition, this specification is focused on the identification of fabrication requirements where the vessel vendor is the primary audience, rather than the creation of a design guideline intended for the purchaser.

## 2 Normative references

The following ~~documents~~publications are referred to in this ~~specification~~document, the procurement data sheet (IOGP S-619D) or the IRS (IOGP S-619L) in such a way that some or all of their content constitutes requirements of this specification. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 578, *Guidelines for a Material Verification Program (MVP) for New and Existing Assets*

API Standard 579-1/ASME FFS-1, *Fitness-For-Service*

API Standard 660, *Shell-and-Tube Heat Exchangers*

ASME B16.5, *Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard*

ASME B16.9, *Factory-Made Wrought Buttwelding Fittings*

ASME B16.47, *Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard*

ASME *BPVC*, Section VIII, Division 1, *Rules for construction of Pressure Vessels*

ASME *BPVC*, Section VIII, Division 2, *Rules for Construction of Pressure Vessels - Alternative Rules*

ASME PCC-1, *Guidelines for Pressure Boundary Bolted Flange Joint Assembly*

ASTM A263, *Standard Specification for Stainless Chromium Steel-Clad Plate*

ASTM A264, *Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate*

ASTM A265, *Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate*

ASTM A388, *Standard Practice for Ultrasonic Examination of Steel Forgings*

ASTM A578, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

AWS A4.2, *Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal*

EN 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*

EN 13445, *Unfired pressure vessels*

IOGP S-705, *Supplementary Specification to API Recommended Practice 582 for Welding of Pressure Containing Equipment and Piping*

ISO 8249, *Welding — Determination of Ferrite Number (FN) in austenitic and duplex ferritic-austenitic Cr-Ni stainless steel weld metals*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 15156-1/NACE MR0175 (all parts), *Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production*

ISO 17782, *Petroleum, petrochemical and natural gas industries — Scheme for conformity assessment of manufacturers of special materials*

ISO 17945/NACE MR01030, *Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments*

NACE TM 0284, *Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*

NORSOK M-601, *Welding and inspection of piping*

NORSOK M-650, *Qualification of manufacturers of special materials*

PD 5500, *Specification for unfired fusion welded pressure vessels*

TEMA, *Standards of the Tubular Exchanger Manufacturers Association*

| | |
|---|---|
| ~~API RP 578~~ | ~~Guidelines for a Material Verification Program (MVP) for New and Existing Assets~~ |
| ~~API RP 582~~ | ~~Welding Guidelines for the Chemical, Oil and Gas Industries~~ |
| ~~API Std 660~~ | ~~Shell-and-tube Heat Exchangers~~ |
| ~~ASME BPVC Section VIII Div.2~~ | ~~Rules for Construction of Pressure Vessels — Alternative Rules~~ |
| ~~ASME BPVC Section IX~~ | ~~Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators~~ |
| ~~ASME PCC-1~~ | ~~Guidelines for Pressure Boundary Bolted Flange Joint Assembly~~ |
| ~~ASTM A262~~ | ~~Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels~~ |
| ~~ASTM A264~~ | ~~Specification for Stainless Chromium Steel-Nickel Steel-Clad Plate~~ |
| ~~ASTM A265~~ | ~~Specification for Nickel and Nickel base alloy clad steel plate~~ |
| ~~ASTM A578~~ | ~~Specification for straight beam ultrasonic examination of rolled steel plates for special applications~~ |
| ~~AWS A4.2~~ | ~~Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal~~ |
| ~~EN 10160~~ | ~~Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm ($\frac{1}{4}$ in) (reflection method)~~ |
| ~~ISO 3834~~ | ~~Quality requirements for fusion welding of metallic materials~~ |
| ~~ISO 9712~~ | ~~Non-destructive testing — Qualification and certification of NDT personnel~~ |
| ~~ISO 14731~~ | ~~Welding Coordination — Tasks and Responsibilities~~ |
| ~~ISO 15156-1/ NACE MR0175-1~~ | ~~Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials.~~ |
| ~~ISO 15156-2/ NACE MR0175-2~~ | ~~Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons~~ |

| | |
|---|---|
| ~~ISO 15156-3/ NACE MR0175-3~~ | ~~Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production — Part 3: Cracking resistant CRAs (corrosion resistant alloys) and other alloys~~ |
| ~~ISO 17945/ NACE MR0103~~ | ~~Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments~~ |
| ~~ISO 17781~~ | ~~Petroleum, petrochemical and natural gas industries — Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels~~ |
| ~~ISO 17782~~ | ~~Petroleum, petrochemical and natural gas industries — Scheme for conformity assessment of manufacturers of special materials~~ |
| ~~NACE TM 0284~~ | ~~Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking~~ |
| ~~NORSOK M-650~~ | ~~Qualification of manufacturers of special materials~~ |
| ~~TEMA~~ | ~~Standards of the Tubular Exchanger Manufacturers Association~~ |
| ~~WRC-297~~ | ~~Local Stresses in Cylindrical Shells Due to External Loading on Nozzles~~ |
| ~~WRC-452~~ | ~~Recommended practices for Local Heating of Welds in Pressure Vessels~~ |
| ~~WRC-537~~ | ~~Precision Equations and Enhanced Diagrams for Local Stresses in Spherical and Cylindrical Shells Due to External Loading for Implementation of WRC Bulletin 107~~ |

# 3 Terms, definitions, acronyms, abbreviations and symbols

## 3.1 Terms and definitions

**3.1.1**
**custom designed flange**
flange (e.g. girth flange, flanged head, nozzle flange, companion flange) designed in accordance with the rules of the specified design code

**3.1.2**
**effective diameter**
outside diameter of the insulated vessel plus the additional diameter for any externally attached piping, ladders and platforms

**3.1.3**
**fitting**
fitting dimensioned and manufactured in conformance with ASME B16.9 or equivalent standard

**3.1.4**
**hydrogen charging service**
service in which the diffusion of atomic hydrogen can occur in the steel

Note 1 to entry: Hydrogen charging services include wet hydrogen sulphide, sour service, hydrofluoric acid service or hydrogen service where the operating temperature is greater than 205 °C (400 °F).

**3.1.5**
**standard flange**
flange dimensioned and manufactured in accordance with ASME B16.5, ASME B16.47 or equivalent standard

**3.1.6**
**design corrosion allowance**
minimum corrosion allowance as specified on the vessel data sheet

**3.1.7**
**maximum allowable working pressure**
**MAWP**
maximum internal gauge pressure permissible at the top of the completed vessel in its normal operating position at the designated coincident design temperature using the entire new (non-corroded) thickness minus the full corrosion allowance

**3.1.8**
**maximum allowable external pressure**
**MAEP**
pressure acting on the completed vessel in its normal operating position, excluding the effect of the static head, at the designated coincident design temperature using the entire new (non-corroded) thickness minus the full corrosion allowance

**3.1.9**
**maximum allowable pressure**
**MAP**
calculated allowable pressure using the entire new (non-corroded) thickness at ambient temperature (sometimes referred to as MAP new and cold)

~~**3.1.1 custom designed flange**~~
~~flange, including girth flange, flanges in flanged heads, nozzle flanges, companion flanges, etc. designed as per the rules of the design code~~

~~**3.1.2 effective diameter**~~

~~insulated outside diameter of the vessel plus the additional diameter for any externally attached piping, ladders and platforms~~

~~**3.1.3 fittings**~~

~~fittings dimensioned and manufactured in conformance with ASME B16.9 or equivalent standard~~

~~**3.1.4 standard flange**~~

~~flanges dimensioned and manufactured in conformance with ASME B16.5, ASME B16.47 or equivalent standard~~

## 3.2 Abbreviated terms and symbols

### 3.2.1 Abbreviated terms

| | |
|---|---|
| ACCP | ASNT Central Certification Program |
| BHN | Brinell hardness number |
| CE | carbon equivalent |
| CLR | crack length ratio |
| CSR | crack sensitivity ratio |
| CTR | crack thickness ratio |

| | |
|---|---|
| DN | nominal diameter |
| FN | ferrite number |
| HIC | hydrogen-induced cracking |
| LNG | liquefied natural gas |
| MACA | maximum allowable corrosion allowance |
| MAEP | maximum allowable external pressure |
| MAP | maximum allowable pressure |
| MAWP | maximum allowable working pressure |
| MT | magnetic particle testing |
| NPS | nominal pipe size |
| NPT | national pipe thread |
| PSA | pressure swing absorber |
| PT | liquid penetrant testing |
| PWHT | post weld heat treatment |
| WFMT | wet fluorescent magnetic particle |
| WRC | Welding Research Council |

~~**3.2 Abbreviations**~~

~~Alphabetical list of abbreviations used in this document:~~

~~ACCP ASNT Central Certification Program~~
~~API American Petroleum Institute~~
~~ASME American Society of Mechanical Engineers~~
~~ASNT American Society for Nondestructive Testing~~
~~ASTM American Society for Testing and Materials~~
~~AWS American Welding Society~~
~~BPVC boiler and pressure vessel code~~
~~CE carbon equivalent (% C + % Mn / 6 + (% Cr + % Mo + % V) / 5 + (% Ni + % Cu) / 15)~~
~~DN nominal diameter~~
~~EN European Norm (standard)~~

~~FCAW flux-cored arc welding~~
~~FN ferrite number~~
~~GMAW-P gas metal arc welding, pulsed arc~~
~~GTAW-P gas tungsten arc welding, pulsed arc~~

~~HIC hydrogen induced cracking~~

~~HRC Rockwell hardness, C scale~~

~~HV Vickers hardness~~

~~ISO International Organisation for Standardisation~~

~~MACA maximum allowable corrosion allowance~~

~~NACE National Association of Corrosion Engineers~~

~~NORSOK Norsk Sokkels Konkuranseposisjon (the Norwegian shelf's competitive position)~~

~~NPS nominal pipe size~~

~~NPT national pipe thread~~

~~PMI positive material identification~~

~~PWHT post weld heat treatment~~

~~SAW submerged arc welding~~

~~SMAW shielded metal arc welding~~

~~WRC Welding Research Council~~

### 3.2.2 Symbols

d average outside diameter of the vessel

D outside diameter of nozzle

h distance from the base of the support to the top tangent line of the vessel

## ~~3.3 Symbols~~

~~*h* distance from the base of the support to the top tangent line of the vessel~~

~~*d* average outside diameter of the top third of the vessel~~

~~$d_i$ inside diameter of shell or head~~

## 4 Vendor's data

### 4.1 Proposal information required

The vendor's proposal shall, as a minimum, include the following documents:

a. completed datasheet;

b. delivery schedule;

c. list of sub-vendors and sub-contractors;

d. concession requests.

### 4.2 Drawings and other information required

The vendor shall submit the following documentation to the purchaser:

a. non-conformance records;

b. concession requests;

c. completed datasheet;

d. quality plan;

e. inspection and test plan;

f. general arrangement drawing;

g. detail drawings;

h. design calculations;

i. welding book;

j. non-destructive examination procedures, if applicable;

k. forming procedure, if applicable;

l. positive material identification procedure, if applicable;

m. pickling and passivation procedure, if applicable;

n. heat treatment procedure, if applicable;

o. pressure test procedure;

p. lifting plan;

q. load testing certification of external lifting devices, if applicable;

r. surface preparation and coating procedure;

s. post welding heat treatment temperature chart;

t. non-destructive examination map;

~~u. material test certificates;~~

~~v. handling, shipping, storage and preservation procedure;~~

~~w. installation, operation and maintenance instructions;~~

~~x. spare part list;~~

~~y. manufacturing record book (MRB).~~

# ~~5 Design~~

## ~~5.1 General~~

### ~~5.1.1~~

~~The vessel shall be designed, fabricated and tested in accordance with the design code as specified in the datasheet.~~

### ~~5.1.2~~

~~Unless otherwise specified on the datasheet, the design life of the vessel shall be 20 years.~~

### ~~5.1.3~~

~~The minimum thickness *t* of the vessel wall shall satisfy all design load combinations specified in the design code and shall not be less than calculated by Equation (1).~~

# 4 Design

## 4.1 General

### 4.1.1

The vessel shall be designed, fabricated, inspected and tested in accordance with the specified design code.

### 4.1.2

The minimum thickness *t* of the vessel wall shall not be less than the thickness calculated in accordance with Equation (1).

~~$t = \frac{d_i}{1000} + c\alpha + x$ (1)~~

$$t = \frac{d_i}{1\,000} + c\alpha + x \qquad (1)$$

where

*t* is the minimum thickness of the vessel wall in mm (in);

~~*ca*~~ *cα* is the corrosion allowance in mm (in);

*x* is 2,5 mm (0,1 in~~)~~);

$d_i$ is the inside diameter of shell or head in mm (in).

NOTE For formed heads, the minimum thickness ~~shall be~~ *t* is after forming.

**~~5~~4.1.~~4~~3**

The use of ASME code cases ~~is~~ shall not be permitted~~, except as allowed in 5.8.3~~.

**~~5~~4.1.~~5~~4**

The ~~maximum allowable working pressure (~~MAWP~~),~~ , ~~maximum allowable pressure – new and cold (~~MAP~~) or maximum allowable corrosion allowance (~~ or MACA~~)~~ of the vessel shall not be limited by fittings, nozzle reinforcement, nozzle neck thickness, ~~nozzle flange or~~ flange bolting or custom designed flanges.

~~5~~NOTE Flanges specified using an industry standard (e.g. ASME B16.5) are permitted to limit the MAWP, MAP or MACA.

**4.1.~~6~~5**

During the hydrotest, the general primary membrane stress in any pressure part shall not exceed 95 % of the material minimum specified yield strength~~, unless otherwise specified by the design code~~.

**~~5~~4.1.~~7~~6**

~~All~~ Pressure components shall be designed for the most severe combination of pressure and coincident temperature~~, which~~.

**4.1.7**

The effects of one or more loads not acting shall be considered.

**4.1.8**

Elements common to two or more pressure chambers (e.g. jacketed vessels, internal heads, tubesheets) shall be designed to accommodate the most severe combination of pressures that may include the effects of coincident vacuum in an adjacent chamber.

**~~5~~4.1.~~8~~9**

~~All~~ Butt welds on the primary pressure boundary shall be full penetration type. ~~Partial penetration welds are not permitted.~~

**~~5~~4.1.~~9~~10**

~~Where the design code provides rules for the component thickness calculation using~~ Design by analysis~~, these~~ methodology shall not be used to justify a thinner thickness~~, unless approved~~ for a pressure component where design by ~~the purchaser.~~ rule thickness requirements are specified (e.g. ASME *BPVC*, Section VIII, Division 1 and ASME *BPVC*, Section VIII, Division 2, Part 4).

**~~5~~4.1.11**

Each vessel support shall have an earthing lug.

**4.1.12**

Attachments intended to be removed prior to commissioning shall be identified on the vessel drawing.

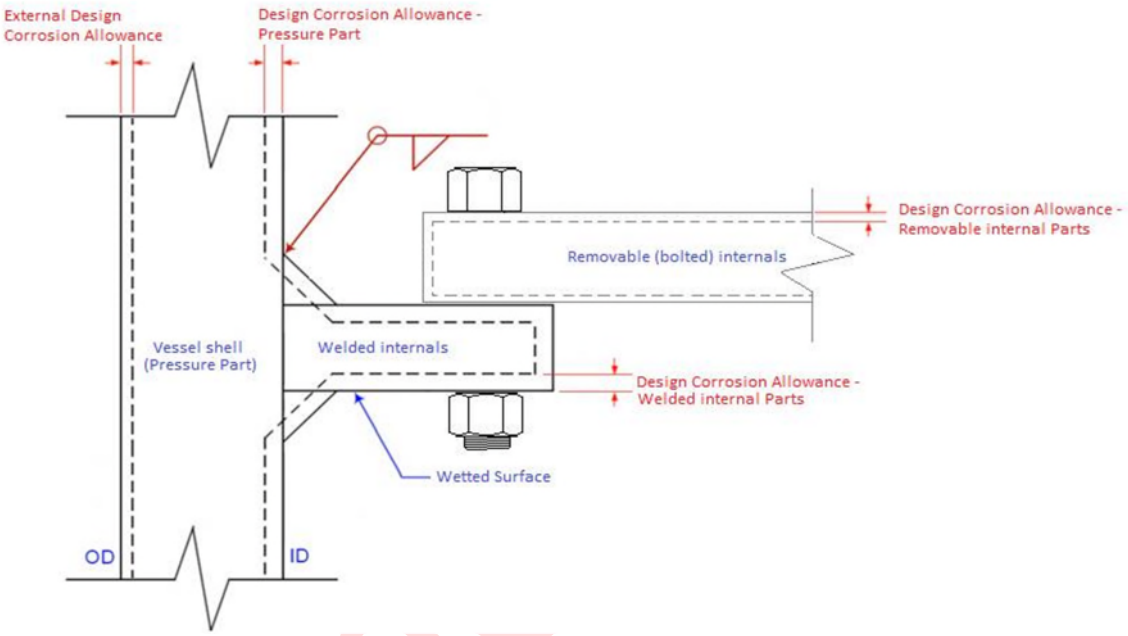
## 4.2 Corrosion allowance

~~5.2.1~~

~~For internals, the corrosion allowance as specified on the datasheet shall be added to each face of the internals in contact with the process fluid (wetted surface).~~

~~5~~4.2.~~2~~1

The corrosion allowance for ~~vessel supports made of carbon steel~~internal parts shall be ~~1,5 mm (0,06~~applied as detailed in~~).~~ Figure 1.




~~5~~

**Figure 1 — Design corrosion allowance**

### 4.2.2 ~~3~~

Corrosion allowance shall not be considered on the gasket seating surface of flanges.

## ~~5~~4.3 Wind, seismic and snow loads

### ~~5~~4.3.1

Wind, seismic~~,~~ and snow loads shall be calculated ~~as per~~in accordance with the applicable code and any additional ~~data~~requirements specified in the ~~datasheet~~data sheet.

### 54.3.2

Vibration analysis for wind induced vortex-excited resonance shall be performed on:

a.) vertical vessels with $5 \leq h/d \leq 15$ and natural frequency of vessel less than 2 Hz;

b. all ) vertical vessels with $h/d > 15$, irrespective of natural frequency.

### 54.3.3

Maximum allowable Deflection at the top of vertical vessels shall not exceed 1:*h*/200 of height *h*, unless otherwise specified.

### 54.3.4

The effective diameter of the vessel shall be used inwhen determining the projected area in the wind load calculations.

## 54.4 Design loads and load combinations

### 5.4.1

Design loads and load combinations shall be as perin accordance with Table 1 and Table 2.

**Table 1 – Design load combinations**

| Design load combination | Description |
|---|---|
| L2 + L10 + L12 + L14 | Erected or (as installed) condition with full wind load and full snow load |
| L3 + L10 + L12 + L13 + L14 + L16 | Operating condition (corroded), no pressure, with full wind load and full snow load |
| L3 + L11 + L12 + L13 + L14 + L16 | Operating condition (corroded), no pressure, with full seismic load and full snow load |
| L3 + L6 + L10 + L12 + L13 + L14 + L16 | Operating condition (corroded and uncorroded) with full pressure, full wind loads and full snow load |
| L3 + L6 + L11 + L12 + L13 + L14 + L16 | Operating condition (corroded and un-corroded) with full pressure, full seismic load s and full snow load |
| L4 + L8 + (0,25)L10 + L12 | Shop (or initial) hydrostatic test condition (uncorroded) |
| L4 + L9 + (0,25)L10 + L12 + L14 | Field (or future) hydrostatic test condition (corroded) |
| L5 + L12 + L17 | Transport condition |
| L3 + L7 + L12 + L13 + L14 + L15 | Blast load condition |

**Table 2 — Design load combination definitions**

| Design load | Description |
|---|---|
| L1 – Fabricated weight | Total weight of the vessel as fabricated in the shop |
| L2 – Empty weight | Total weight of the vessel sitting on the foundation, fully dressed, waiting for operating liquid |
| L3 – Operating weight | Empty weight plus any operating fluid weight |
| L4 – Hydrotest weight [a] | ~~Empty~~ Weight of the vessel under hydrostatic test condition including the weight of the test fluid |
| L5 – Shipping weight | Fabricated weight of the vessel plus any weight added for shipping purposes ~~such as~~ (e.g. shipping saddle) |
| L6 | Internal (including static head) or external design pressure and internal or external design temperature |
| L7 | Normal operating pressure and temperature |
| L8 | Shop (or initial) hydro test pressure and temperature |
| L9 | Field (or future) hydro test pressure and temperature |
| L10 | Wind load (not wind speed) |
| L11 | Seismic load |
| L12 | Snow load |
| L13 | Static reactions from the load of attached equipment, such as motors, machinery, other vessels and piping |
| L14 – Motion induced load | Hull/floating unit movement effect, towing out motion ~~, etc.~~ whenever applicable~~.~~ |
| L15 | Blast load |
| L16 – Thermal load | Steady state or transient effect of fluid flow ~~such as~~ (e.g. icing, chilling, thermal shock~~, etc.~~) |
| L17 | Transportation load (transportation acceleration forces) |
| [a] The removable internals that are not included in field hydrotest weight shall be identified in the vessel data sheet. | |

## ~~5~~4.5 Lifting loads

### ~~5~~4.5.1

For vessels lifted in conditions expected to be stable, lifting attachments shall be designed using a factor of 1,5 on the weight of the vessel during lifting.

### 4.5.2

For vessels lifted in conditions expected to be dynamic (e.g. lifting from a barge subject to wave action), lifting attachments shall be designed using a factor of 2,0 on the weight of the vessel during lifting.

### 4.5.~~5.2~~3

~~Unless otherwise specified in the datasheet,~~ Skirt supported vertical vessels with a total height ~~of~~ $h \geq$ ~~$h$~~ greater than or equal to 20 m (65 ft~~), irrespective of the~~) or an empty weight ~~and empty weight ≥~~ greater than or equal to 20 000 kg (44 000 lb~~), irrespective of height,~~) shall be provided with tailing devices.

4.5.~~5.3~~4

Vertical vessels ~~along with~~including the lifting attachments shall be designed for erection from a horizontal to a vertical position.

4.5.5

The design shall be ~~verified~~evaluated at 5° increments ~~of no greater than 5°.~~when lifting the vessel from a horizontal to a vertical position.

## ~~5~~4.6 Local loads

~~5~~4.6.1

Localized ~~stresses caused by~~stress resulting from concentrated loads on nozzles or ~~any external~~structural ~~attachment due to piping reactions, supported equipment, lifting of vessel etc.~~attachments shall be evaluated~~. The evaluation shall be performed in accordance with~~ using a recognized industry standard or method (e.g. WRC ~~297, WRC 537 or by~~ bulletin, finite element analysis~~. Use of any other standard or numerical method is subject to the approval of the purchaser. All~~ ).

4.6.2

Geometrical limits specified in ~~methods (such as~~the selected method (e.g. WRC~~, etc.)~~) used for local load analysis shall be followed.

4.6.3

Extrapolation beyond the stated geometrical limits ~~is~~in the method selected for local load analysis shall not ~~allowed~~be permitted.

~~5~~4.6.~~2~~4

~~Allowable nozzle loads at nozzle to shell or head junction shall be as per API Std 660. For nozzle sizes greater than DN 600 (24 in), maximum allowable nozzle loads shall be agreed with the purchaser.~~

~~5.6.3~~

Nozzles shall be designed for the external loads specified in API Standard 660, Annex K or the loads determined by a pipe stress analysis (when available).

NOTE Where the default nozzle loads ~~specified~~ lead to an increase in local shell and head thickness, ~~mutually acceptable loads shall be agreed with the purchaser.~~a reduction in the default loads based on the piping layout and/or nozzle flexibility can be considered.

4.6.5

Nozzles where external piping is not connected (e.g. manways, inspection openings, nozzles for thermowells and other similar instruments, packing withdrawal, ventilation) and where the total weight supported by the nozzle is less than four blind flanges that match the size and pressure class of the nozzle shall be excluded from the evaluation required by 4.6.1.

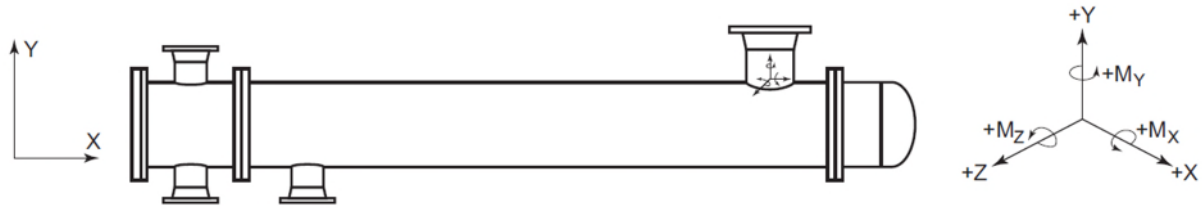



**Figure 2 — Directions of moments and forces on nozzles**

## 4.7 Nozzles, manways and reinforcements

### ~~5~~4.7.1

~~**Except where set-in type nozzles are required by this specification (e.g. for sour service), set**~~ **Set-on ~~type~~ nozzles**

#### 4.7.1.1

Set-on nozzle connections may be ~~welded~~used if one of the following applies:

a) The nozzle is attached to the header box of an air-cooled heat exchanger.

b) All of the following apply:

1) the vessel shell or head ~~with a~~ thickness is greater than 50 mm (2 in~~) and~~);

2) the nozzle thickness is less than ~~or equal to~~ half of the shell ~~or head~~ thickness~~.~~; and

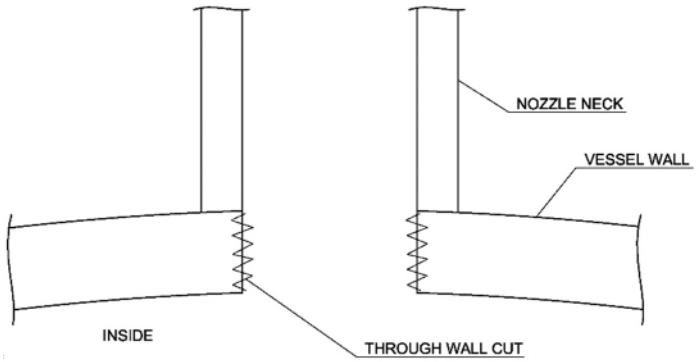
~~In this case, liquid penetrant or magnetic particle examination of~~3) when set-in nozzles are not required based on service (e.g. sour service or hydrogen charging service).

#### 4.7.1.2

Prior to fit-up of set-on type nozzles, the surface of the through wall cut (see Figure~~ 1), and a lamination check by 100 %~~ 3) shall be examined using the liquid penetrant or magnetic particle method with zero defects allowed on this surface.

#### 4.7.1.3

Prior to the fit-up of set-on type nozzles, the entire area of the plate adjacent to the nozzle opening shall be examined using the ultrasonic ~~examination of the base plate~~ method to a distance of 100 mm (4 in) around the ~~nozzle opening shall be performed prior to nozzle fit-up. The acceptance criteria shall be zero defects.~~ opening, with indications graded to Acceptance Level C in accordance with ASTM A578.




~~Figure 1 — Through-wall-cut~~

~~5~~4.7.1.4

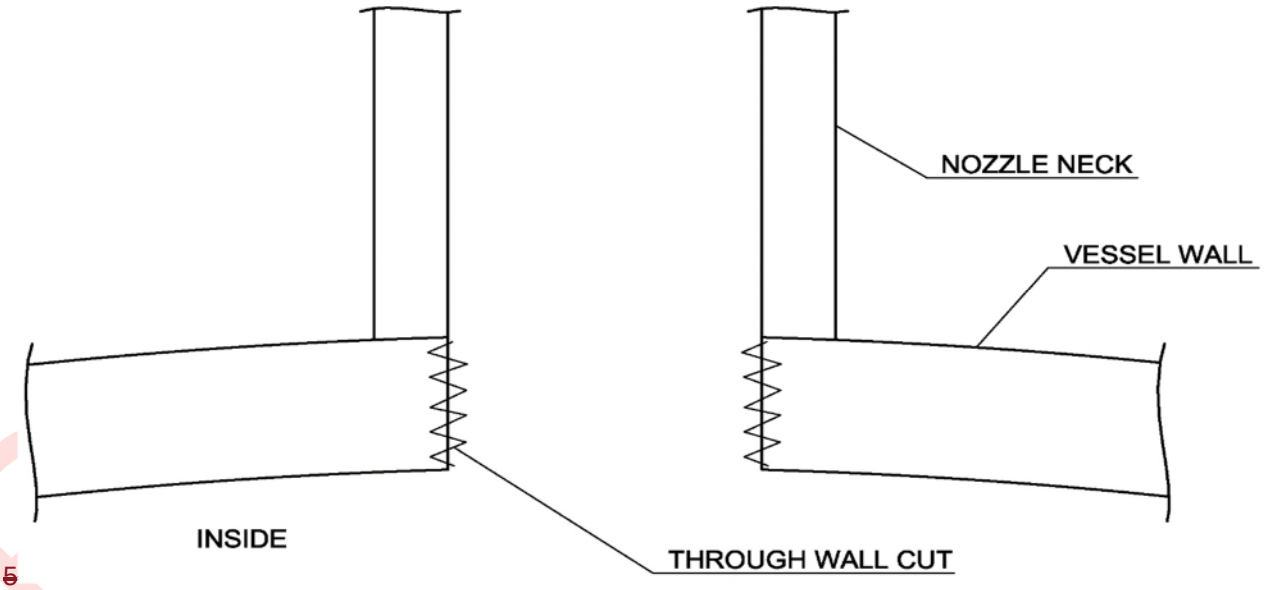
For set-on nozzles attached to plate with a thickness greater than 19 mm (3/4 in), 100 % UT examination shall be performed on the attachment weld from the back side of the plate (when accessible) subjected to through-thickness shrinkage stresses.

4.7.2

The minimum nozzle size shall be DN 40 (NPS ~~1 1/2).~~ 1½).

~~5~~4.7.3

~~All~~ Nozzle connections shall be ~~either~~ weld neck flange, long weld neck flange or stub-end (butt weld).




~~5~~

Figure 3 — Through-wall-cut

4.7.4

Flanged nozzles DN 40 (NPS 1~~ 1/2)~~ ½) and DN 50 (NPS 2) shall be long weld neck flanges or fabricated from seamless pipe with a minimum nominal wall thickness ~~per Table 3~~ of schedule 160 or schedule 80S as applicable.

~~Table 3 – Fabricated flanged nozzles~~

| ~~Flanged nozzles size~~ | ~~Nominal wall thickness of seamless pipe~~ |
|---|---|
| ~~DN 40 (NPS 1 ½)~~ | ~~7,14 mm (0,281 in)~~ ~~or~~ ~~10,15 mm (0,400 in)~~ |
| ~~DN 50 (NPS 2)~~ | ~~8,74 mm (0,344 in)~~ ~~or~~ ~~11,07 mm (0,436 in)~~ |

**4.7.5** ~~**7.5**~~

~~Fittings shall not be directly welded to vessel wall.~~

~~**5.7.6**~~

No threaded connection~~s~~ shall be screwed directly into any pressure part of the vessel.

~~**5**~~**4.7.~~7~~6**

For vessels with removable internals, access shall be provided for maintenance or replacement.

~~**5**~~**4.7.~~8~~7**

For vessels with an internal diameter less than 1 000 mm (40 in), the use of bolted heads or body flanges ~~may be used~~ for access shall be acceptable.

~~**5**~~**4.7.~~9~~8**

Inspection openings shall not be less than DN 100 (NPS 4).

~~**5**~~**4.7.~~10~~9**

Nozzle-to-vessel wall ~~joints~~and reinforcement pad to nozzle neck weld joint shall ~~have~~ be full penetration welds.

~~**5**~~**4.7.~~11~~10**

Internal reinforcing pads shall not be used for nozzles.

~~**5**~~**4.7.~~12~~11**

The minimum manway inside diameter shall be 546 mm (21,5 in).

~~**5.7.13**~~

~~Minimum nozzle projections shall be as per Figure 2, Figure 3 and Table 4.~~

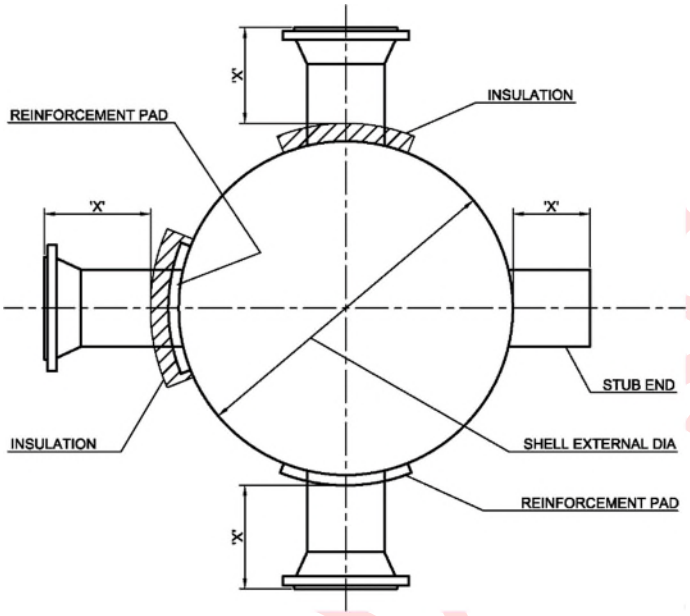
### ~~**5**~~**4.7.12 Set-in nozzles**

**4.7.~~14~~12.1**

Set-in nozzles shall be ground to match the contour of the vessel inside diameter ~~and~~.

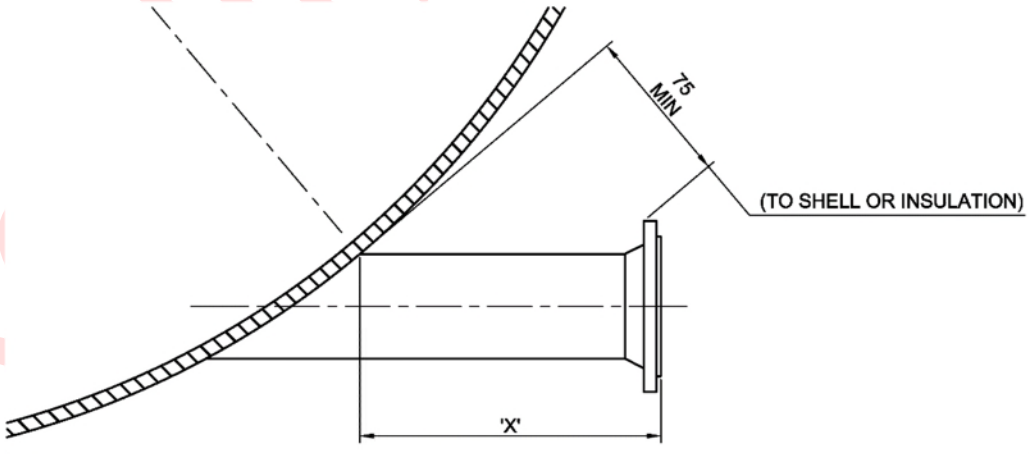
#### 4.7.12.2

Inside edges of nozzles wall shall be rounded off~~.~~ to a radius of at least 3 mm ($^1/_8$ in).




~~**Figure 2—Determining radial nozzle standout length "X"**~~

~~SOURCE: Equinor TR1053, V.9.01, 2016, Fig.1~~




~~**Figure 3—Determining offset nozzle standout length "X"**~~

~~SOURCE: Equinor TR1053, V.9.01, 2016, Fig.1~~

4.7.13

**Table 4 – Minimum nozzle standout**

| Flange Class | Minimum nozzle standout length "X" Dimensions in millimetres (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DN 50 | DN 80 | DN 100 | DN 150 | DN 200 | DN 250 | DN 300 | DN 350 | DN 400 | DN 450 | DN 500 | DN 600 |
| | NPS 2 | NPS 3 | NPS 4 | NPS 6 | NPS 8 | NPS 10 | NPS 12 | NPS 14 | NPS 16 | NPS 18 | NPS 20 | NPS 24 |
| Cl 150 | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 320 (13) |
| Cl 300 | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 320 (13) |
| Cl 600 | 200 (8) | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 220 (9) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 320 (13) |
| Cl 900 | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 320 (13) |
| Cl 1500 | 220 (9) | 220 (9) | 260 (10,5) | 260 (10,5) | 260 (10,5) | 320 (13) | 320 (13) | 320 (13) | 320 (13) | 400 (16) | 400 (16) | 400 (16) |
| Cl 2500 | 260 (10,5) | 260 (10,5) | 320 (13) | 320 (13) | 320 (13) | 400 (16) | 400 (16) | | | | | |

SOURCE: Equinor TR1053, V.9.01, 2016, Table 2

**5.7.15**

Unless otherwise specified, Flanges on nozzles including manways and access openings shall be raised face.

**54.7.1614**

Reinforcing pads for nozzles shall be limited to a maximum of two pieces.

**54.7.1715**

The thickness of nozzlethe reinforcing pads shall be no thinner thanelement for non-integrally reinforced nozzles shall not exceed the smaller of 50 mm (2 in) or of the nominal thickness of the vessel wall thickness minus the total corrosion allowance and shall not exceed 50 mm (2 in).at the location of the opening unless limited further by the code of construction.

~~5~~4.7.~~18~~16

Removable internals shall ~~be designed to~~ pass through vessel manways.

~~5~~4.7.17

For vessels in cryogenic service, manway covers shall be hinged (see Annex J, Drawing S619 J.12).

## 4.8 Custom designed flanges

~~5~~4.8.1

Minimum bolt spacing shall be in accordance with TEMA.

4.8.2

If hydraulic bolt tensioning is required, ~~sufficient~~ spacing shall be provided between bolts~~to allow hydraulic bolt tensioning~~.

~~5.8.2~~

~~Nubbins are not permitted.~~

~~5~~4.8.3

~~In addition to design pressure,~~The flange design shall account for ~~all~~the design pressure and other ~~loadings~~applicable loads (e.g. externally applied bending moment~~ or~~, axial thrust loadings~~), as applicable. ASME Code Case 2901 may be used for the evaluation of external loads.~~).

~~5~~4.8.4

~~Unless otherwise~~If not specified in the design code, the gasket seating surface finish and flatness tolerance for custom designed flanges shall be ~~as per~~in accordance with ASME PCC-1.

~~5~~4.8.5

The flatness of ~~all~~ gasket contact surfaces for custom designed flanges shall be measured after heat treatment and final machining.

## ~~5~~4.9 Flange bolting

~~5~~4.9.1

Bolts shall be studs, threaded full length, with heavy hex nuts.

~~5~~4.9.2

Stud ~~lengths~~bolts shall be ~~such that they extend beyond~~ installed flush with the nut ~~by~~ at ~~least three threads at each~~ one end~~.~~ of the stud.

~~5~~4.9.3

When bolt tensioning is used, studs shall have the additional threaded length equivalent to one stud diameter, extending from the nut at one end~~, to allow attachment of~~.

**4.9.4**

When the stud bolt ~~tightening device.~~ length is increased as required for bolt tensioning, the exposed length of the stud bolts shall be protected with ~~an additional~~a second heavy hex nut.

## ~~5~~4.10 Skirt support

**~~5~~4.10.1**

~~Skirts~~The skirt thickness shall be ~~no thinner~~less than ~~the lesser of~~ or equal to 6 mm ~~(~~¼~~(~~¼ in) inclusive of any skirt corrosion allowance or the nominal thickness of the vessel component to which it is attached.

**~~5~~4.10.2**

~~Access openings~~Skirts shall be provided ~~in skirts. No~~ with an access opening (see Figure J.3).

**4.10.3**

Piping shall ~~run~~ not be routed through skirt access openings.

**~~5~~4.10.~~3~~4**

~~No~~ Flanged connection shall not be install~~ow~~ed inside the skirt.

**~~5~~4.10.~~4~~5**

Skirt openings shall be provided with rings or collars sized ~~to ensure that~~for the structural stability ~~of the skirt is not compromised.~~.

**~~5~~4.10.~~5~~6**

~~If specified in the datasheet, provision shall be made for venting and draining of the skirt. The location of the vent shall take into account any required insulation of the bottom head.~~

~~5~~Skirt vents and drains shall be provided in accordance with Figure J.3.

## 4.11 ~~Legs~~Leg supports

**~~5~~4.11.1**

~~Small, cylindrical,~~The use of leg supports on vertical vessels ~~[$d_i \leq$ 1 000 mm (40 in.)] may be supported by legs,~~ shall be permitted if ~~all of~~ the following conditions are met:

~~the~~ a) vessel internal diameter no greater than 1 500 mm (60 in);

b) design temperature ~~is not~~no greater than 230 °C (450 °F);

~~the~~ c) vessel height ($h$~~/$d_i$~~) to internal diameter ratio ~~is~~ no greater than 5~~.~~;

~~5~~d) vessel not in cyclic service.

**4.11.2**

If a vessel is supported with legs, base plates drilled with anchor bolt holes shall be welded to each leg support.

## 4.12 Saddles

### ~~5~~4.12.1

Horizontal vessels shall be supported on two saddles, one fixed and one sliding.

### ~~5~~4.12.2

Vessels shall be evaluated for stresses imposed by all ~~the~~ applicable loading on the saddles.

## ~~6 Materials~~

### ~~6.1~~

~~Material specified in the datasheet shall not be substituted by the vendor without purchaser approval.~~

### ~~6~~4.13

Vessels designed for internal pressure only shall be stamped for the calculated MAEPs at the internal pressure design temperature.

## 4.14 Name plate brackets

### 4.14.1

The nameplate bracket shall be a "C" shape.

### 4.14.2

The nameplate bracket shall be welded externally to the vessel shell or vessel support along the two edges.

### 4.14.3

Welds between the nameplate bracket and to vessel wall shall be full fillets on one side.

### 4.14.4

The nameplate bracket material thickness shall be greater or equal to 5 mm (¼ in).

# 5 Materials

### 5.1

Castings shall not be used.

### ~~6.3~~

~~Unless specified in the datasheet,~~ 5.2 Permanent attachments

### 5.2.1

Permanent attachments including vessel supports welded directly ~~welded~~ to pressure parts shall be of the same nominal chemistry as the pressure part. ~~These~~

**5.2.2**

Permanent attachments shall be suitable for the minimum design metal temperature of the vessel.

~~**6.4**~~

~~**For stainless steel vessels,** **5.2.3**~~

The structural shape of stiffening rings or insulation support rings shall not hold water.

**5.3**

The skirt support material shall be the same nominal chemistry as the vessel wall base material for a minimum ~~length as calculated by~~distance below the vessel-to-skirt connection line in accordance with Equation (2) or 300 mm (12 in~~)~~), whichever is larger~~, below the vessel-to-skirt connection line~~.

~~Minimum length of skirt support = $1{,}8 \times \sqrt{D_s \times T_s}$ (2)~~

$$\text{Minimum length of skirt support with matching nominal chemistry} = 1{,}8 \times \sqrt{Ds \times Ts} \quad (2)$$

where

*Ds* is the skirt outside diameter;

*Ts* is the skirt nominal thickness.

~~**The remainder of** **5.4**~~

Achieving the ~~skirt may be code-approved carbon steel provided it is suitable for the design minimum ambient temperature to avoid brittle fracture.~~

~~**6.5**~~

~~The~~specified minimum design metal temperature ~~specified in the datasheet shall be used to evaluate the~~without impact ~~test requirements and exemptions as per the design code. Further reduction in the minimum design metal temperature (e.g. reduction for thickness ratio) for impact test exemption is not allowed~~testing by using a reduced stress ratio method shall not be permitted.

~~**6.6**~~

~~**Repair welding**~~**5.5**

Use of ~~forged or rolled base~~ non-impact tested materials ~~is not permitted, unless approved~~as allowed by ~~the purchaser.~~

~~**6.7**~~

~~Positive material identification~~ASME *BPVC*, Section VIII, Division 1, UG-20 (f) shall not be ~~carried out at vessel shop in accordance with API RP 578 or other equivalent standard to verify all~~ permitted.

**5.6**

The proposed repair of defects in the as-received base metal of pressure ~~part~~ components shall be approved.

**5.7**

Positive material identification of alloy steel ~~material including~~pressure containing parts, weldments, cladding and weld overlay ~~welding~~shall be performed in accordance with API Recommended Practice 578 or NORSOK M-601.

**6~~.8~~**

~~Extent of PMI shall be as specified in the datasheet.~~

**~~7~~**

# 6 Fabrication

## ~~7~~6.1 General

### ~~7~~6.1.1

~~All~~ Continuously welded external ~~reinforcing pads and similar~~ attachments (e.g. wrapper plate for saddles, ~~nozzle reinforcing plates,~~ wear plates~~, etc.)~~) shall be provided with one 6 mm (¼ in) diameter vent hole in each segment at the lowest practical point of the pad or attachment. ~~Alternatively for continuously welded internal attachments, 25 mm (1 in) length at the low point may be left un-welded to create a vent.~~

### ~~7~~6.1.2

The vent hole in the nozzle reinforcement pad ~~vent hole~~ shall be tapped DN 8 (~~¼~~¼ NPT).

### ~~7~~6.1.3

Non-circular attachment pads shall have a corner radius of at least five times the pad thickness or 50 mm (2 in), whichever is smaller.

### ~~7~~6.1.4

Production test plates~~, if required per the design code or indicated in the datasheet,~~ shall be ~~fabricated using the same base material, of same~~ welded and heat ~~and thickness, and shall be subjected to the same welding~~ treated in accordance with the procedures ~~and thermal treatment~~ used for ~~the longitudinal and circumferential weld joints~~production welds in the shell and head.

### ~~7~~6.1.5

The distance between main seam welds (longitudinal and circumferential joints) and nozzles, reinforcement or other welded attachments shall be at least 50 mm (2 in), measured weld toe to weld toe~~.~~ (see Figure 4).

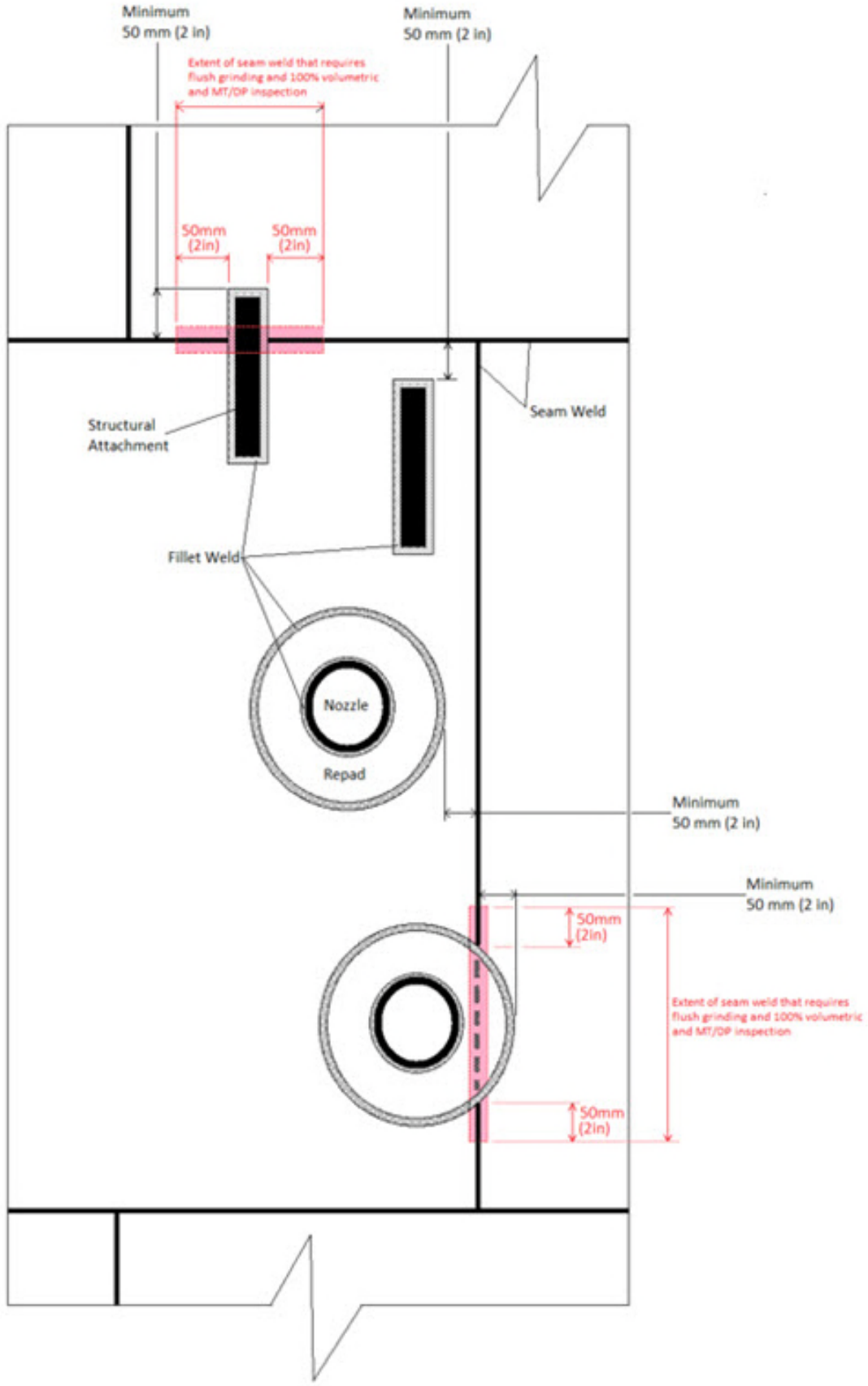



Figure 4 — Weld seams clearance and Overlapping

**6.1.6**

Where attachments ~~will~~ cover main seam welds, the length of the main seam weld covered by the attachment and projecting at least 50 mm (2 in) beyond each side of the attachment shall be ground flush ~~and inspected with 100 % volumetric examination and magnetic particle or liquid penetrant examination.~~(see Figure 4).

**~~7~~6.1.7**

~~All surfaces to be welded shall be clean and free from paint, oil, dirt, scale, oxides and other foreign material detrimental to weld integrity.~~

**~~7.1.8~~**

~~Arc strikes outside~~Where attachments cover main seam welds, the length of the main seam weld ~~area shall be removed~~covered by ~~light grinding and~~ the attachment and projecting at least 50 mm (2 in) beyond each side of the attachment shall be inspected with 100 % volumetric examination and magnetic particle or liquid penetrant examination~~.~~ (see Figure 4).

**~~7~~6.1.~~9~~8**

The thickness of all formed pressure parts shall be measured and recorded after forming ~~and shall be recorded~~.

**~~7~~6.1.~~10~~**

## 9 Permanent marking~~, if required~~

**6.1.9.1**

Permanent marking on the pressure boundary~~,~~ shall be ~~done~~applied with low-stress stamps on the outside of the vessel ~~and~~wall.

**6.1.9.2**

Permanent marking shall be applied before ~~any post weld heat treatment is performed~~PWHT.

**~~7~~6.1.~~11~~10**

Local thin areas, as defined ~~per~~in accordance with the design code, that fall below the nominal thickness of the vessel wall ~~less~~(including consideration of the specified tolerance~~,~~) shall be repaired or ~~the component shall be~~ replaced.

**6.1.11**

Fitness for service ~~or an equivalent~~ calculation shall not be used as ~~a~~ justification for ~~not repairing~~accepting identified defects ~~such as local thin areas.~~ without repair.

**~~7~~6.1.12**

Longitudinal weld seams of horizontal vessels shall be located on or above the horizontal plane through the centreline of the vessel.

## ~~7~~6.2 Welding

**~~7~~6.2.1**

~~Welding~~Pressure part welding requirements shall be in accordance with IOGP S-705.

**6.2.2**

Welds between a saddle, skirt, stiffening ring or similar external attachment and ~~welder~~a pressure part shall be continuous (intermittent welds are not allowed).

## 7 Heat treatment

When additional simulated PWHT cycles are required for weld procedure qualification, mechanical tests shall be performed ~~as per the requirements specified in the design code, datasheet and the requirements of this specification~~after the first and final PWHT cycles.

~~**7.2.2**~~

~~All welding and related activities shall comply with the requirements of ISO 3834 and ISO 14731 or ASME Section IX, if applicable.~~

~~**7.2.3**~~

~~FCAW self shielded is not permitted. FCAW gas shielded is acceptable for weld passes other than the root pass in single sided weld joints.~~

~~**7.2.4**~~

~~GTAW-P and GMAW-P shall be performed with the same make and model of equipment, and using the same program settings as those used in the qualification procedure.~~

~~**7.2.5**~~

~~Active flux shall not be used for submerged arc welding.~~

~~**7.2.6**~~

~~Any change in the following welding variables shall require requalification of the applicable welding procedure.~~

~~a. base materials:~~

~~1. carbon steel material, an increase in CE of more than 0,03 than the value qualified in the procedure qualification record, when any of the following conditions apply:~~

~~i. subject to sour service regardless of their wall thickness;~~

~~ii. the wall thickness greater than 38mm (1,5 in), regardless of the service;~~

~~iii. subject to PWHT due to service, regardless of their wall thickness;~~

~~iv. subject to impact toughness requirements.~~

~~2. carbon steel material other than covered in a.1, an increase in CE of more than 0,03 when the relevant value of the material tested during procedure qualification is greater than 0,43;~~

~~3. from type 22Cr duplex to type 25Cr duplex.~~

~~b. welding consumables:~~

~~1. consumable brand name when impact testing is required. This does not apply to solid wire provided with documentation confirming there is no change in origin, chemical composition and mechanical properties;~~

2. for SMAW, any increase of size in consumable in the root run of single sided welds;

3. for FCAW gas shielded, any increase of size in consumable other than in the root run of single sided welds;

4. for SAW, whenever the welding flux is changed from one consumable brand name to another.

c. welding position:

1. from vertical uphill to vertical downhill welding;

2. from vertical downhill to vertical uphill welding.

d. technique:

1. from multi pass to single pass when impact testing is required.

e. joints:

1. from double sided welding to single sided welding;

NOTE Single sided welding with backing strip is equivalent to double sided welding.

2. decrease in the included angle of more than 10° for included angles less than 60°;

3. deviation from qualified angle or more than ± 2,5° if the qualified angle is less than 30° (except for portions of compound bevels).

**7.2.7**

Permanent backing strips are not permitted.

**7.2.8**

After the removal of temporary backing strips, the root of the weld shall be examined by either magnetic particle or liquid penetrant examination. When metallic backing strips are used, the root of the weld shall be ground smooth before examination.

**7.2.9**

All welds directly on to pressure parts shall be continuous except for insulation support ring welds. Insulation support ring welds may be discontinuous subject to approval of the purchaser.

**7.2.10**

Tack welds incorporated into the main weld shall have their ends ground and feathered, and shall be free of visible defects.

**7.2.11**

All welding consumables shall be individually marked as per the consumable specification.

**7.2.12 Preheating**

Preheating, if required, shall satisfy the following requirements.

~~7.2.12.1~~

~~The required preheat temperature shall be reached before commencement of welding and maintained until the welding has been completed.~~

~~7.2.12.2~~

~~The preheat temperature shall be measured at a distance of not less than 75 mm (3 in) on either side of the weld groove.~~

~~7.2.12.3~~

~~The interpass temperature measurements shall be taken from deposited weld metal. The minimum interpass temperature shall not be less than the specified preheat temperature.~~

~~7.2.13~~

~~Weld repair procedures shall be approved by the purchaser prior to the commencement of any repair.~~

## ~~8 Heat treatment~~

~~8.1~~

~~When post weld heat treatment is required, simulated post weld heat treatment of production test plates and weld procedure qualifications shall be subjected to a minimum of one additional post weld heat treatment cycle.~~

~~8.2~~

~~Complete weld procedure qualification mechanical testing shall be performed both after the initial heat treatment and a second simulated post weld heat treatment.~~

~~8.3~~

~~When post weld heat treatment is required, it shall be performed after completion of all welding including any weld repairs and all weld overlay and clad restoration, if applicable.~~

~~8.4~~

~~For quenched and tempered or normalized and tempered carbon steel materials, the post weld heat treatment holding temperature shall be at least 15 °C (25 °F) below the original tempering temperature of the base metal, unless the vendor demonstrates and the purchaser approves that mechanical properties can be achieved at a different post weld heat treatment temperature and holding time.~~

~~8.5~~

~~Thermocouples, in contact with both the internal and external surfaces of the vessel, shall be used to continuously and automatically record the post weld heat treatment temperature on a chart from the start of controlled heating until the end of the controlled cooldown. The thermocouples shall be insulated from the heat source.~~

~~8.6~~

~~When post weld heat treatment is required, the minimum soak time shall not be less than one hour.~~

~~8.7~~

~~Reduced post weld heat treatment temperatures for longer duration shall not be permitted.~~

~~8.8~~

~~Any heating method associated with post weld heat treatment, which implies direct flame impingement on any part of the vessel is not permitted.~~

~~8.9~~

~~Local post weld heat treatment shall not be permitted, unless approved by the purchaser. When permitted, local PWHT design shall be based on WRC 452.~~

# 8 Non-destructive examination

## ~~9~~8.1 General

### ~~9~~8.1.1

~~All required~~ Non-destructive examination of welded joints and weld overlay for final acceptance of the vessel shall be performed after the completion of ~~all~~ welding, weld repairs and ~~post weld heat treatment, if required,~~ PWHT, and prior to pressure testing.

### ~~9~~8.1.2

The person responsible ~~person~~ for the non-destructive examination shall be qualified to ISO 9712 level III, ~~ASNT Central Certification Program (~~ACCP ~~)~~ level III or equivalent. ~~All~~

### 8.1.3

Non-destructive examination operators shall be qualified ~~to~~ in accordance with ISO 9712 level II~~,~~ or ACCP level II or equivalent ~~if specified in the datasheet~~.

### ~~9.1.3~~

~~Acceptance criteria for all non-destructive examinations shall be as per the design code or as specified in the data sheet.~~

## ~~9~~8.2 Radiographic and ultrasonic examination

### ~~9~~8.2.1

~~The extent of examination shall be in accordance with the requirements of the design code and as specified in the datasheet.~~

### ~~9.2.2~~

Where allowed by the design code, ultrasonic examination shall be acceptable in lieu of radiographic examination ~~where allowed by the design code.~~.

### ~~9~~8.2.~~3~~2

Where 100 % volumetric examination is specified, the complete length of ~~all~~ butt welds, nozzle-to-vessel wall joints, nozzle neck weld seams, nozzle to flange joints and skirt to ~~forged ring (if applicable)~~vessel wall welds shall be examined.

**~~9~~8.2.~~4~~3**

The welds of heads constructed from two or more pieces shall be ~~examined by~~subjected to 100 % volumetric examination after forming.

**~~9~~8.2.~~5~~4**

When spot radiography is ~~applicable~~specified, the purchaser or the purchaser's representative shall designate the locations at which the spot radiographs shall be taken.

**~~9~~8.2.5**

All plates with a nominal thickness greater than or equal to 50 mm (2 in), excluding any thickness of cladding or weld overlay, shall be inspected in accordance with the requirements of ASTM A578, including supplementary requirement S1 or EN 10160, as specified in the data sheet.

**8.2.6**

All forgings with a nominal thickness greater than or equal to 50 mm (2 in), excluding any cladding or weld overlay, shall be in accordance with the requirements of ASTM A388.

## 8.3 Magnetic particle or liquid penetrant examination

**~~9~~8.3.1**

~~Unless otherwise~~If not specified ~~in~~by the ~~datasheet~~design code, the minimum extent of MT or PT examination shall be as per ASME *BPVC*~~,~~ Section VIII~~-2:2017,~~, Division 2, Table 7.2.

**~~9~~8.3.2**

~~All~~ Cold formed heads shall have the inside and outside surfaces of the knuckle region examined by magnetic particle or liquid penetrant examination after completion of ~~all~~ forming and material heat treatment.

**~~10~~8.3.3**

MT or PT examination shall be performed for all lifting attachment welds.

# 9 Pressure testing

**~~10~~9.1**

~~All~~ Vessels shall be hydrostatically tested ~~at the hydrotest pressure as~~using potable water or water filtered through a 10 micrometre (1 250 openings per ~~the design code and the basis specified in the datasheet.~~ inch mesh).

**~~10~~9.2**

The ~~minimum~~more stringent water quality requirements of Annex B, Annex C or Annex D shall apply when applicable.

**9.3**

The hold time at hydrotest pressure shall ~~be one hour, unless otherwise specified on the datasheet~~not be less than 1 h.

~~10.3~~9.4

Vertical vessels ~~may be shop tested~~hydrotested in a horizontal position ~~with adequate support~~shall be supported to prevent overstress ~~ing~~ during testing.

~~10.4~~9.5

Each reinforcing pad segment shall be tested at a ~~gauge~~ pressure of 100 kPag (15 psig) with dry air or nitrogen and a bubble forming solution.

~~10.5~~

~~Hydrostatic~~9.6

Gaskets and bolting used during pressure testing shall be ~~performed with gaskets and bolting~~ identical in geometry, dimensions, bolt strength and gasket m and y factors to those required ~~in~~for service. ~~These gaskets may be service gaskets~~

NOTE If the bolted joint is not disassembled after completion of hydrostatic pressure testing, these gaskets can be service gaskets.

~~10.6~~

~~No paint, primer or any other type of coating~~ 9.7

Surface preparation and painting shall not be applied to the vessel prior to hydrostatic testing.

~~11 Coating and painting~~

~~Requirement and extent of coating shall be as specified by the purchaser.~~

## 10 Preparation for shipment

### ~~12~~10.1 General

#### ~~12~~10.1.1

~~All~~ Vent holes shall be plugged after testing.

#### 10.1.2

The ~~plugging~~ material used to plug vent holes shall not be capable of sustaining pressure between the reinforcing plate and the vessel wall.

#### ~~12~~10.1.~~2~~3

~~Unless otherwise specified,~~ The vessel shall be shipped with service gaskets and bolting in place for ~~all~~ body flanges, custom designed flanges and permanently blinded connections.

#### ~~12.1.3~~

~~Unless otherwise specified, steel shipping saddles shall be provided for vertical vessels.~~

### ~~12~~10.1.4

A barrier material shall be provided between shipping saddles and the vessel to prevent damages to the surface of the vessel or contamination of the vessel material.

### ~~12.1.5~~

~~Baseplates, saddles or skirts may be welded to the deck of ships, barges, railcars, and trailers even if the vessel has been post weld heat treated.~~

## ~~12~~10.2 Protection

### ~~12~~10.2.1

~~All~~ Liquids used for cleaning or testing shall be drained from the vessel and any residues dried prior to shipment.

### ~~12~~10.2.2

The vessel shall be free of any foreign matter prior to shipment.

### ~~12~~10.2.3

Removable internal and external parts assembled with the vessel prior to shipment shall be tied or braced with temporary supports~~, as necessary, to prevent damage or dislodgement during shipment and installation~~.

### ~~12~~10.2.4

Temporary supports shall be painted with a fluorescent colour paint.

### ~~12~~10.2.5

~~All~~ Exposed machined and threaded surfaces on the vessel and parts to be shipped loose shall be ~~suitably~~ protected ~~to prevent damage and corrosion~~with rust preventive.

### ~~12~~10.2.6

~~Unless otherwise specified,~~ Flanges shall be blanked with oil-resistant rubber gaskets or self-adhesive flange protectors and steel or water resistant plywood blanks with a minimum of four bolts~~ sufficient to provide mechanical protection, and water and dust tight sealing.~~.

### ~~12~~10.2.7

~~**Unless specified in the datasheet, the use of nitrogen or other means of creating an oxygen deficient atmosphere shall not be used for**~~ **Vessel purging** ~~**during transportation and storage.**~~

### ~~12~~10.2.7.1

When an inert gas purge is specified, the pressure shall be maintained at ~~no less than a gauge pressure~~a minimum of 35 kPag (5 psig) indicated by a pressure gauge during transportation and storage.

**~~12~~10.2.7.2**

Gauges shall be ~~suitably~~ protected from damage during transportation.

**~~12~~10.2.7.3**

When the vessel is purged with dry air and desiccant bags are placed in the vessel, the ~~vendor shall record the~~ quantity and location of the desiccant bags shall be recorded.

## ~~12~~10.3 Identification

**~~12~~10.3.1**

The exterior of the vessel shall be marked with the vessel tag number, shipping weight and purchase order number with a minimum of 75 mm (3 in) high letters of contrasting colour~~. For vessels less than 1 000 mm (40 in) inside diameter these markings may have 25 mm (1 in) high letters.~~ against the background.

**~~12.3.2~~**

~~For all vessels,~~NOTE Other markings ~~other than those required under 12.3.1~~ may have 25 mm (1 in) high letters.

**~~12~~10.3.~~3~~2**

The centre of gravity shall be marked on each side of the exterior of the vessel.

**~~12~~10.3.~~4~~3**

Vessels that have received ~~post weld heat treatment~~PWHT shall be labelled or painted with the text ~~“~~"POST WELD HEAT TREATED – DO NOT BURN OR WELD~~”.~~".

**~~12~~10.3.~~5~~4**

~~Any~~ Equipment protected by an inert gas fill shall ~~have~~display the warning "DANGER - NON-LIFE SUPPORTING ATMOSPHERE" ~~displayed~~ in the immediate vicinity of any ~~manways or~~manway and other point~~s~~ of access to the interior of the vessel.

# Annex A
(normative)
# Additional requirements for sour service vessels

## A.1

The requirements specified by this annex are minimum requirements. If more stringent requirements such as butt-welded type nozzles, forged ring type skirt to head joints, and full penetration groove welds for welded attachments, etc. are required based on severity of the service, these shall be agreed between the purchaser and the vendor.

## A.2

AllThe requirements of ISO 15156 / /NACE MR0175 (all parts) or ISO 17945 / /NACE MR0103 shall be satisfied.

## A.3

All Nozzles shall be set-in type, integrally reinforced and fitted flush with the shell or head.

## A.4

All Butt welds shall be subjected to 100 % volumetric examination.

## A.5

Nozzle-to-vessel wall joints shall be 100 % ultrasonically tested.

## A.56

All Welds directly to the internal surfaces of the pressure part shall be subjected to 100 % surface inspection by magnetic particleWFMT or liquid penetrant examination.

## A.6

For carbon steel vessels, the preheat temperature reported during procedure qualification is an essential variable and shall be the minimum specified preheat temperature for production welding.

## A.7

Welding procedures for the fabrication of vessels shall be qualified using supplementary hardness testing after the minimum anticipated heat treatment cycle (normally, the first heat treatment cycle).

## A.8

Heat input values (per welding process) used for production welding shall not be less than the minimum heat input (per welding process) reported during procedure qualification.

## A.9

The following dissimilar welds if in contact with process fluid (wetted surface) are not permitted unless approved by the purchaser:

a. ferritic steels and austenitic stainless steel;

b. ferritic steels and 22Cr duplex or 25Cr duplex;

c. ferritic steels and nickel base alloy steels.

A.10When HIC testing is specified in the datasheet, one plate per lot shall be HIC tested in accordance with NACE TM0284, using test solution A and the following.

## A.8

The acceptance criteria shall apply for HIC testing for sour service shall be in accordance with the following:

a. crack length ratio (a) CLR) ≤ lesser than or equal to 15 % per specimen;

b. crack thickness ratio (b) CTR) ≤ lesser than or equal to 5 % per specimen;

c. crack sensitivity ratio (c) CSR) ≤ lesser than or equal to 2 % per specimen;

d.) 5 mm (0,2 in) maximum individual crack length.;

e.) ultrasonically tested as per ASTM A578 S1;, S2.1 or EN 10160 quality classes S2 (plate) E3 (edge).

## A.9

PWHT shall be performed for all vessels in sour service.

## A.10

Unless they are vented in accordance with 6.1.1, external attachments shall be welded to the pressure boundary with full penetration welds.

## A.11

Internal attachments shall be welded to the pressure boundary with full penetration welds.

# Annex B
(normative)
# Additional requirements for integrally clad and weld overlay vessels

This annex covers the requirements for integrally clad and weld overlaid carbon steel with austenitic stainless steel, alloy 276, alloy 625 or alloy 825.

## B.1 General

### B.1.1

~~Acceptable~~The method of cladding ~~methods are:~~

~~a.~~ shall be integral cladding ~~achieved~~ by hot rolling ~~or~~, explosion bonding~~;~~

~~b.~~ or weld overlay.

### B.1.2

The base metal nominal thickness shall not be less than 10 mm (~~3/8~~(⅜ in).

### B.1.3

The minimum thickness of cladding or overlay welding shall be 3 mm (~~1/8~~(⅛ in~~).~~) after machining.

### B.1.4

Design calculations shall be based on the base material thickness after clad restoration, excluding the ~~thickness of the cladding.~~

~~**B.1.5**~~

~~When post weld heat treatment is required, weld procedure qualifications shall include corrosion testing according to ASTM A262 practice E~~ machining allowance for ~~austenitic stainless steel.~~

~~Test coupons shall be heat treated prior to testing with at least twice the fabrication heat treatment soak time as specified for the equipment.~~

~~B.1~~clad restoration (see Annex J, Drawing S619 J.6).

~~Surfaces contaminated with iron during fabrication shall be pickled and passivated.~~

### B.1.~~7~~5

The chloride content of the hydrostatic test water shall not exceed 50 mg/kg (50 parts per million by mass).

## B.~~1.8~~2 Nozzles

### B.2.1 ~~.8.1~~

The minimum nozzle size for nozzles in cladded sections shall be DN 50 (NPS 2~~) unless otherwise specified by the purchaser in the datasheet.~~).

### B.~~1.8.~~2.2

Nozzles shall be clad, either integrally or by weld overlay.

NOTE Nozzles DN 100 (NPS 4) and smaller and girth flanges may be of solid alloy subject to the purchaser~~'~~'s approval.

### ~~If~~B.2.3

When nozzles are rolled from integrally clad plate, the longitudinal and circumferential welds in the nozzle section shall be subjected to 100 % volumetric examination.

### B.~~1.8.3~~2.4

Radius or profiling at nozzle connections shall not reduce ~~any~~the clad thickness below the specified minimum value.

## B.~~2~~3 Integral cladding

### B.~~2~~3.1

~~Unless specified in the design code,~~Integrally clad plates shall comply with the requirements of ASTM A263, ASTM A264 or ASTM A265~~.~~ including supplementary requirement S12 with a bond quality level of Class 1.

### B.3.2 ~~2~~

~~Plates shall be ultrasonically tested as per acceptance criteria agreed with the purchaser.~~

### ~~B.2.3~~

Formed heads or sections shall be ultrasonically tested after forming~~.~~

### ~~B.2.4~~

~~Cut areas shall be ultrasonically examined within 50 mm (2 in) from~~ in accordance with the ~~edge of the opening~~requirements specified under B.3.1.

### B.~~2.5~~3.3

~~Attachments may~~Shear strength tests shall be ~~welded directly to~~performed on all integrally clad steel plates ~~if all~~ in accordance with the provisions of the ~~following conditions are met~~applicable material specification.

### ~~a.~~ B.3.4 Internal attachments

### B.3.4.1

When the induced weld stress due to thermal and mechanical loads on the attachment ~~do not exceed~~exceeds 25 % of the allowable shear stress or 50 % of the allowable tensile stress for the weld~~;~~, welding of internal attachments to integrally clad plates shall not be permitted.

~~b. the temperature difference between the shell and the attachment is not expected to exceed 14 °C (25 °F).~~

### ~~All other~~B.3.4.2

Internal welded attachments that do not meet the requirements in B.3.4.1 shall be welded directly to the base metal after stripping back the cladding locally. ~~Cladding shall be restored by weld overlay.~~

~~B.2.6~~

~~When clad restoration is required, the clad layer shall be stripped back to a minimum distance of 5 mm (0,2 in) from the edge of the bevel. The edge of the cladding shall be rounded with a minimum radius of 1,5 mm (0,06 in) or tapered to a minimum angle of 30°. The stripped back area shall be etched with either a nitric acid or copper sulfate solution to ensure complete removal of the clad.~~

~~B.3~~B.3.4.3

When an integrally clad plate has regions that are locally stripped back, the stripped back areas shall be restored by weld overlay.

## B.4 Weld overlay

### B.~~3~~4.1

~~A minimum of two layers shall be applied for all overlay welding. Electroslag strip cladding may be performed with a single pass subject to the purchaser's approval.~~

~~B.3.2~~

~~The weld qualification procedure shall establish that the specified chemical composition of the filler metal is met at a depth of at least 1,5 mm (0,06 in) from the minimum specified thickness.~~

~~B.3.3~~

~~The maximum iron content for alloy 276 and alloy 625 overlay shall be 10 %.~~

~~B.3.4~~

Internal attachments in weld overlaid sections shall be welded ~~directly~~ to the overlay.

### B.~~3.5~~4.2

For transition areas at nozzles and flanges, ~~the vendor shall provide~~ a fabrication procedure ~~which~~ shall ~~as a minimum~~be provided.

### B.4.3

The fabrication procedure shall include~~:~~ as a minimum all of the following.

a~~.~~) Detailed arrangement drawing showing:

~~–~~1) functionality of the nozzle or flange;

~~–~~2) set in or set on;

~~–~~3) preparation of the nozzle or flange;

~~–~~4) tapering;

~~–~~5) line up and measurement prior to overlay welding.

b~~.~~) Details of overlay welding ~~,–~~including:

~~–~~1) reference to the applicable welding procedure;

–2) number of layers.

c~~;~~) Method of preparation after overlay welding~~;~~.

d~~.~~) Examination after overlay welding ~~,~~–including:

–1) thickness;

–2) liquid penetrant~~;~~;

3) ferrite testing.

**B.~~3.6~~4.4**

~~The frequency and extent of thickness verification shall be agreed between the purchaser and the vendor.~~

**~~B.3.7~~**

Where there is change in geometry for highly stressed areas (~~such as~~e.g. nozzle or manway welds in shells or heads, internal beam support weld build-ups~~, etc.),~~), the weld overlay shall ~~have~~be provided with a smooth contour finish ~~with~~and a minimum radius of 6 mm ~~(0,25~~(¼ in).

**B.~~3.8~~ 4.5**

~~All~~Weld overlay, clad restoration welds~~, clad restoration~~ and internal attachment welds ~~and internal attachment welds~~ shall be subject~~ed~~ to 100 % liquid penetrant examination.

**B.~~3.9~~4.6**

~~If overlay welding is to be machined, such as nozzles and flange facings, machined surfaces shall be subject to liquid penetrant examination. If the overlay is examined 100 % prior to any final post weld heat treatment, the overlay shall be re-examined after heat treatment and final hydrostatic testing.~~

Weld overlaid surfaces shall be examined with the liquid penetrant method after final machining.

**B.~~3.10~~4.7**

The test acceptance criteria for liquid penetrant ~~examination~~inspection of weld overlay shall be zero ~~linear~~ cracks or crack-like indications~~. All linear indications shall be repaired.~~ and zero open defects of any size.

**B.~~3.11~~4.8**

~~For~~ Any linear indication in the weld overlay as identified by the liquid penetrant ~~examination of austenitic stainless steel, neither the penetrant nor the developer~~test shall ~~contain any chlorides.~~

be repaired.

### B.4.9

When partial removal of the final weld overlay or clad layer is performed by grinding, machining or another method, a copper sulphate test shall be performed on all surfaces that were subjected to metal removal during the grinding or machining process.

# Annex C
(normative)
# Additional requirements for carbon steel vessels

## C.1

~~All plates having a nominal thickness greater than or equal to 50 mm (2 in) shall be subject to ultrasonic examination. The acceptance criteria shall be as specified in the datasheet.~~

## ~~C.2~~

~~All forgings (except standard flanges) having a nominal thickness greater than or equal to 50 mm (2 in) shall be subject to ultrasonic examination. The acceptance criteria shall be as specified in the datasheet.~~

## ~~C.3~~

The maximum allowable CE shall be in accordance with Table C.1.

**Table C.1 — Maximum allowable CE**

| Nominal plate thickness | Maximum allowable CE |
|---|---|
| ≤ 50 mm (2 in) | 0,43 |
| > 50 mm (2 in) ≤ 100 mm (4 in) | 0,45 |
| > 100 mm (4 in) | 0,48 |

## C.~~4~~2

The maximum carbon content of carbon steel material shall not exceed 0,23 %.

## C.~~5~~3

Cold formed heads shall be normali~~s~~zed after forming.

## C.4

Hot formed heads not formed in the normali~~s~~zing range shall be normali~~s~~zed.

## C.~~6~~5

The ~~maximum interpass temperature shall be 315 °C (600 °F).~~

## ~~C.7~~

~~When magnetic particle testing is applicable, internal welds shall be examined using the wet fluorescent method. External welds shall be examined using either the wet visible or wet fluorescent method.~~

## ~~C.8~~

~~Minimum acceptable~~ minimum Charpy impact ~~energy~~ values, at the minimum design metal temperature or impact testing temperature specified in design code (whichever is lower~~,~~), shall be ~~average~~ 27 J (20 ft-lb)

average of three specimens and ~~single~~ 20 J (15 ft~~-~~-lb) ~~or as specified in~~minimum for a single specimen, unless the design code~~, whichever is higher.~~ contains more stringent requirements.

## C.6

Impact testing shall include testing of specimens from the base metal, weld metal and heat affected zone.

## C.~~9~~7

The chloride content of the hydrostatic test water shall not exceed 250 mg/kg (250 parts per million by mass).

# Annex D
(normative)
# Additional requirements for austenitic stainless steel, 22Cr and 25Cr duplex vessels

## D.1 General

### D.1.1

Materials shall be supplied in a solution annealed condition. ~~Stainless steel grades 321 and 347 shall be stabilized after solution annealing heat treatment.~~

### D.1.2

Cold formed heads and tori-conical transition sections shall be solution annealed after forming and before welding to the shell.

### D.1.3

Hot formed heads shall be solution annealed followed by rapid cooling.

### D.1.4

Arc-air or oxy-gas methods of cutting and bevelling ~~are~~ shall not be permitted.

## D.2 Contamination control

### D.2.1

~~The vendor~~Procedures shall ~~have~~be in place ~~measures~~ to ensure no cross-contamination between ferritic ~~and~~ , austenitic ~~and~~ or duplex materials.

### D.2.2

~~Only stainless steel brushes and clean, iron-free sand, ceramic or stainless steel grit shall be used for cleaning surfaces.~~

~~**D.2.3**~~

~~Cleaning tools or materials shall not have been previously used on carbon steel.~~

~~D.2.4~~Exterior surfaces shall be protected from chloride exposure during fabrication, shipping and storage.

**D.2.3**

Materials for marking, painting or inspection shall not contain halides and heavy metals.

**D.2.4**~~**at all times**~~

Aluminium and zinc containing paints shall not be used for material identification.

**D.2.5**

~~Materials for marking, painting or inspection containing halides and heavy metals shall not be used. Aluminium and zinc based paints shall not be used for material identification.~~

**~~D.2.6~~**

The chloride content of the hydrostatic test water shall not exceed 50 mg/kg (50 parts per million by mass).

## D.3 Ferrite ~~control~~measurement

**D.3.1**

~~Ferrite control shall be required for austenitic stainless steel weld metal if any of the following conditions are met.~~

~~a. the material is operating in high temperature service;~~

~~b. the weld will be post weld heat treated;~~

~~c. the welding procedure is qualified with impact testing.~~

~~D.3.2~~The ~~ferrite number (~~FN~~)~~ shall be measured during procedure qualification and production welding prior to any post weld heat treatment using a ~~ferritescope~~ferrite scope calibrated in accordance with ISO 8249 or AWS A4.2.

**D.3.2**

**~~D.3.3~~**

Ferrite number measurements of production welds shall ~~as a minimum~~ include all longitudinal and circumferential pressure retaining welds~~, and~~.

**D.3.3**

A minimum of three separate measurements per weld shall be performed~~ per weld.~~.

**~~D.3.4~~**

~~The ferrite number for procedures qualification and production welds of austenitic stainless steel material requiring impact testing or in high temperature service shall not exceed 8FN.~~

**~~D.3.5~~**

~~When post weld heat treatment is specified, the acceptable ferrite number range shall be 3FN to 10FN, except for type 347 weld deposit which shall have a minimum of 5FN~~

## D.4 Welding

**~~D.4.1~~**

~~The chemical composition of welding consumables and as welded deposits during procedure qualification shall met the requirements of API RP 582.~~

**~~D.4.2~~**

The minimum preheat temperature shall be 10 °C (50 °F).

~~D.4.3~~

~~Unless otherwise qualified, the maximum interpass temperature shall not exceed the values listed in Table D.1.~~

~~Table D.1 – Interpass temperature limits~~

| ~~Material~~ | ~~Maximum interpass temperature~~ |
|---|---|
| ~~Austenitic stainless steel~~ | ~~175 °C (350 °F)~~ |
| ~~22Cr Duplex~~ | ~~150 °C (300 °F)~~ |
| ~~25Cr Duplex~~ | ~~120 °C (250 °F)~~ |

~~D.4.4~~

~~The maximum variation in heat input shall be ± 15 %.~~

## D.5 Pickling and passivation

### D.5.1

The internal surfaces of vessels with a wall thickness of less than 10 mm ~~(3/8~~(⅜ in~~),~~) shall be pickled and passivated after completion of all welding activities.

### D.5.2

Surfaces contaminated with iron during fabrication shall be pickled and passivated.

~~Surfaces contaminated with iron during fabrication shall be pickled and passivated.~~

### D.5.3

~~All~~ Internal and external surfaces of welds shall be pickled and passivated.

## D.6 Special requirements for 22Cr duplex and 25Cr duplex

### D.6.1

~~All~~ Pressure retaining components shall be supplied by manufacturers qualified in accordance with the requirements of ISO 17782 or NORSOK M-650.

### D.6.2 ~~Welding procedure qualification~~

~~D.6.2.1~~

The ~~weld hardness~~maximum number of repairs of the same defective area shall not exceed the values listed in Table D.~~2~~1.

**Table D.~~2 — Hardness~~1 — Repair limits**

| Material | ~~Maximum weld hardness~~Repairs allowed |
|---|---|
| 22Cr Duplex | ~~320 HV10 or 28 HRC~~2 |
| 25Cr Duplex | ~~350 HV10 or 32 HRC~~1 |

~~D.6.2.2~~

~~For 25Cr duplex with thickness ≤ 7mm (0,276 in), the minimum thickness qualified shall be the thickness of the test piece.~~

**D.6.3**

~~Corrosion testing, impact testing, ferrite measurement and microstructure examination shall be carried out according to ISO 17781.~~

~~D.6.4~~

~~Ferrite measurement shall include the heat affected zone and shall comply with the ferrite content requirements of the weld metal.~~

~~D.6.5~~

~~The maximum number of repairs of the same defective area shall not exceed the values list in Table D.3.~~

~~Table D.3 – Repair limits~~

| ~~Material~~ | ~~Repairs allowed~~ |
|---|---|
| ~~22Cr Duplex~~ | ~~2~~ |
| ~~25Cr Duplex~~ | ~~1~~ |

~~D.6.6~~

22Cr duplex and 25Cr duplex shall not be post weld heat treated.

# Annex E
(normative)
# Vessel tolerances

## E.1

~~Unless otherwise specified by the design code,~~ Tolerances shall be in accordance with the design code, and Figure E.1 or Figure E.2.

## E.2

Where tolerances for horizontal vessels are not shown, vertical vessel tolerances shall be applied.

## E.3

Tangent lines, principal axis centre lines and orientation shall be punch marked externally.

## E.4

Out of roundness tolerance for skirts shall be ~~as per~~ in accordance with the design code for shell under external pressure.

## E.5

Flatness tolerances for vessel support base plates (e.g. skirts, legs, lugs and saddles) shall be ±6 mm ~~(¼~~ (¼ in).

## E.6

For nozzles supplied with an agitator mounting, the maximum out of plane ~~,~~ tolerance shall be ±0,25°.

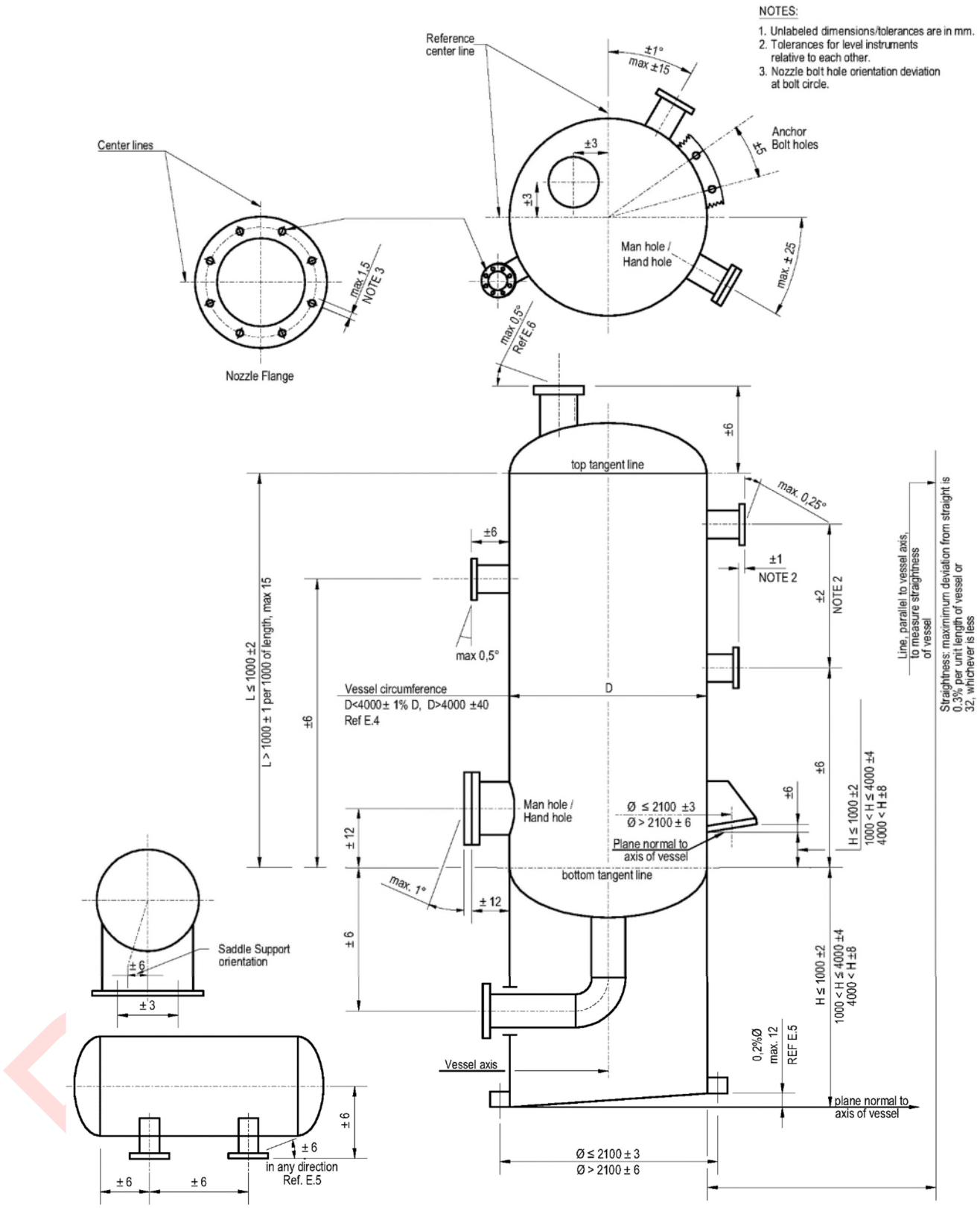
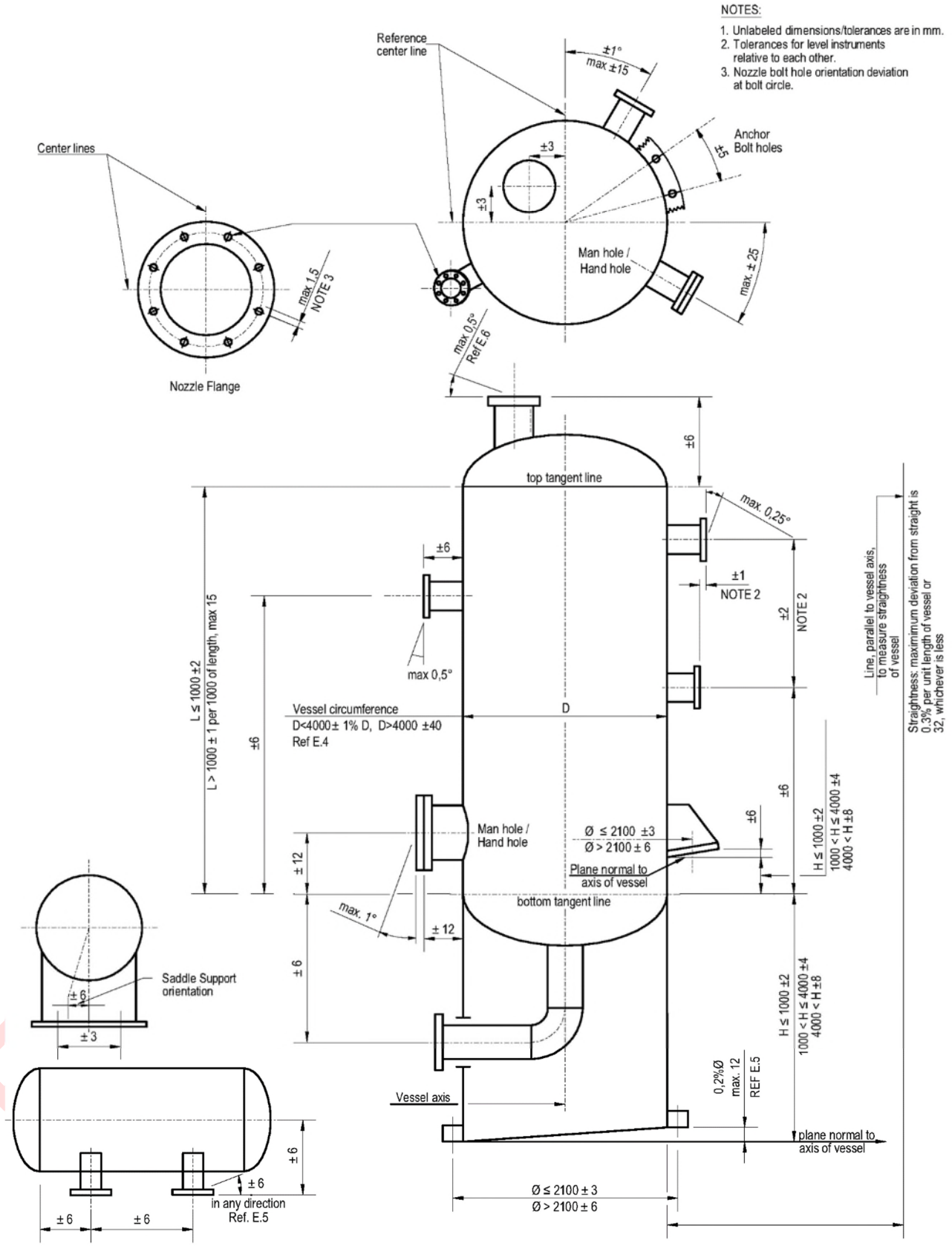



**Figure E.1 — Vessel tolerances (SI units)**


NOTES:
1. Unlabeled dimensions/tolerances are in mm.
2. Tolerances for level instruments relative to each other.
3. Nozzle bolt hole orientation deviation at bolt circle.
Reference center line
±1°
max ±15
Anchor Bolt holes
±3
Center lines
Man hole / Hand hole
max. ± 25
max 1,5
NOTE 3
Nozzle Flange
max 0,5°
Ref E.6
±6
top tangent line
max. 0,25°
±6
±1
NOTE 2
±2
NOTE 2
max 0,5°
L ≤ 1000 ±2
L > 1000 ± 1 per 1000 of length, max 15
±6
Vessel circumference
D<4000± 1% D, D>4000 ±40
Ref E.4
D
Line, parallel to vessel axis, to measure straightness of vessel
Straightness: maximum deviation from straight is 0.3% per unit length of vessel or 32, whichever is less
Man hole / Hand hole
Ø ≤ 2100 ±3
Ø > 2100 ± 6
±6
±6
H ≤ 1000 ±2
1000 < H ≤ 4000 ±4
4000 < H ±8
Plane normal to axis of vessel
±12
bottom tangent line
max. 1°
±12
±6
Saddle Support orientation
±6
±3
H ≤ 1000 ±2
1000 < H ≤ 4000 ±4
4000 < H ±8
0,2%Ø
max. 12
REF E.5
Vessel axis
plane normal to axis of vessel
±6
±6
in any direction
Ref. E.5
±6
±6
Ø ≤ 2100 ± 3
Ø > 2100 ± 6

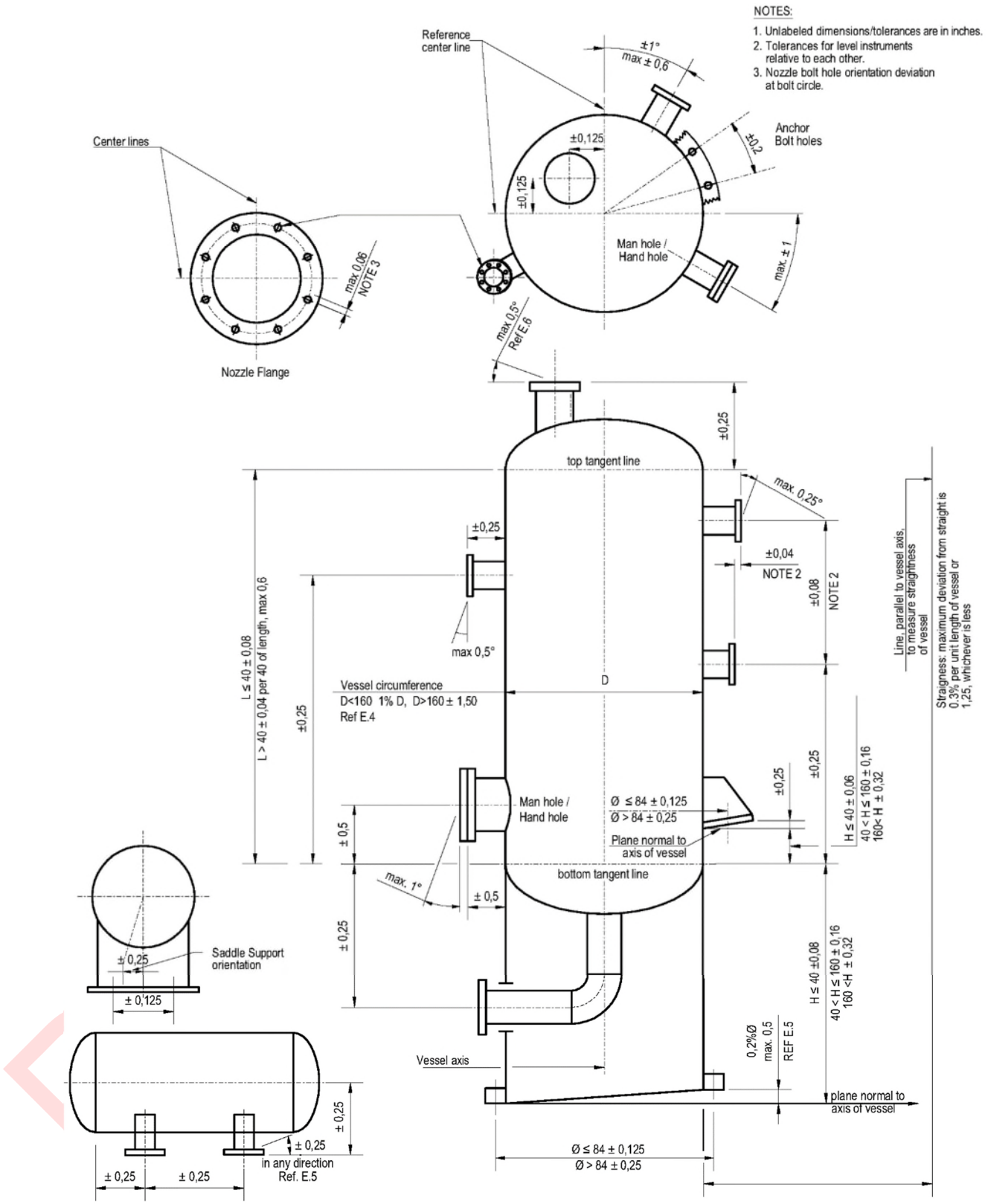
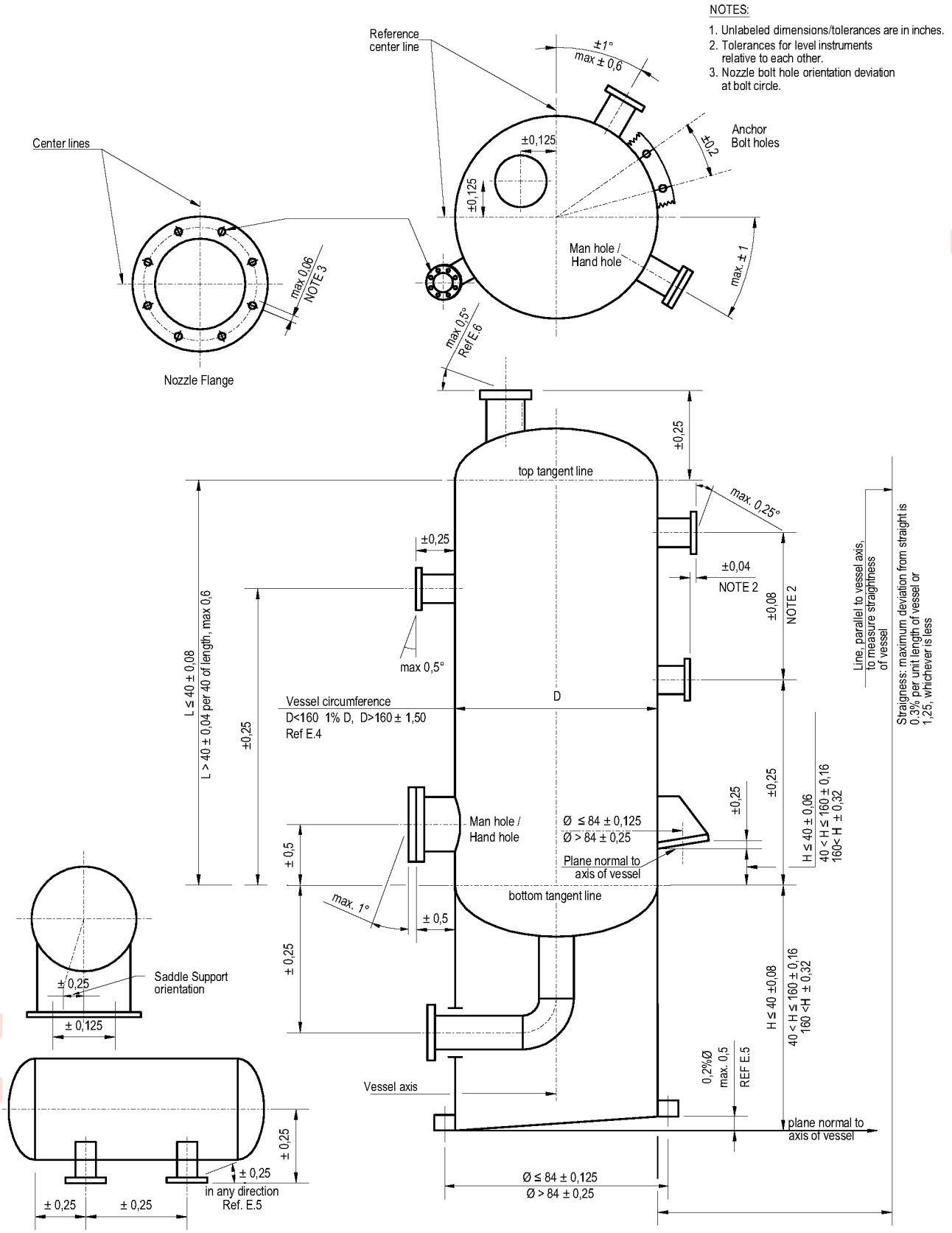



**Figure E.2 — Vessel tolerances (US customary units)**


NOTES:
1. Unlabeled dimensions/tolerances are in inches.
2. Tolerances for level instruments relative to each other.
3. Nozzle bolt hole orientation deviation at bolt circle.
Reference center line
±1°
max ± 0,6
Center lines
±0,125
Anchor Bolt holes
±0,2
±0,125
Man hole / Hand hole
max. ± 1
max. 0,06 NOTE 3
Nozzle Flange
max. 0,5° Ref E.6
±0,25
top tangent line
max. 0,25°
±0,25
±0,04
NOTE 2
±0,08
NOTE 2
max 0,5°
L ≤ 40 ± 0,08
L > 40 ± 0,04 per 40 of length, max 0,6
±0,25
Vessel circumference
D<160 1% D, D>160 ± 1,50
Ref E.4
D
Line, parallel to vessel axis, to measure straightness of vessel
Straigness: maximum deviation from straight is 0,3% per unit length of vessel or 1,25, whichever is less
±0,25
±0,25
H ≤ 40 ± 0,06
40 < H ≤ 160 ± 0,16
160< H ± 0,32
Man hole / Hand hole
Ø ≤ 84 ± 0,125
Ø > 84 ± 0,25
Plane normal to axis of vessel
±0,5
max. 1°
± 0,5
bottom tangent line
± 0,25
Saddle Support orientation
± 0,25
± 0,125
H ≤ 40 ±0,08
40 < H ≤ 160 ± 0,16
160 <H ± 0,32
0,2%Ø max. 0,5
REF E.5
Vessel axis
plane normal to axis of vessel
± 0,25
± 0,25
in any direction Ref. E.5
± 0,25
± 0,25
Ø ≤ 84 ± 0,125
Ø > 84 ± 0,25

# Annex F
(normative)
# Requirements for maximum allowable corrosion allowance (MACA)

The MACA for pressure components is the difference between the nominal thickness and the calculated required (retirement) thickness ~~as per~~in accordance with the design code. The MACA is the sum of the design minimum corrosion allowance (internal, external or both) plus the ~~rounded~~thickness added ("round up thickness~~. These are added~~") to obtain a commercially available nominal thickness.

## ~~F.1~~

~~When~~The MACA methodology is ~~specified in the datasheet, the following requirements shall be applied~~used to optimize the design for ~~corrosion allowance.~~

## ~~F.2~~

~~For formed components, nominal thickness shall be as measured after forming.~~

## ~~F.3~~

~~To calculate MACA, the maximum allowable working pressure of the vessel shall be equal to the design pressure.~~

## ~~F.4~~

~~Nozzle reinforcement calculations per the design code shall be performed using the area contributed by the vessel wall equal to zero. Additional thickness that is added to the vessel wall for the sole purpose of reinforcement may be used for the area contributed by vessel wall.~~

~~EXAMPLE~~

~~A vessel designed per ASME BPVC Sec. VIII based on an area replacement philosophy, the nozzle reinforcement calculations per ASME BPVC.VIII.1, UG-37 or ASME BPVC.VIII.2, Part 4.5 is performed using $A_1$ = 0. Additional thickness that is added to the component for the sole purpose of reinforcement may be used for $A_1$.~~

## ~~F.5~~

~~If the pressure area method is used for nozzle reinforcement calculation, plate thickened solely for nozzle reinforcement~~the CA. The CA is not required to be ~~counted towards MACA.~~displayed on the nameplate by the ASME code or by this specification.

## ~~F.6~~

~~When attached~~Calculation of the MAWP is not required for vessels build to ~~cylindrical shell~~ ASME *BPVC*, Section VIII, Division 1; the design pressure may be substituted for the MAWP. However, this specification allows for the MAWP to be calculated as an option after the MACA has been determined. This calculated MAWP may be slightly higher than the design pressure.

## F.1

The MACA shall be determined individually for each of the cylindrical, straight conical or flat major components~~, the corrosion allowance of~~ first.

## F.2

The MACA shall be calculated regardless of whether the CA is internal or external.

NOTE Where the as-built head and minor ~~components (e.g.~~component (typically a nozzle~~ neck, nozzle flange, etc.) shall~~) configuration allows, it is preferable for the minor component to inherit the MACA of ~~the cylindrical~~its parent major component.

## F.3

The reinforcement requirements of openings shall be calculated after the MACA for the parent component has been determined.

## F.4

Thickness added to the component for additional reinforcement or for meeting the supplemental minimum thickness requirements of other standards is not required to be counted towards the MACA.

EXAMPLE 1 (SI) A shell course may be designed with a required thickness of 5,7 mm plus a design CA of 3,0 mm at 8,7 mm. This is rounded up to 10 mm as the next commonly available thickness. If the fabricator chooses or is required by TEMA to use 12 700 mm plate, the MACA is calculated based on 10 mm, thus MACA is 4,3 mm. Accounting for the slight increase in ID with a larger CA as well as roundoff error, it is likely that the actual MACA will drop to 4,2 mm. The excess 3 mm can be allocated to opening reinforcement, external nozzle loads, etc. or at the fabricator's option added to the MACA.

EXAMPLE 2 (US Customary) A shell ~~component.~~course may be designed with a required thickness of 0,225 in plus a design CA of 0,125 in at 0,350 in. This is rounded to 0,375 in as the next commonly available thickness. If the fabricator chooses or is required by TEMA to use 0,500 in plate, the MACA is calculated based on 0,375 in, thus MACA is 0,15 in. Accounting for the slight increase in ID with a larger CA as well as roundoff error, it is likely that the actual MACA will drop to 0,14 in. The excess 0,250 in can be allocated to opening reinforcement, external nozzle loads, etc. or at the fabricator's option added to the MACA.

## F.~~7~~5

~~When attached to a formed head or formed transition component, the corrosion allowance of minor components shall be 150 % of the vessel's design corrosion allowance.~~

## ~~F.8~~

~~MACA for each major component shall be, as a minimum, calculated to the nearest 0,2 mm (0,01 in).~~

## ~~F.9~~

The MACA of the pressure component need not exceed twice the design ~~corrosion allowance~~CA for that component.

## F.6

When attached to a formed head or formed transition component, the CA of minor components may be designed using 150 % of the vessel design corrosion allowance instead of a calculated MACA.

## F.7

The MACA for each major component shall be calculated to the nearest 0,2 mm (0.01 in).

## F.8

For vessels with more than one shell course, the MACA shall be calculated separately for each course.

## F.9

When attached to cylindrical shell components, straight conical transitions or flat heads, the CA of minor components (e.g. nozzle neck, nozzle flange) shall inherit the MACA of the cylindrical shell or flat head component that it is attached to.

## F.10

The thickness of formed heads and formed knuckles for conical transition components shall be measured after forming.

## F.11

The as-built MACA shall be calculated based on the as-received thickness.

## F.12

Calculations shall clearly state the minimum required thickness for all major components of the vessel.

## F.13

The minimum required thickness for all major components shall be included in a table on the general arrangement drawing.

## F.14

The MACA of each major component shall be listed on the manufacturer’s data report.

## F.15

The manufacturer's draft data report shall be submitted to the purchaser for review and approval.

# Annex G
(normative)
# Additional requirements for vessels in cyclic service

There is a range of operating conditions that may be considered fatigue service based upon the cyclic loading screening requirements in the selected code of construction. However, some vessels may be designed for a relatively small number of operating cycles (e.g. the range of 100 to 1 000 cycles) and may therefore be operating in a lower severity cyclic service application. In other cases, a vessel may be designed for a large number of cycles (e.g. 100 000 or more cycles) and/or experience extreme stress cycles associated pressure and thermal stress, and are as such in a more severe cyclic service application. Examples of this category include PSA vessels, molecular sieve dryer vessels, or coke drums.

Appropriate mechanical details for vessels in these two broad categories may be quite different. For vessels that are designed for a small number of operating cycles, the mechanical details specified in Section 4 to Section 10 may prove to be sufficient provided the local stress at critical locations is accurately accounted for in the fatigue design calculations.

For vessels designed for a larger number of operating cycles, experience has shown that the mechanical details similar to those included in Section 4 to Section 10 of this specification may not be sufficient to ensure reliable, predictable operation. This is due to the following difficulties:

a) accurately predicting the local stress at a discontinuity;

b) assuring a defect free vessel for some detail types during initial fabrication;

c) inspecting certain detail types for fatigue cracks after the vessel has experienced a number of operating cycles.

The mechanical design requirements in Annex G have been selected assuming that a vessel is designed for a cyclic operating condition that is more likely to result in unreliable, unpredictable fatigue life if the Annex G requirements are not followed.

The mechanical design of vessels intended for less severe cyclic service applications is outside the scope of this annex. However, the mechanical design of the vessels shall be evaluated for cyclic service in accordance with the code of construction and either found to be exempt or analyzed in order to demonstrate compliance to the code. Vessels intended to be stamped as compliant with ASME *BPVC*, Section VIII, Division 1 can either be demonstrated to be exempt from fatigue analysis basis and the ASME cyclic loading screening criteria or to pass a fatigue analysis in accordance with ASME *BPVC,* Section VIII, Division 2, Part 5.

## G.1

If the selected design code is ASME *BPVC*, Section VIII, Division 1, the screening and evaluation method for fatigue analysis shall be in accordance with ASME *BPVC*, Section VIII, Division 2.

## G.2

If other than ASME *BPVC*, Section VIII, Division 1, the selected design code does not include a screening and evaluation method for fatigue analysis, ASME *BPVC*, Section VIII, Division 2, EN 13445, PD 5500 or API Standard 579-1/ASME FFS-1 shall be used.

## G.3

Fatigue analysis shall include attachments welded to the pressure envelope and the following locations:

a) head-to-shell;

b) support-to-vessel;

c) nozzle-to-vessel wall, considering external piping loads.

## G.4

Integrally reinforced nozzles shall be used.

## G.5

Internal and external attachments welds shall be full penetration type excluding welds attaching saddle wear pads to a vessel wall.

## G.6

The cap of all butt welds shall be ground smooth with the parent material.

## G.7

Fillet welds caps on a full penetration weld shall be ground to form a smooth transition with the parent metal.

## G.8

Butt welds shall be subjected to 100 % volumetric examination and surface examination by MT or PT.

## G.9

Nozzle-to-vessel wall welds shall be subjected to 100 % volumetric examination and surface examination by MT or PT.

## G.10

Welds between attachments and the pressure envelope shall be subjected to 100 % surface examination by WFMT or PT.

## G.11

Conical transitions shall be made with a knuckle at both ends.

## G.12

Lifting attachments on a pressure part shall be designed for removal prior to commissioning.

## G.13

The weld toe to weld toe distance between a nozzle and an adjacent structural discontinuity shall be a minimum of 1,8 x $(D \times t_{min})^{0,5}$ or 50 mm (2 in), whichever is greater.

## G.14

Permanent attachments or openings in the knuckle region of a formed head shall be prohibited.

## G.15

If not specified in the code of construction, the requirements of ASME *BPVC,* Section VIII, Division 2 for "Peaking of Welds in Shells and Heads for Internal Pressure" shall be satisfied.

NOTE See ASME *BPVC*, Section VIII, Division 2, 6.1.6.3.

## G.16

The back of the root pass, if applicable, shall be examined by MT or PT after preparation for welding.

# Annex H
(normative)
# Additional requirements for carbon steel vessels in caustic and lean amine service vessels

## H.1

All welds in contact with the process fluid shall be inspected with the WFMT method after PWHT (if performed).

## H.2

If crack-like indications are identified via the WFMT inspection (regardless of the code of construction acceptance criteria) and the indications are not removed, a dimensional map shall be provided with sizing and information allowing location of indication during the inspections.

# Annex I
(normative)
# Additional requirements for vessels in hydrogen charging service

## I.1

Nozzle-to-vessel wall connections shall be set-in type.

## I.2

Integrally reinforced nozzles shall be used.

## I.3

Butt welds shall be subjected to 100 % volumetric examination.

## I.4

Butt welds shall be subjected to MT or PT examination of all weld surfaces exposed to the process fluid, including a 25 mm (1 in) wide band on either side of the weld.

## I.5

Nozzle-to-vessel wall welds shall be subjected to 100 % volumetric examination.

## I.6

Nozzle-to-vessel wall welds shall be subjected to MT or PT examination of all weld surfaces exposed to the process fluid, including a 25 mm (1 in) wide band on either side of the weld.

## I.7

Welds between attachments and the pressure envelope shall be subjected to 100 % surface examination by WFMT or PT method.

## I.8

External attachments shall be welded to the pressure boundary with full penetration welds unless they are vented in accordance with 6.1.1.

## I.9

Internal attachments shall be welded to the pressure boundary with full penetration welds.

## I.10

Wetted surfaces of pressure boundary and attachment welds shall be hardness tested.

## I.11

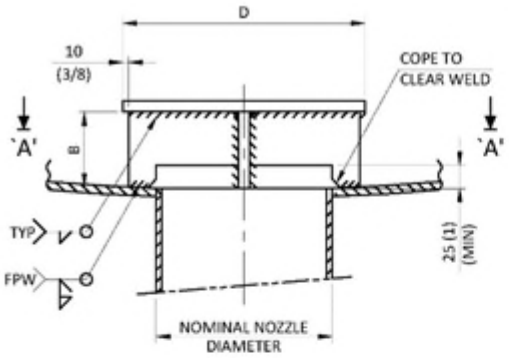
The hardness of attachment welds shall not exceed 200 BHN.

## I.12

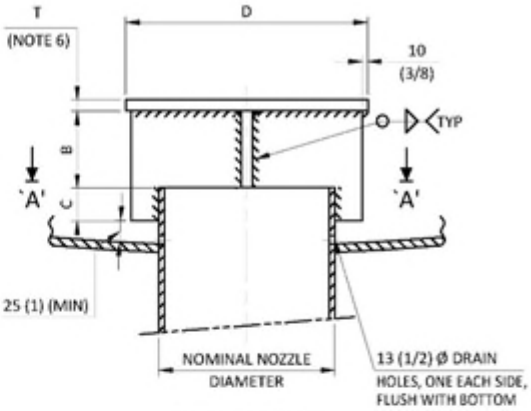
PWHT shall be performed for all vessels in hydrogen charging service.

# Annex J
(normative)
# Standard drawings

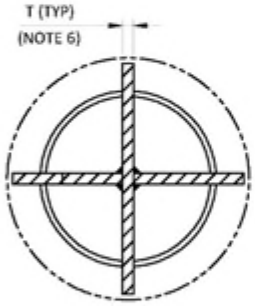
## J.1 Vortex breaker – cross type




SET IN OR SET ON
CONNECTION




SET THROUGH
CONNECTION




SECTION A-A

| NOMINAL DIAMETER | B | C | D |
|---|---|---|---|
| DN 40 (1 1/2) | 50 (2) | 25 (1) | 80 (3) |
| DN 50 (2) | | | 100 (4) |
| DN 80 (3) | | | 125 (5) |
| DN 100 (4) | | | 160 (6 1/2) |
| DN 150 (6) | 75 (3) | | 225 (9) |
| DN 200 (8) | 100 (4) | | 300 (12) |
| DN 250 (10) | 125 (5) | 40 (1 1/2) | 375 (15) |
| DN 300 (12) | 150 (6) | | 450 (18) |
| DN 350 (14) | 175 (7) | | 525 (21) |
| DN 400 (16) | 200 (8) | | 600 (24) |
| DN 450 (18) | 225 (9) | 50 (2) | 700 (28) |
| DN 500 (20) | 250 (10) | | 750 (30) |
| DN 600 (24) | 300 (12) | | 900 (36) |

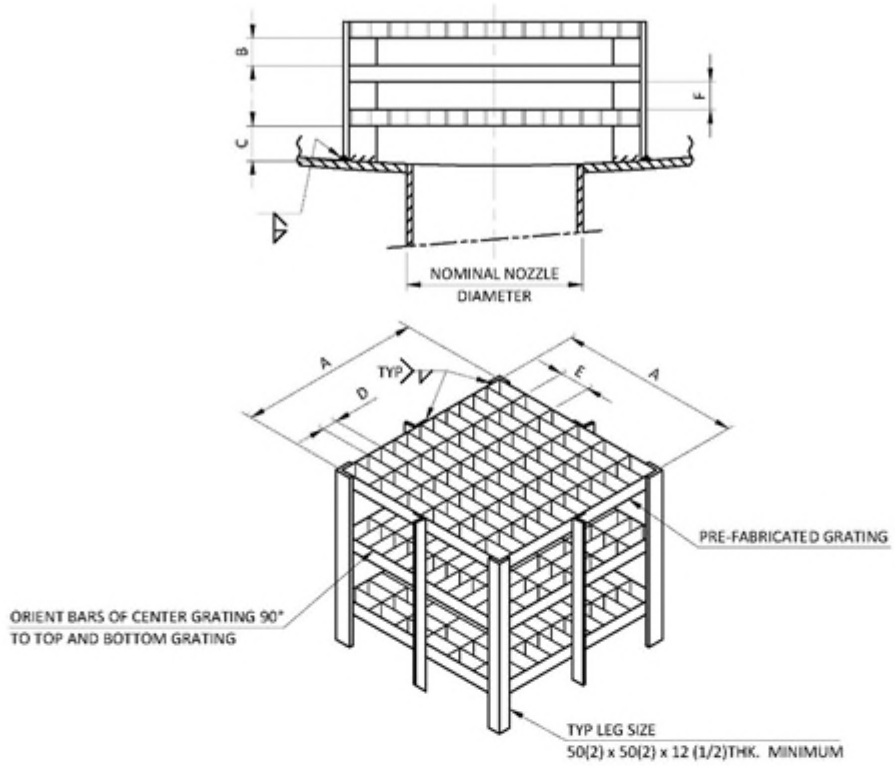
NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. IF MATERIAL IS NOT NOTED ON VESSEL DATA SHEET, USE MATERIAL SAME AS VESSEL MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD).
4. IN CASE OF CLADDED VESSEL, USE MATERIAL SAME AS ALLOY CLADDING OR WELD OVERLAY MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD)
5. ROUND OFF ALL SHARP EDGES.
6. T (THICKNESS) = 5MM (3/16 INCH) EXCLUDING CORROSION ALLOWANCE.
7. WHERE WELD DIMENSIONS ARE NOT SHOWN, WELDS ARE INTENDED TO BE AS STRONG AS POSSIBLE FOR A GIVEN WELD JOINT. FOR EXAMPLE, AN UNDIMENSIONED GROOVE WELD SHALL HAVE A FULL THICKNESS GROOVE; AN UNDIMENSIONED FILLET WELD SHALL HAVE A LEG SIZE EQUAL TO THE THICKNESS OF THE THINNER OF THE TWO COMPONENTS BEING JOINED.

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | VORTEX BREAKER–CROSS TYPE | S619 J.1 |
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 1 OF 1 |

## J.2 Vortex breaker – grid type

SOURCE: EXXON MOBIL



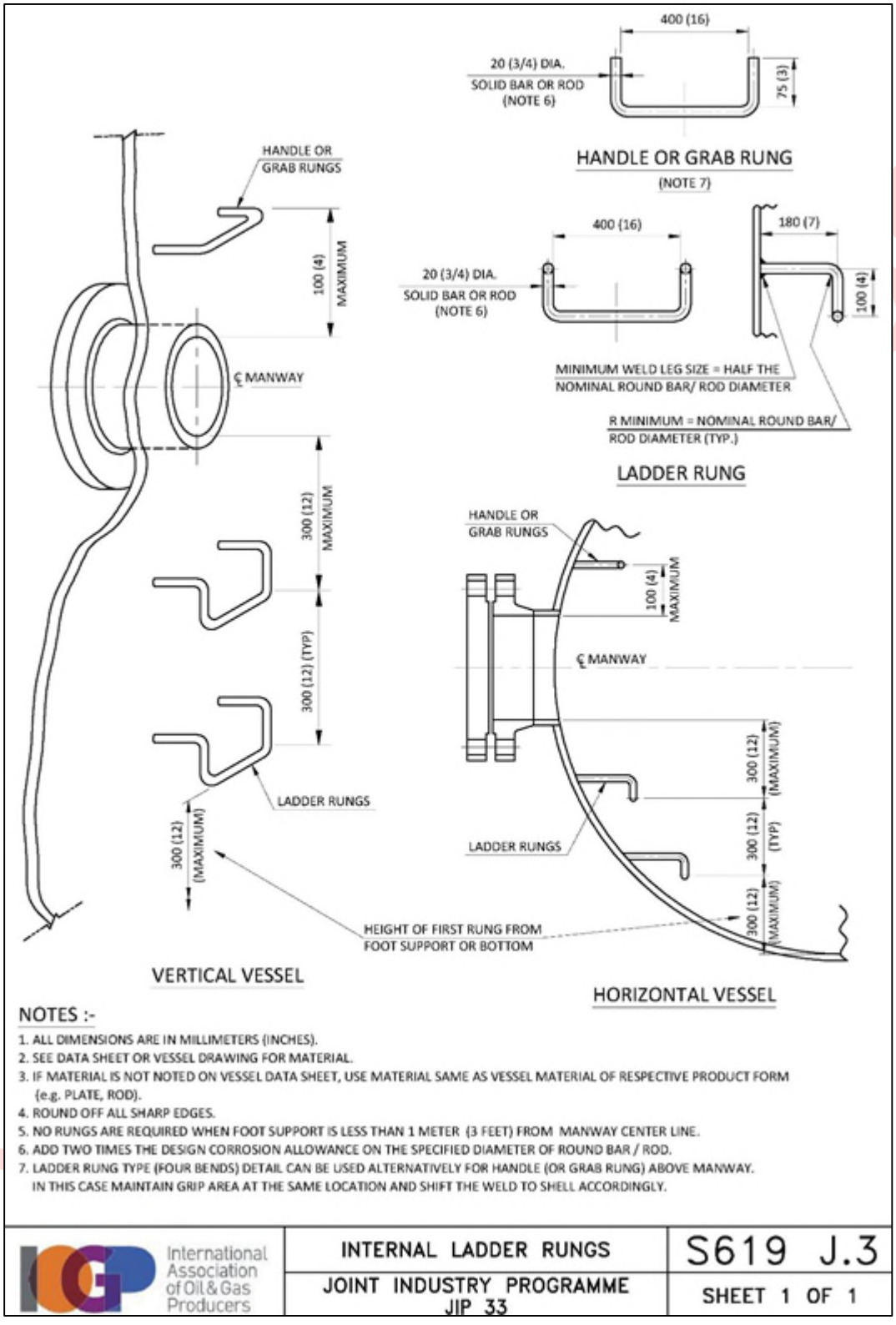

| | FOR VERTICAL VESSELS | FOR HORIZONTAL VESSELS |
|---|---|---|
| GRATING COUNT | 3 | 2 |
| GRATING HEIGHT | 25 (1) | 25 (1) |
| GRATING THICKNESS | 3 (1/8) | 3 (1/8) |
| A | 3D OR 0.5 x VESSEL I.D., WHICHEVER IS SMALLER | 3D OR 0.5 x VESSEL I.D., WHICHEVER IS SMALLER |
| B | 50 (2) | 50 (2) |
| C | 50 (2) FROM VESSEL SURFACE FOR NOZZLE WITH INTERNAL PROJECTION, THE LOWER GRATING SHALL BE STAND OFF 50 (2) FROM THE END OF THE NOZZLE | 50 (2) FROM VESSEL SURFACE FOR NOZZLE WITH INTERNAL PROJECTION, THE LOWER GRATING SHALL BE STAND OFF 50 (2) FROM THE END OF THE NOZZLE |
| D | 25 (1) | 25 (1) |
| E | 100 (4) | 100 (4) |
| F | 50 (2) | 25 (1) |

NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. IF MATERIAL IS NOT NOTED ON VESSEL DATA SHEET, USE MATERIAL SAME AS VESSEL MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD).
4. IN CASE OF CLADDED VESSEL, USE MATERIAL SAME AS ALLOY CLADDING OR WELD OVERLAY MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD)
5. ROUND OFF ALL SHARP EDGES.
6. WHERE WELD DIMENSIONS ARE NOT SHOWN, WELDS ARE INTENDED TO BE AS STRONG AS POSSIBLE FOR A GIVEN WELD JOINT. FOR EXAMPLE, AN UNDIMENSIONED GROOVE WELD SHALL HAVE A FULL THICKNESS GROOVE; AN UNDIMENSIONED FILLET WELD SHALL HAVE A LEG SIZE EQUAL TO THE THICKNESS OF THE THINNER OF THE TWO COMPONENTS BEING JOINED.

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | VORTEX BREAKER–GRID TYPE<br>JOINT INDUSTRY PROGRAMME JIP 33 | S619 J.2<br>SHEET 1 OF 1 |

## J.3 Internal ladder rungs

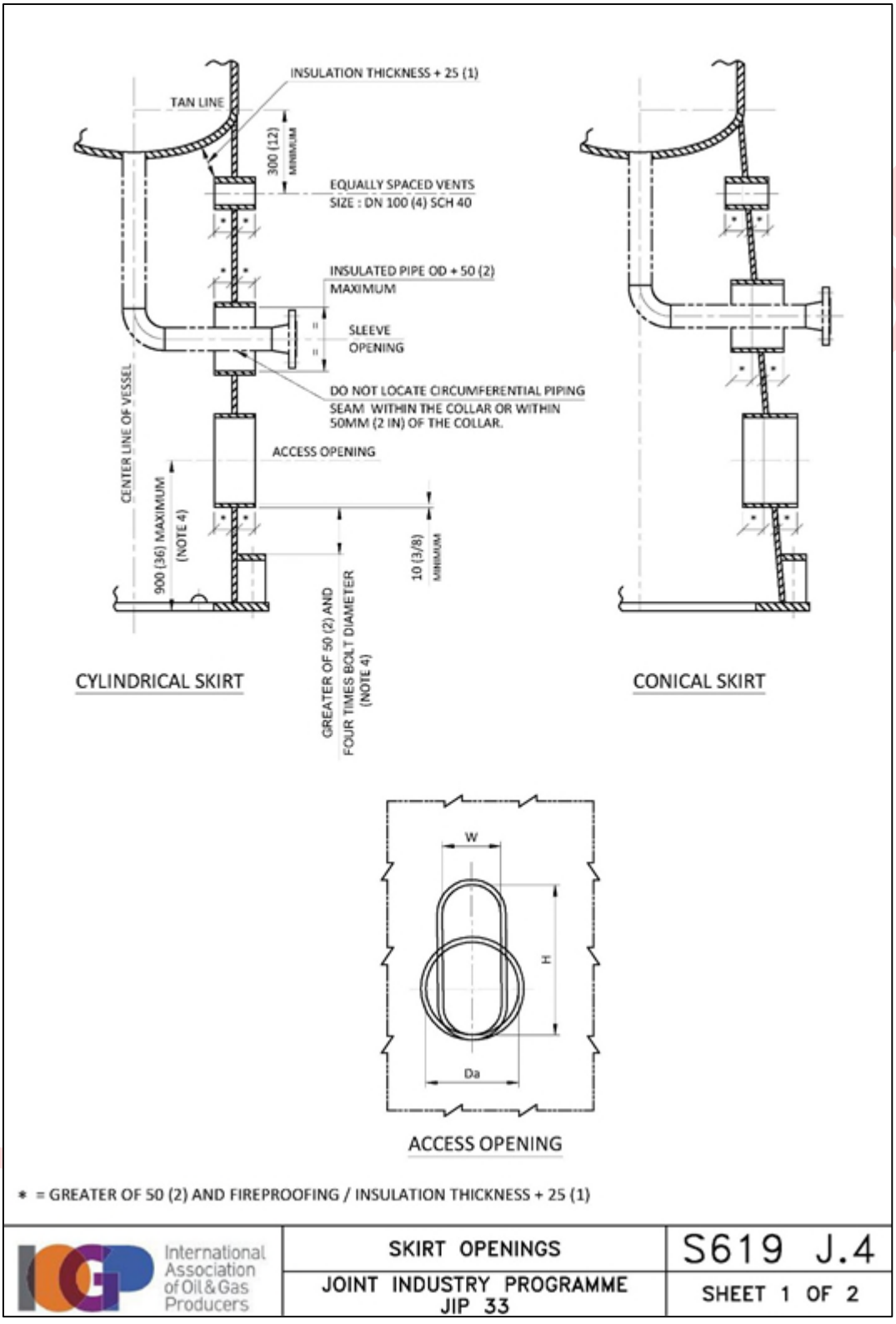


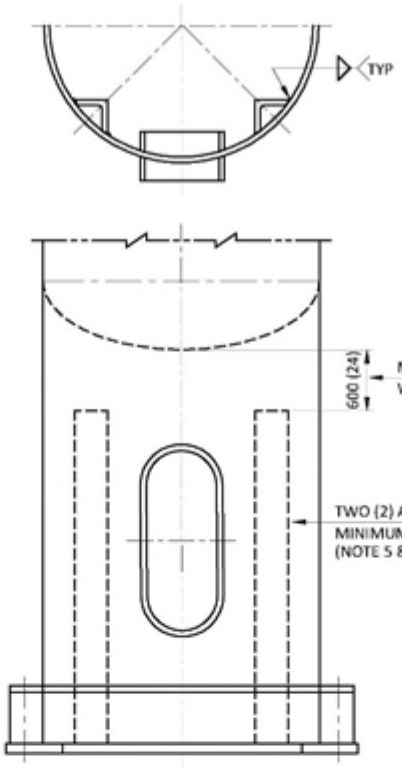

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. IF MATERIAL IS NOT NOTED ON VESSEL DATA SHEET, USE MATERIAL SAME AS VESSEL MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD).
4. ROUND OFF ALL SHARP EDGES.
5. NO RUNGS ARE REQUIRED WHEN FOOT SUPPORT IS LESS THAN 1 METER (3 FEET) FROM MANWAY CENTER LINE.
6. ADD TWO TIMES THE DESIGN CORROSION ALLOWANCE ON THE SPECIFIED DIAMETER OF ROUND BAR / ROD.
7. LADDER RUNG TYPE (FOUR BENDS) DETAIL CAN BE USED ALTERNATIVELY FOR HANDLE (OR GRAB RUNG) ABOVE MANWAY. IN THIS CASE MAINTAIN GRIP AREA AT THE SAME LOCATION AND SHIFT THE WELD TO SHELL ACCORDINGLY.

| International Association of Oil & Gas Producers | INTERNAL LADDER RUNGS<br>JOINT INDUSTRY PROGRAMME<br>JIP 33 | S619 J.3<br>SHEET 1 OF 1 |
|---|---|---|

## J.4 Skirt openings






## ANGLE STIFFENERS FOR OBROUND TYPE ACCESS OPENING

| VESSEL INSIDE DIAMETER | ACCESS OPENING | | | | VENT QUANTITY |
|---|---|---|---|---|---|
| | QUANTITY | TYPE | Da | W x H | |
| < 750 (30) | 1 | CIRCULAR | 250 (10) | - | 3 |
| 750 (30) < 1200 (48) | 1 | OBROUND | - | 400 (16) x 900 (36) | |
| 1200 (48) < 2400 (96) | 1 | CIRCULAR / OBROUND | 600 (24) | 450 (18) x 1200 (48) | |
| 2400 (96) < 4000 (156) | 2 | CIRCULAR / OBROUND | 600 (24) | 450 (18) x 1200 (48) | 4 |
| 4000 (156) < 6000 (240) | | | | | 6 |
| > 6000 (240) | | | | | 8 |

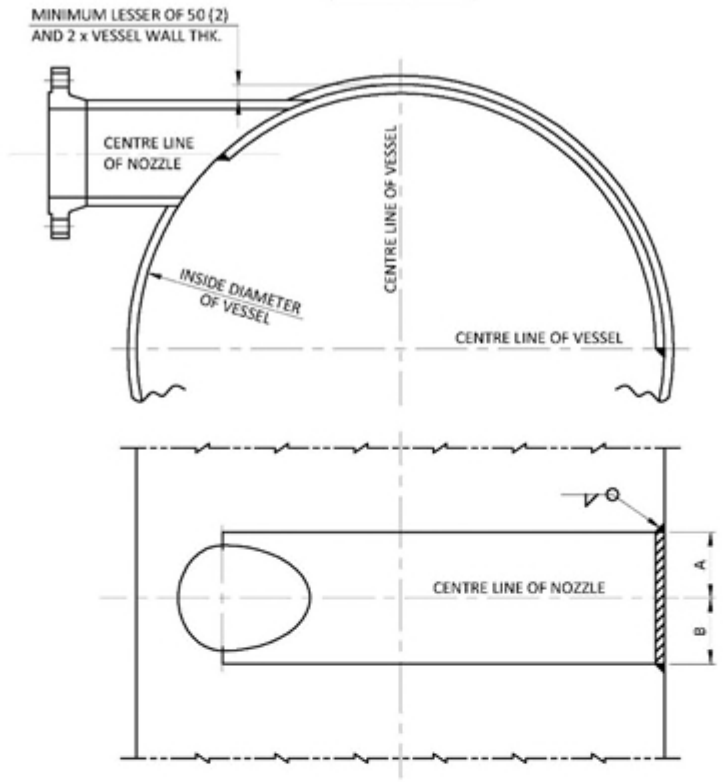
NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. ROUND OFF ALL SHARP EDGES.
4. LOCATE ACCESS OPENING AS LOW AS POSSIBLE FROM BASE RING BOTTOM. PROVIDE SUFFICIENT DISTANCE BETWEEN ACCESS OPENING BOTTOM AND TOP OF COMPRESSION RING OR CHAIR PLATE IN ORDER TO TIGHTEN OR REMOVE THE NUT ON TOP OF AN ANCHOR BOLT
5. MANWAY REINFORCEMENT SHOWN IN THE DRAWING IS A MINIMUM REQUIREMENT. A CHECK OF ADEQUATE AREA REINFORCEMENT IN THE HORIZONTAL PLANE SHALL BE COMPLETED, AND ADDITIONAL REINFORCEMENT SHALL BE ADDED IF NECESSARY. VERTICAL ANGLE IRON CONTRIBUTES TO REINFORCEMENT.
6. ADEQUATE OPENING REINFORCEMENT USING THE AREA REPLACEMENT METHOD MUST BE PROVIDED IN THE SKIRT HORIZONTAL PLANE. CIRCULAR OPENING SLEEVE REINFORCEMENT LENGTH SHALL NOT EXCEED THE DIAMETER OF THE OPENING. ADDITIONAL REINFORCEMENT VIA OTHER MEANS TO SUPPLEMENT THE SLEEVE (I. E. VERTICAL ANGEL IRON IN CLOSE PROXIMITY) IS ACCEPTABLE.

| International Association of Oil & Gas Producers | SKIRT OPENINGS | S619 J.4 |
|---|---|---|
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 2 OF 2 |

## J.5 Tangential nozzle anti-erosion plate

SOURCE : ENI




| NOZZLE SIZE DN (NPS) | A | B |
|---|---|---|
| 80 (3) | 90 (3 1/2) | 160 (6) |
| 100 (4) | 115 (4 1/2) | 200 (8) |
| 150 (6) | 170 (7) | 300 (12) |
| 200 (8) | 220 (9) | 385 (15) |
| 250 (10) | 275 (11) | 480 (20) |
| 300 (12) | 325 (13) | 570 (24) |
| 350 (14) | 355 (14) | 620 (24) |

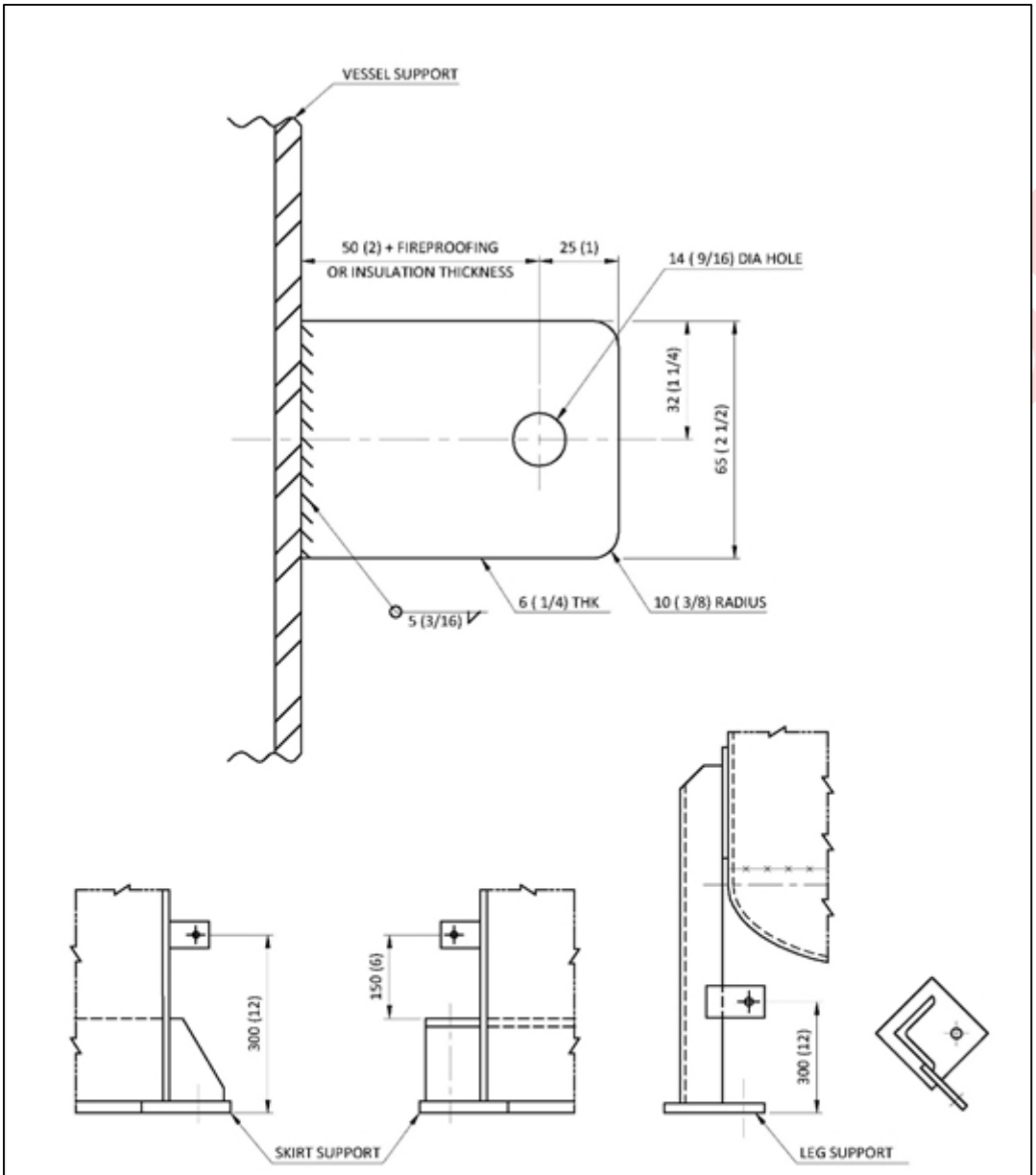
| NOZZLE SIZE DN (NPS) | A | B |
|---|---|---|
| 400 (16) | 405 (16) | 710 (28) |
| 450 (18) | 460 (18) | 810 (32) |
| 500 (20) | 510 (20) | 890 (35) |
| 550 (22) | 560 (22) | 990 (39) |
| 600 (24) | 610 (24) | 1090 (43) |
| 650 (26) | 660 (26) | 1170 (46) |
| 750 (30) | 760 (30) | 1345 (53) |

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. IF MATERIAL IS NOT NOTED ON VESSEL DATA SHEET, USE MATERIAL SAME AS VESSEL MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD ).
4. ROUND OFF ALL SHARP EDGES.
5. WHERE A FILLET WELD IS SHOWN WITHOUT A DIMENSION, THE INTENT IS THAT IT BE A "FULL" FILLET. THIS MEANS THAT THE LEG SIZE SHALL BE THE THICKNESS OF THE THINNER OF THE PLATES BEING JOINED
6. SPECIFY REQUIREMENT OF WEAR PLATE AND THICKNESS OF WEAR PLATE ON THE DATASHEET SKETCH OR NOZZLE OPENING NOTE.
7. AN ALTERNATE DESIGN UTILIZING WELD OVERLAY OR BUILDUP MAY BE SUBSTITUTED FOR THE PLATE DESIGN WHICH IS SHOWN.

| International Association of Oil & Gas Producers | TANGENTIAL NOZZLE WITH ANTI-EROSION PLATE | S619 J.5 |
|---|---|---|
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 1 OF 1 |

## J.6 Earthing (grounding) lug

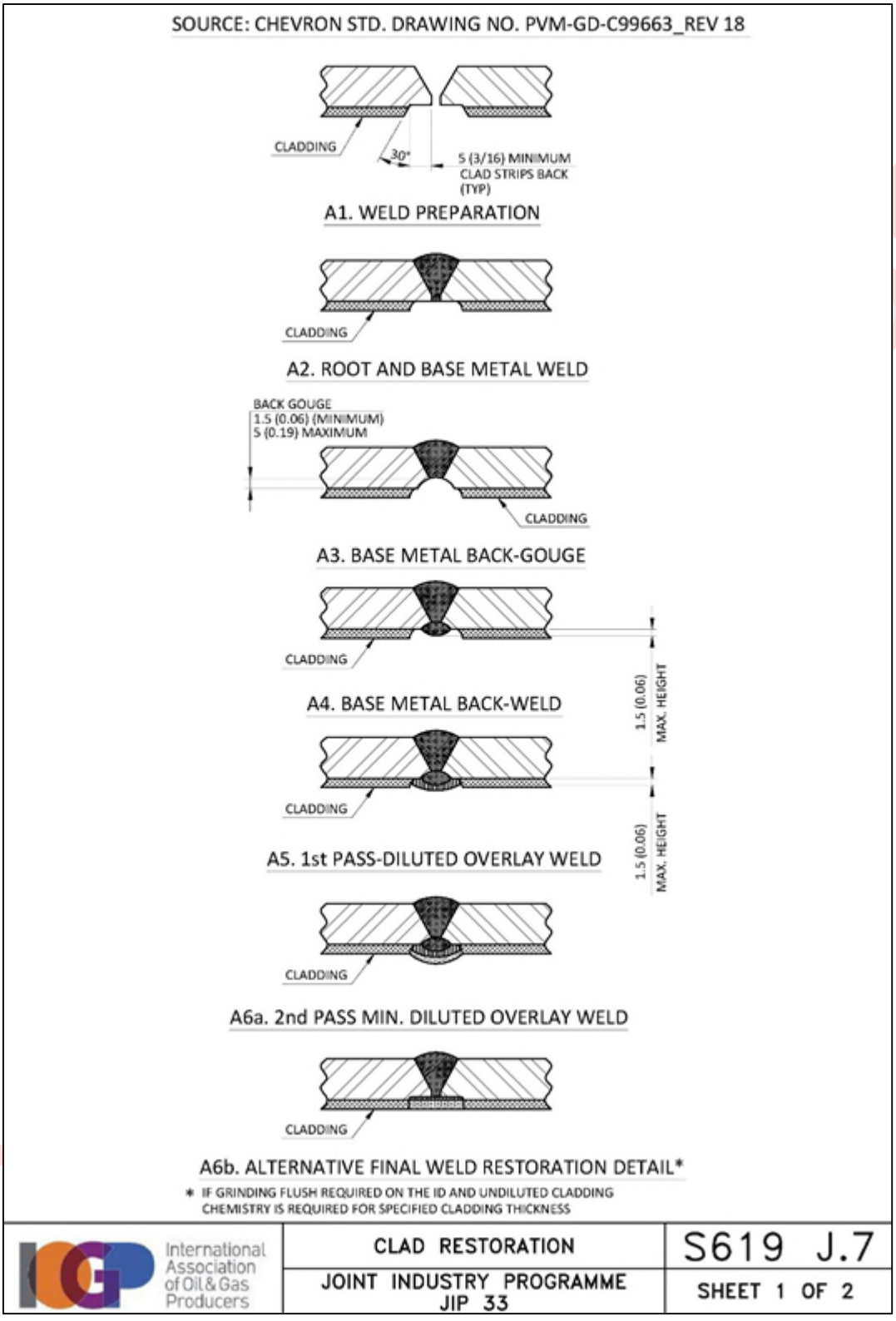


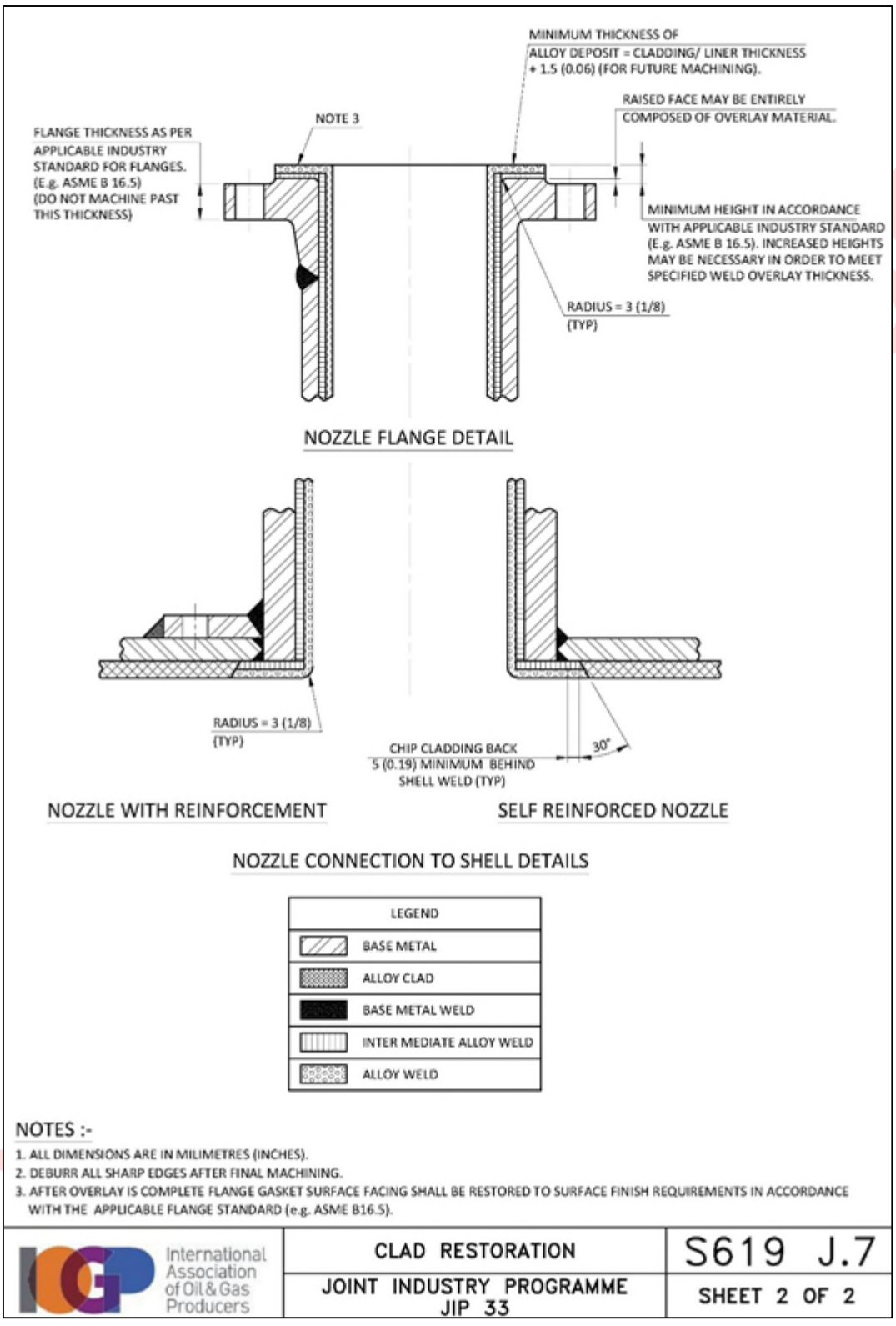

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. LUG MATERIAL AUSTENITIC STAINLESS STEEL.
3. NO PAINTING ON EARTHING (GROUNDING) LUG.
4. FOR EARTHING LUG LOCATIONS ON SADDLE AND LUG TYPE SUPPORT, REFER STANDARD DRAWING NO. S619 J.10 AND S619 J.11 RESPECTIVELY.
5. DO NOT WELD EARTHING (GROUNDING) LUGS TO PRESSURE PARTS.
6. LOCATE EARTHING (GROUNDING) LUGS ON SKIRT IN BETWEEN ANCHOR BOLTS.

| International Association of Oil & Gas Producers | EARTHING (GROUNDING) LUG<br>JOINT INDUSTRY PROGRAMME<br>JIP 33 | S619 J.6<br>SHEET 1 OF 1 |
|---|---|---|

## J.7 Clad restoration



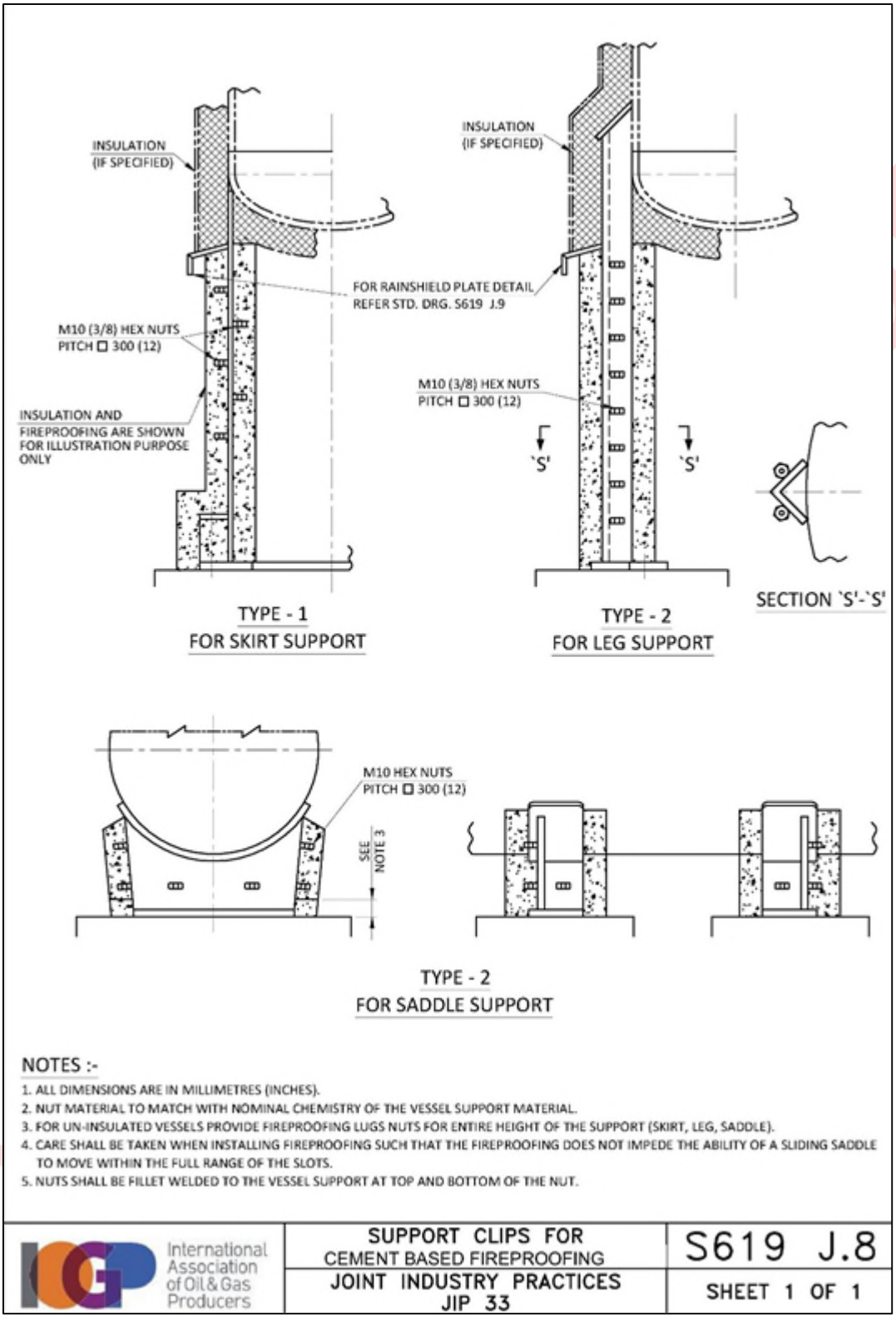



NOTES :-

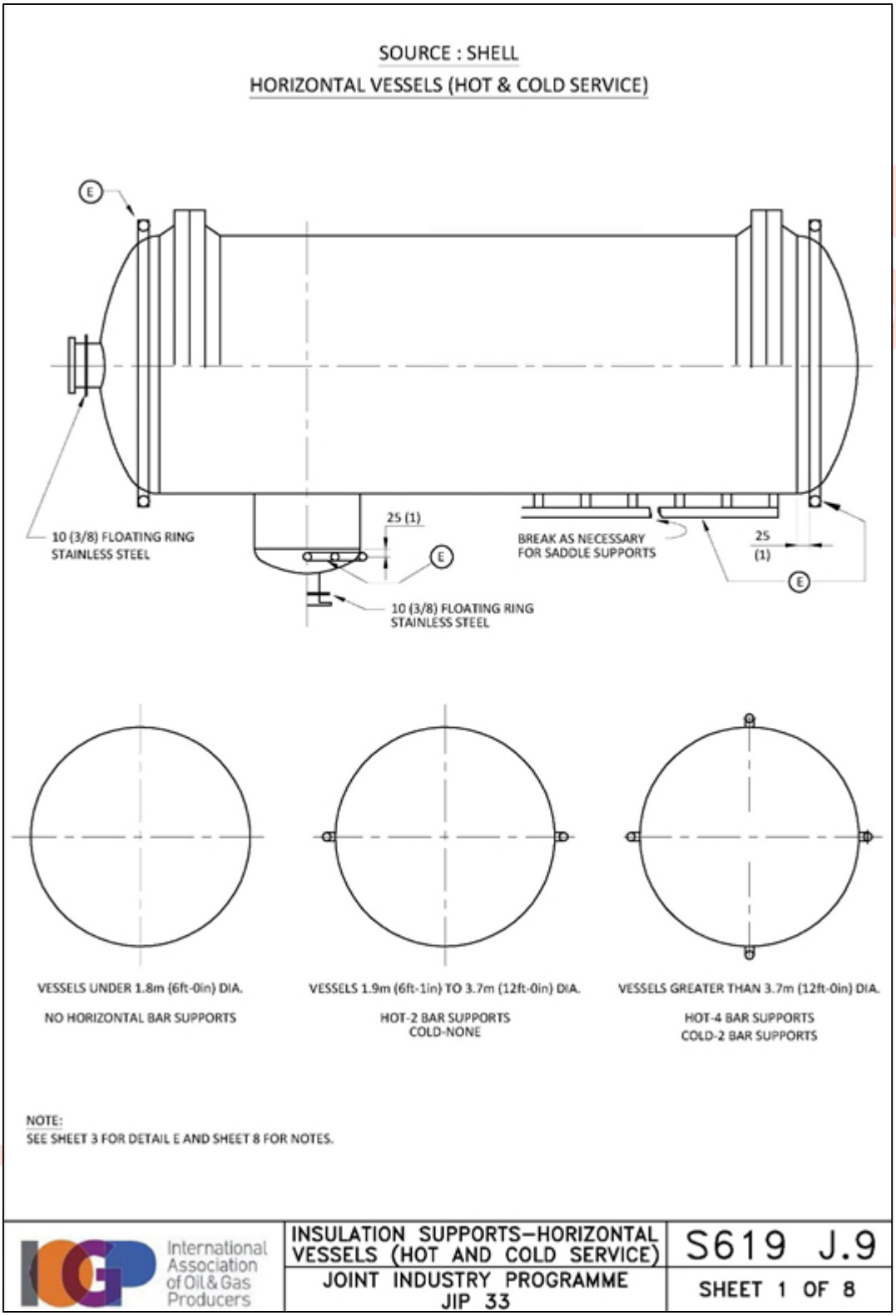
1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. DEBURR ALL SHARP EDGES AFTER FINAL MACHINING.
3. AFTER OVERLAY IS COMPLETE FLANGE GASKET SURFACE FACING SHALL BE RESTORED TO SURFACE FINISH REQUIREMENTS IN ACCORDANCE WITH THE APPLICABLE FLANGE STANDARD (e.g. ASME B16.5).

| International Association of Oil & Gas Producers | CLAD RESTORATION | S619 J.7 |
|---|---|---|
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 2 OF 2 |

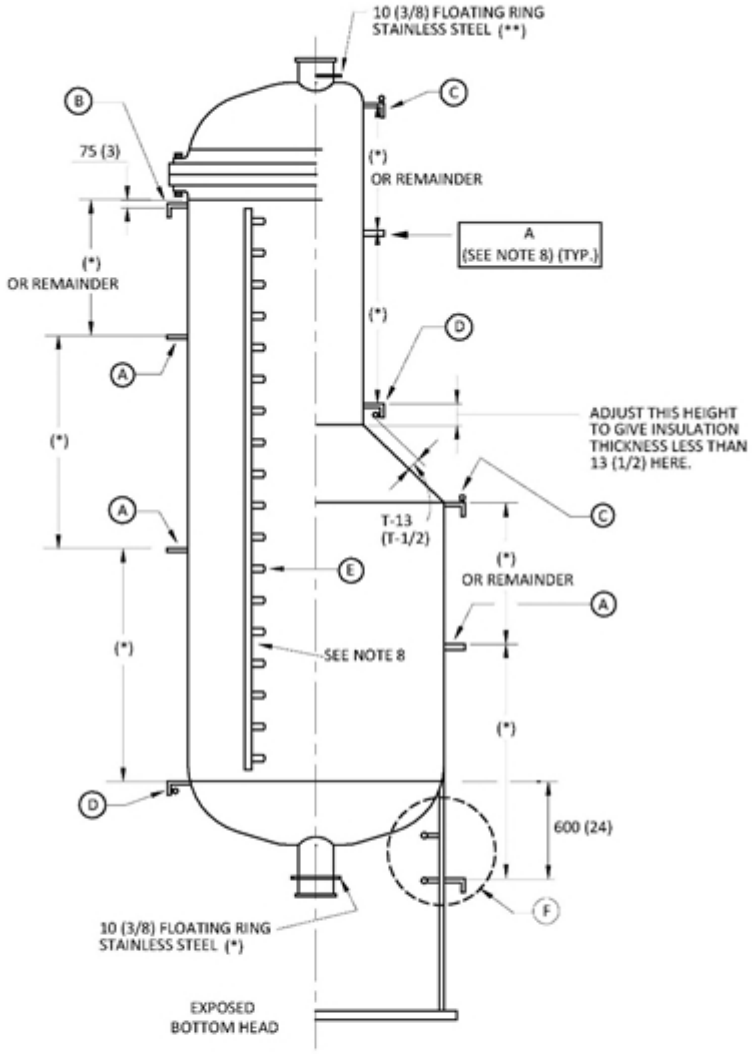
## J.8 Support clips for fireproofing



## J.9 Insulation supports (hot and cold)



## VERTICAL VESSELS (HOT SERVICE)

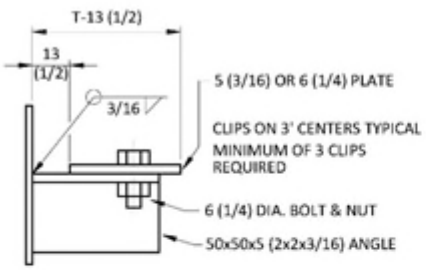



(*) MAXIMUM DISTANCE BETWEEN SUPPORT RINGS IS 3660 MM (12 ft).

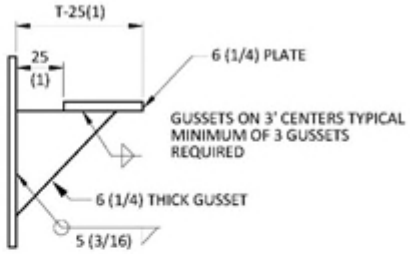
(**) LOCATE FLOATING RINGS ON THE CENTER NOZZLE ON EACH HEAD

NOTE:
SEE SHEETS 3 FOR DETAILS A, B, C, D, & E AND SHEET 8 FOR NOTES.

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | INSULATION SUPPORTS–VERTICAL VESSELS (HOT SERVICE)<br>JOINT INDUSTRY PROGRAMME JIP 33 | S619 J.9<br>SHEET 2 OF 8 |

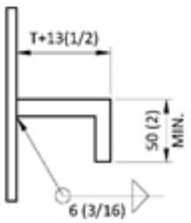



INSULATION THICKNESS 50 (2) TO 75 (3)



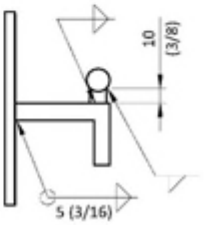

INSULATION THICKNESS GREATER THAN 75 (3)

DETAIL A
(NOTE 8)



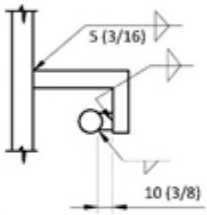

TOP AND BOTTOM RINGS ARE 6 (1/4) ANGLE.
OUTSIDE LIP IS 50 (2) WIDE MIN.
WIDTH IS SAME AS INSULATION THICKNESS + 13 (1/2).

DETAIL B



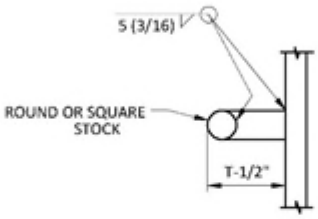

WIDTH OF SUPPORT RING IS SAME AS
IN DETAIL B BUT WITH 10 (3/8) ROUND BAR
ON TOP SIDE SPACED OFF RING 10 (3/8)
ON 0.9m (3') CENTERS.

DETAIL C



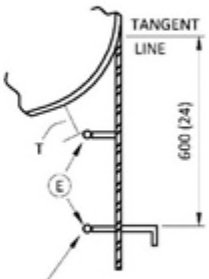

WIDTH OF SUPPORT RING IS THE SAME AS
IN DETAIL B BUT WITH 10 (3/8) ROUND BAR
ON INSIDE OF ANGLE LIP SPACED OFF LIP 10 (3/8)
WITH SPACERS ON 0.9m (3') CENTERS.

DETAIL D




10 (3/8) DIA. BAR WELDED TO 10 (3/8) PINS ON
300 (12) SPACING UP TO 75 (3) INSULATION THICKNESS.
USE 13 (1/2) DIA. BAR FOR OVER 75 (3) INSULATION
THICKNESS. BAR EXTENDS OUT TO 13 (1/2")LESS THAN
INSULATION THICKNESS TYPICAL.

DETAIL E
(APPLICABLE FOR HOT AND COLD SERVICE)




REQUIRED ONLY ON EXCHANGERS
WITH A DESIGN TEMPERATURE GREATER
THAN 370°c (700F).

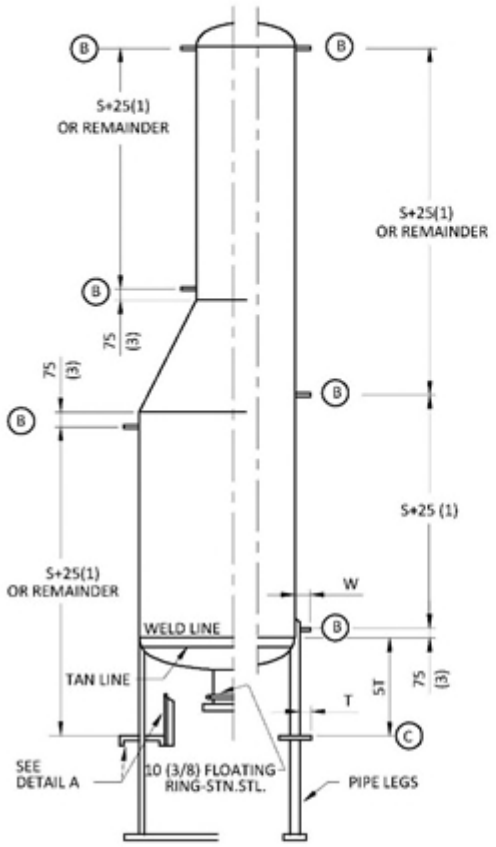
DETAIL F

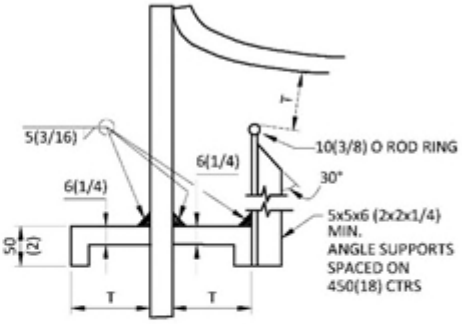
International Association of Oil & Gas Producers

INSULATION SUPPORTS–VERTICAL VESSELS (HOT SERVICE)
JOINT INDUSTRY PROGRAMME
JIP 33

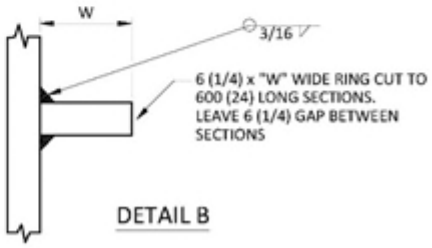
S619 J.9
SHEET 3 OF 8

## VERTICAL VESSELS (COLD SERVICE)

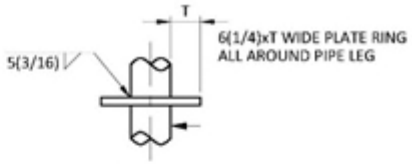



DETAIL A




DETAIL B



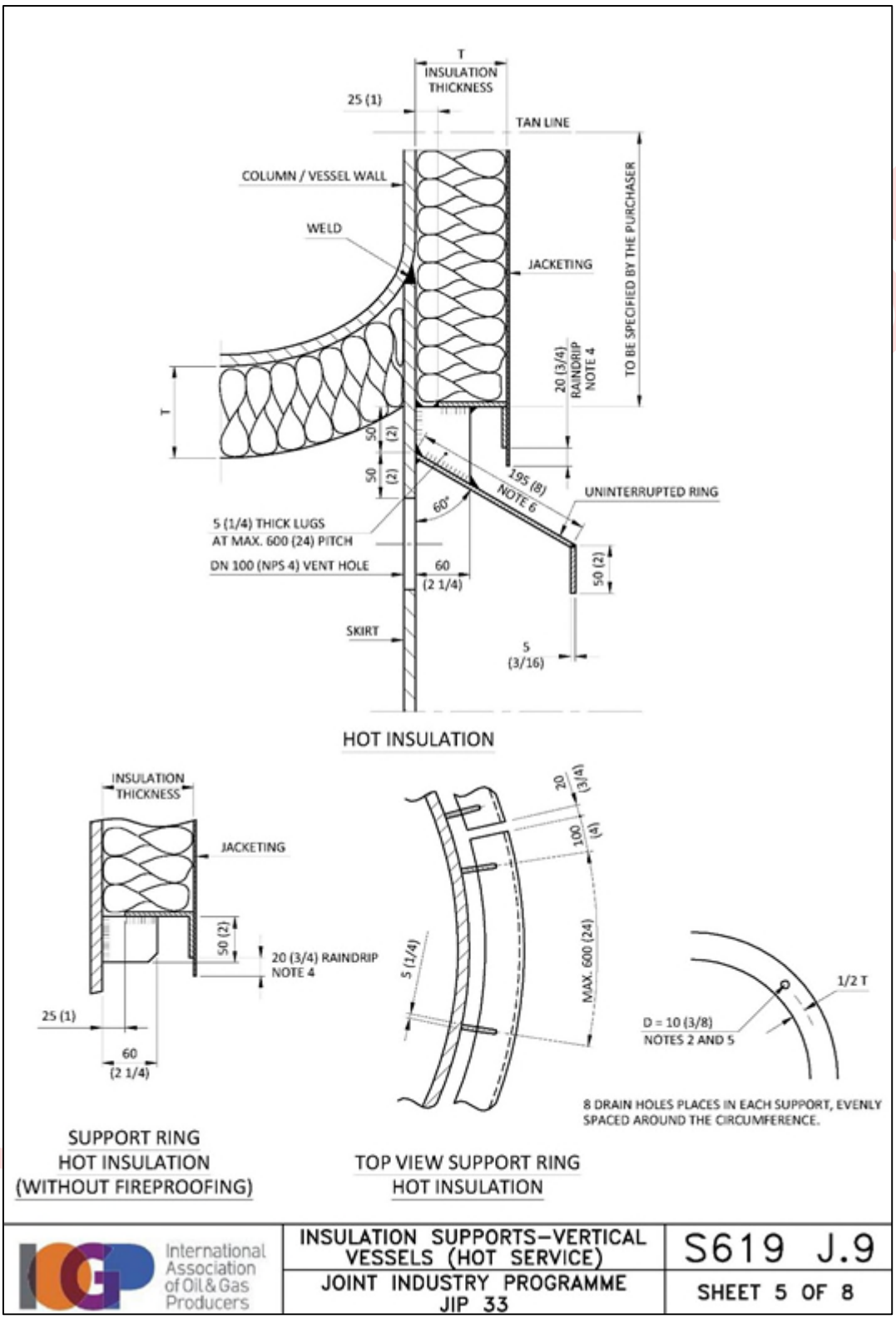

DETAIL C

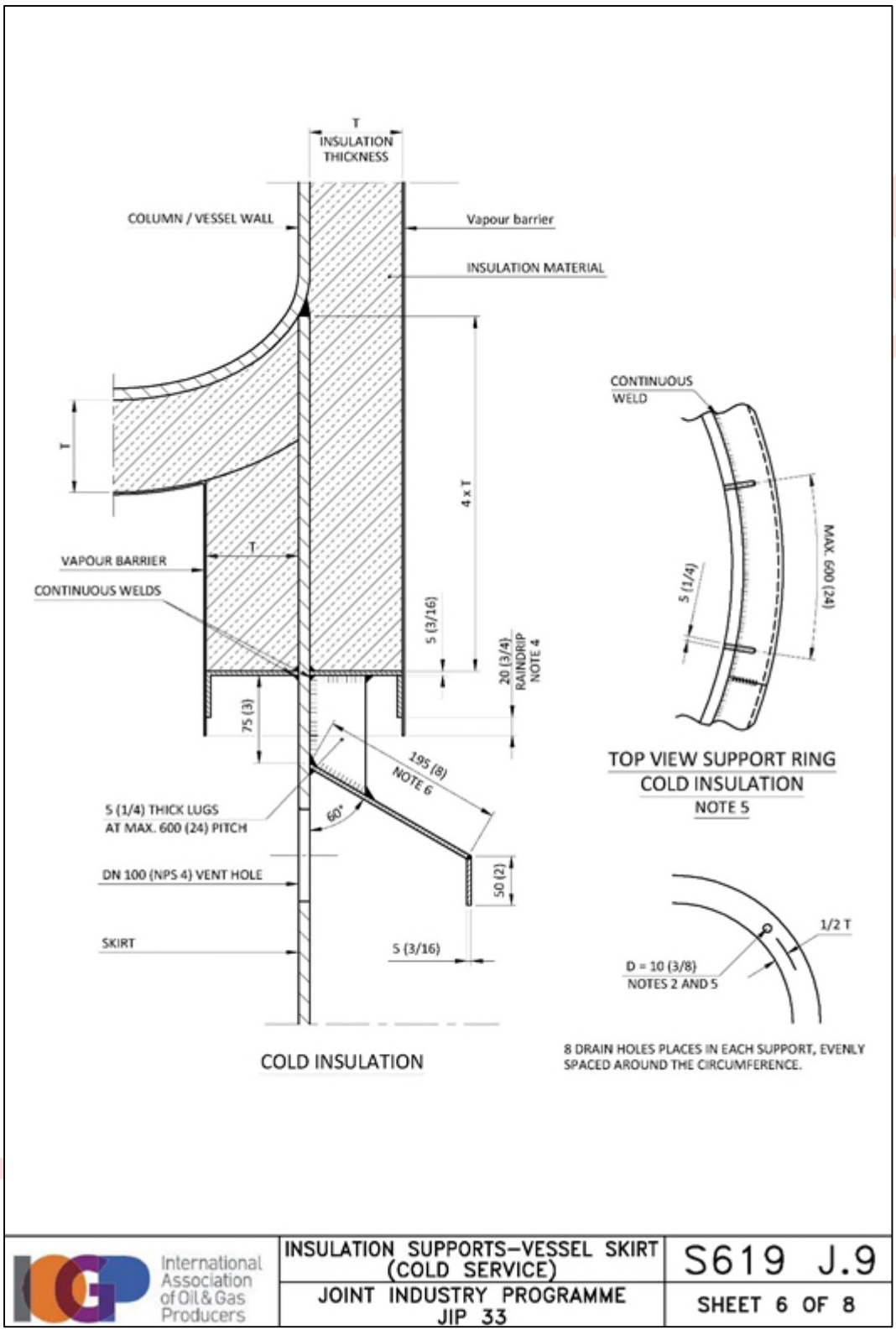
| COLD INSULATION | | | |
|---|---|---|---|
| OPERATING TEMPERATURE °C (°F) | S SUPPORT SPACING (FT) | | |
| | STEEL | ST. STEEL | AL |
| 0 (32) | 30.5 (100) | 24.4 (80) | 15.2 (50) |
| -18 (0) | 15.2 (50) | 9.1 (30) | 6.1 (20) |
| -45 (-50) | 6.1 (20) | 6.1 (20) | 4.6 (15) |
| -100 (-150) | | 4.6 (15) | 3.0 (10) |
| <-100 (<-150) | | 3.7 (12) | 2.44 (8) |

W=1/2 OF INSULATION THICKNESS FOR SINGLE LAYER INSULATION

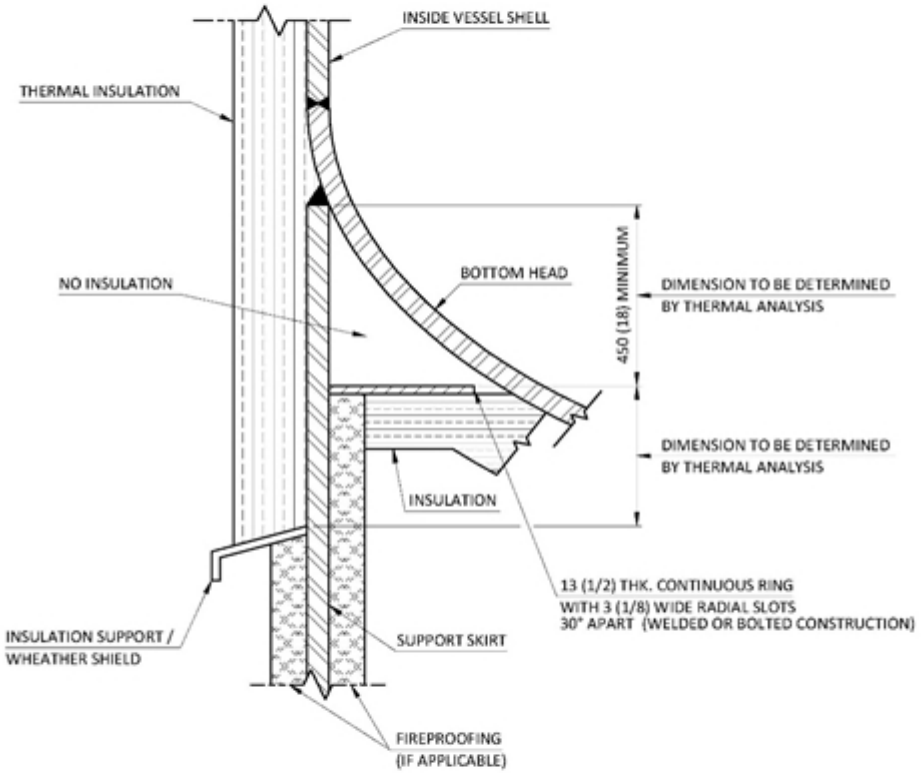
W=THICKNESS OF 1st LAYER + 1/2 THICKNESS OF SECOND LAYER FOR DOUBLE LAYER INSULATION

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | INSULATION SUPPORTS–VERTICAL VESSELS (COLD SERVICE)<br>JOINT INDUSTRY PROGRAMME JIP 33 | S619 J.9<br>SHEET 4 OF 8 |


T
INSULATION THICKNESS
25 (1)
TAN LINE
COLUMN / VESSEL WALL
WELD
JACKETING
TO BE SPECIFIED BY THE PURCHASER
20 (3/4) RAINDRIP NOTE 4
T
50 (2)
50 (2)
195 (8) NOTE 6
UNINTERRUPTED RING
60°
5 (1/4) THICK LUGS AT MAX. 600 (24) PITCH
DN 100 (NPS 4) VENT HOLE
60 (2 1/4)
50 (2)
SKIRT
5 (3/16)
HOT INSULATION
INSULATION THICKNESS
JACKETING
50 (2)
20 (3/4) RAINDRIP NOTE 4
25 (1)
60 (2 1/4)
SUPPORT RING HOT INSULATION (WITHOUT FIREPROOFING)
20 (3/4)
100 (4)
5 (1/4)
MAX. 600 (24)
1/2 T
D = 10 (3/8) NOTES 2 AND 5
8 DRAIN HOLES PLACES IN EACH SUPPORT, EVENLY SPACED AROUND THE CIRCUMFERENCE.
TOP VIEW SUPPORT RING HOT INSULATION
International Association of Oil & Gas Producers
INSULATION SUPPORTS–VERTICAL VESSELS (HOT SERVICE)
JOINT INDUSTRY PROGRAMME JIP 33
S619 J.9
SHEET 5 OF 8


T
INSULATION THICKNESS
COLUMN / VESSEL WALL
Vapour barrier
INSULATION MATERIAL
T
4 x T
VAPOUR BARRIER
T
CONTINUOUS WELDS
5 (3/16)
20 (3/4) RAINDRIP NOTE 4
75 (3)
195 (8) NOTE 6
60°
5 (1/4) THICK LUGS AT MAX. 600 (24) PITCH
DN 100 (NPS 4) VENT HOLE
50 (2)
SKIRT
5 (3/16)
COLD INSULATION
CONTINUOUS WELD
5 (1/4)
MAX 600 (24)
TOP VIEW SUPPORT RING
COLD INSULATION
NOTE 5
1/2 T
D = 10 (3/8)
NOTES 2 AND 5
8 DRAIN HOLES PLACES IN EACH SUPPORT, EVENLY SPACED AROUND THE CIRCUMFERENCE.
International Association of Oil & Gas Producers
INSULATION SUPPORTS–VESSEL SKIRT (COLD SERVICE)
JOINT INDUSTRY PROGRAMME JIP 33
S619 J.9
SHEET 6 OF 8

SOURCE : ExxonMobil




HOT BOX ARRANEGEMENT FOR SKIRT SUPPPORTED VESSELS

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | INSULATION SUPPORTS–HOT BOX ARRANGEMENT<br>JOINT INDUSTRY PROGRAMME JIP 33 | S619 J.9<br>SHEET 7 OF 8 |

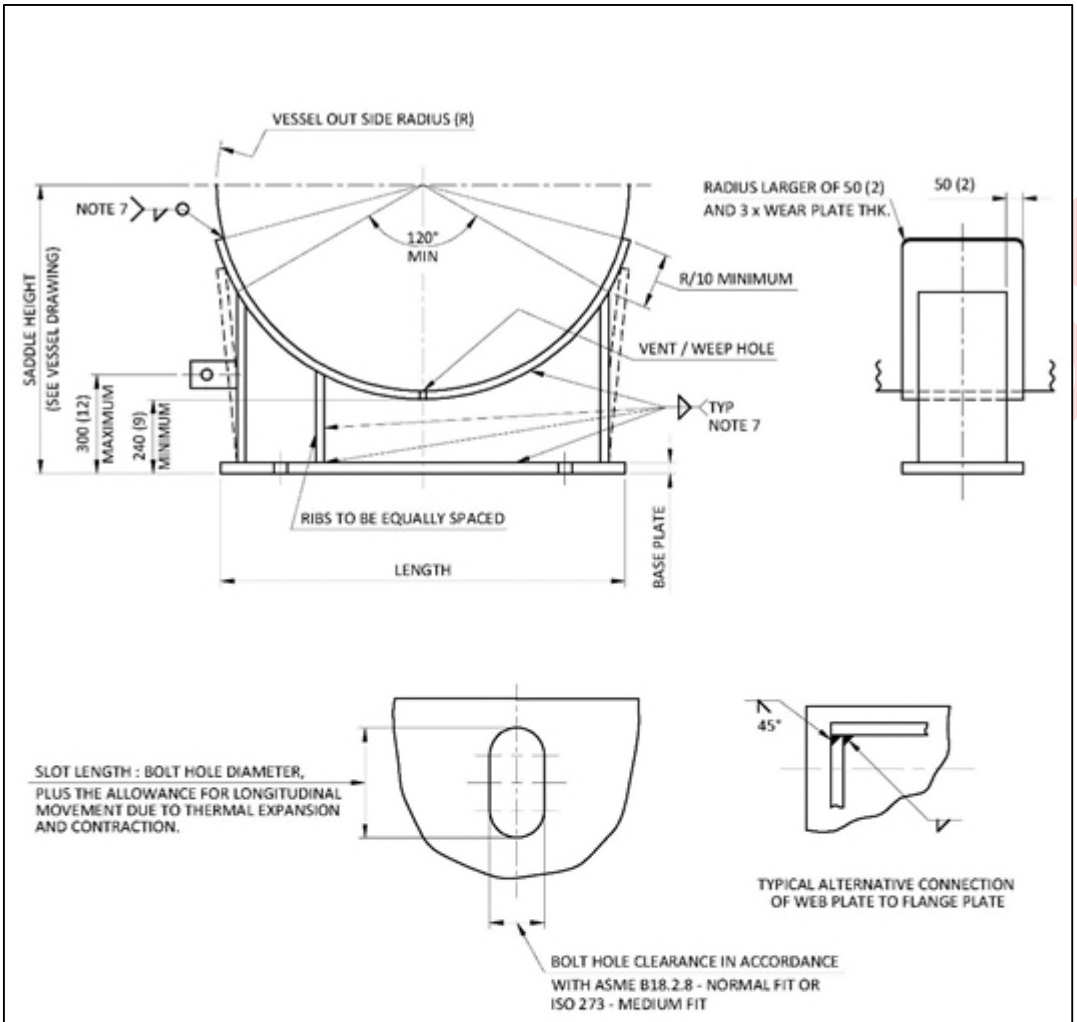
NOTES:

1. ALL DIMENSIONS ARE IN mm (inches) UNLESS STATED OTHERWISE.
2. DRAIN HOLES NOT TO PENETRATE THE PRIMARY VAPOR BARRIER.
3. SUPPORT RING CAN EITHER BE WELDED OR ROLLED ANGLE IRON.
4. RAINDRIP TO BE PROVIDED BY THE INSULATION CONTRACTOR (e.g. BY EXTENSION OF JACKETING). USE OF A JACKET END CAP DETAIL FOR THE TERMINATION OF THE INSULATION OF A COLUMN INSTEAD OF THE INSULATION SUPPORT RING THAT IS SHOWN SHALL BE AGREED WITH PURCHASER.
5. FOR INSULATION SUPPORTS INSTALLED ON VESSELS OPERATING BETWEEN 0 °C (32 °F) AND 175 °C (350 °F), INSTALL A MOISTURE DRAIN.
6. THE WIDTH SHOWN OF THE RAIN CAP IS FOR BRICKWORK AS A FIRE PROTECTION MATERIAL.
7. WHEN USING VACUUM SUPPORT RINGS FOR INSULATION SUPPORTS, THE RING WIDTH IS SELECTED TO MATCH THE REQUIRED WIDTH OF INSULATION SUPPORTS.
8. TYPE A INTERMEDIATE SUPPORTS NOT REQUIRED FOR VESSELS LESS THAN 1.8m (12') TAN TO TAN.
9. WHERE EVER THERE IS A CHANGE IN INSULATION THICKNESS AND THE UPPER PORTION OF THE INSULATION IS THICKER THAN THE LOWER PORTION, A NEW SUPPORT MUST BE ADDED AT THE CHANGE IN THICKNESS AND TYPICAL SPACING CONTINUED.
10. MATERIAL OF SUPPORTS IS THE SAME AS MATERIAL OF THE VESSEL.
11. LOCATE SUPPORTS AWAY FROM NOZZLES AND MANWAYS

T = INSULATION THICKNESS.

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | INSULATION SUPPORT (HOT AND COLD)<br>JOINT INDUSTRY PROGRAMME<br>JIP 33 | S619 J.9<br>SHEET 8 OF 8 |

## J.10 Saddles for horizontal vessels



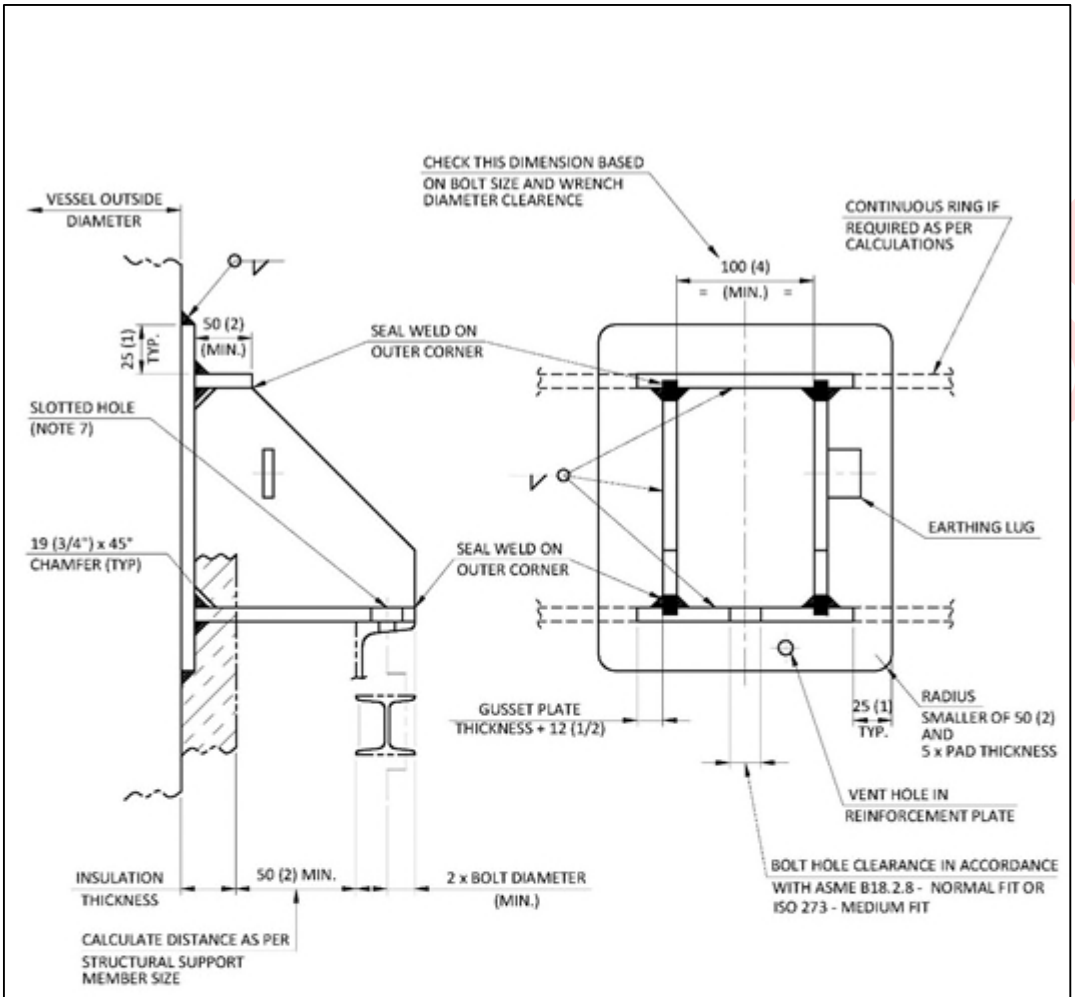

SLOTTED HOLE FOR SLIDING SADDLE

NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. IF MATERIAL IS NOT NOTED ON VESSEL DATA SHEET, USE MATERIAL SAME AS VESSEL MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD).
4. ROUND OFF ALL SHARP EDGES.
5. WHERE WELD DIMENSIONS ARE NOT SHOWN, WELDS ARE INTENDED TO BE AS STRONG AS POSSIBLE FOR A GIVEN WELD JOINT. FOR EXAMPLE, AN UNDIMENSIONED GROOVE WELD SHALL HAVE A FULL THICKNESS GROOVE; AN UNDIMENSIONED FILLET WELD SHALL HAVE A LEG SIZE EQUAL TO THE THICKNESS OF THE THINNER OF THE TWO PLATES BEING JOINED.
6. ALL WELDS SHALL BE CONTINUOUS.
7. SADDLE WELD DETAILS AND CONNECTION TO THE VESSEL SHALL BE SUBJECT TO FATIGUE ASSESSMENT (S619 ANNEX G), WHERE APPLICABLE.

| International Association of Oil & Gas Producers | SADDLES FOR HORIZONTAL VESSELS<br>JOINT INDUSTRY PROGRAMME<br>JIP 33 | S619 J.10<br>SHEET 1 OF 1 |
|---|---|---|

## J.11 Support lugs and rings

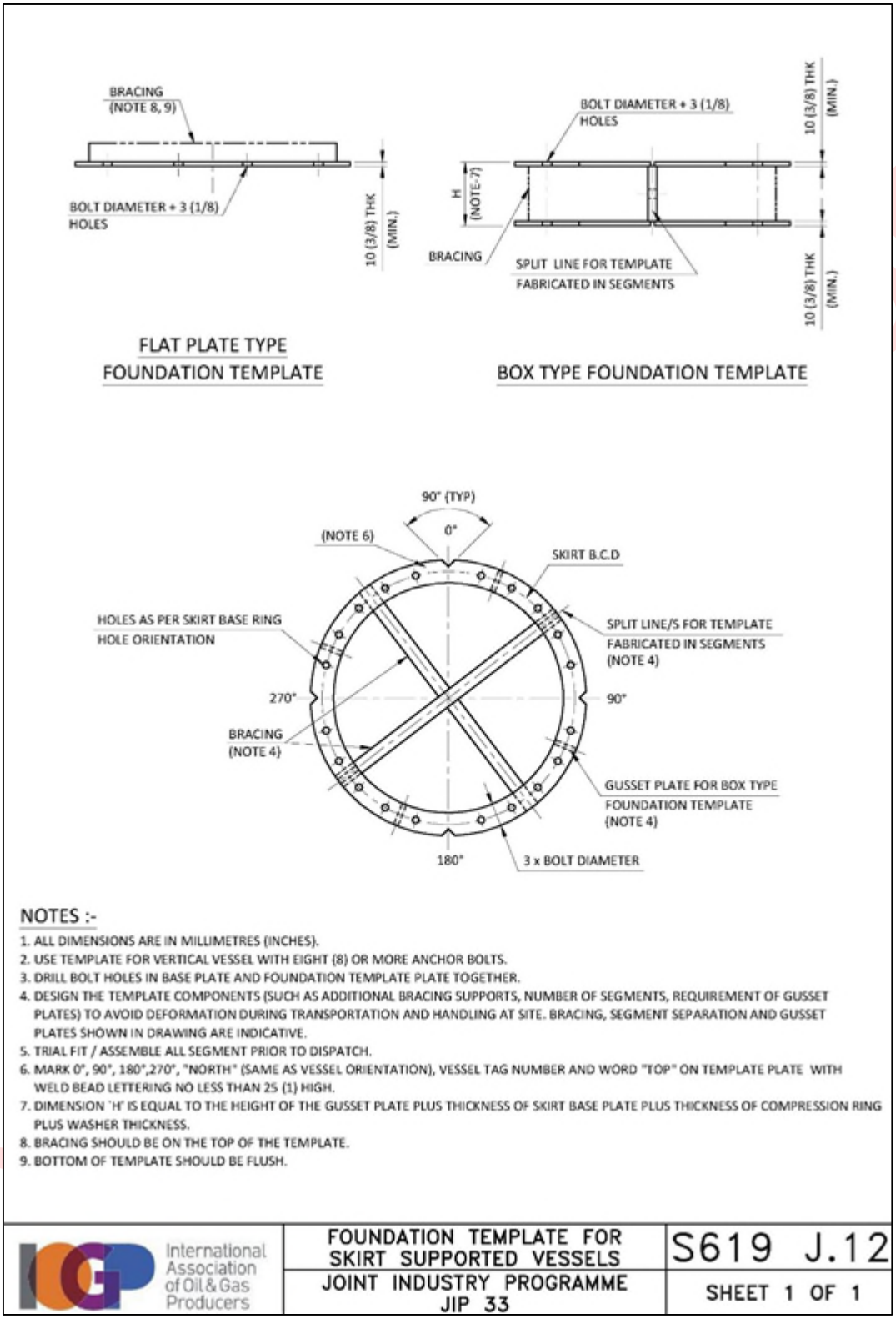



NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. SEE DATA SHEET OR VESSEL DRAWING FOR MATERIAL.
3. IF MATERIAL IS NOT NOTED ON VESSEL DATA SHEET, USE MATERIAL SAME AS VESSEL MATERIAL OF RESPECTIVE PRODUCT FORM (e.g. PLATE, ROD).
4. ROUND OFF ALL SHARP EDGES.
5. DIMENSION AND THICKNESS CRITERIA IS FOR THE PURPOSE OF STANDARDIZATION AND IS A STARTING POINT FOR DESIGN. FINAL THICKNESSES AND DIMENSIONS TO BE AS REQUIRED IN ACCORDANCE WITH CALCULATIONS.
6. USE MINIMUM THICKNESS 10 (3/8) FOR ALL LUG COMPONENTS.
7. SLOT LENGTH : BOLT HOLE DIAMETER, PLUS THE ALLOWANCE FOR RADIAL MOVEMENT DUE TO THERMAL EXPANSION AND CONTRACTION.

| International Association of Oil & Gas Producers | SUPPORT LUGS AND RINGS | S619 J.11 |
|---|---|---|
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 1 OF 1 |

## J.12 Foundation template for skirt supported vessels

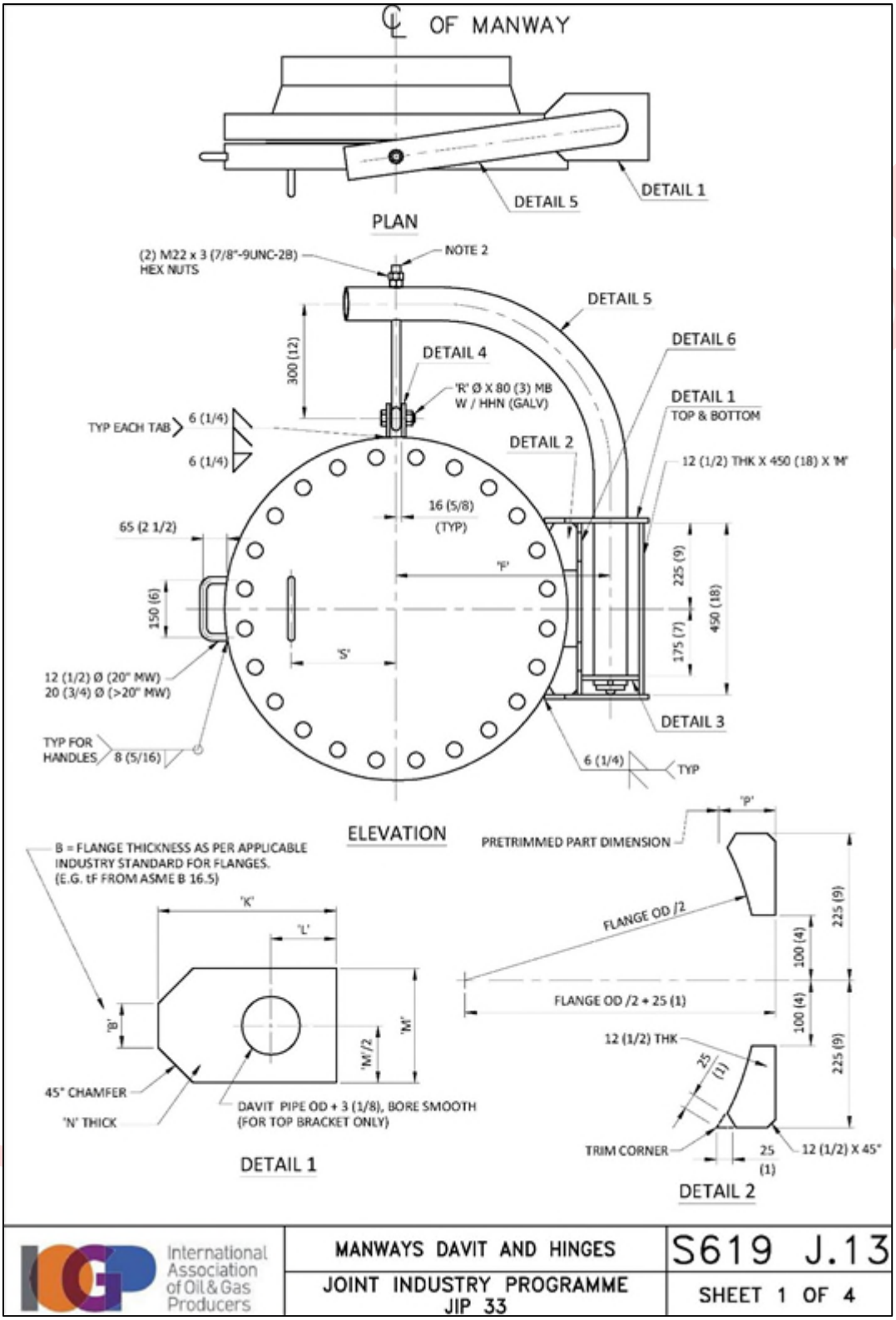


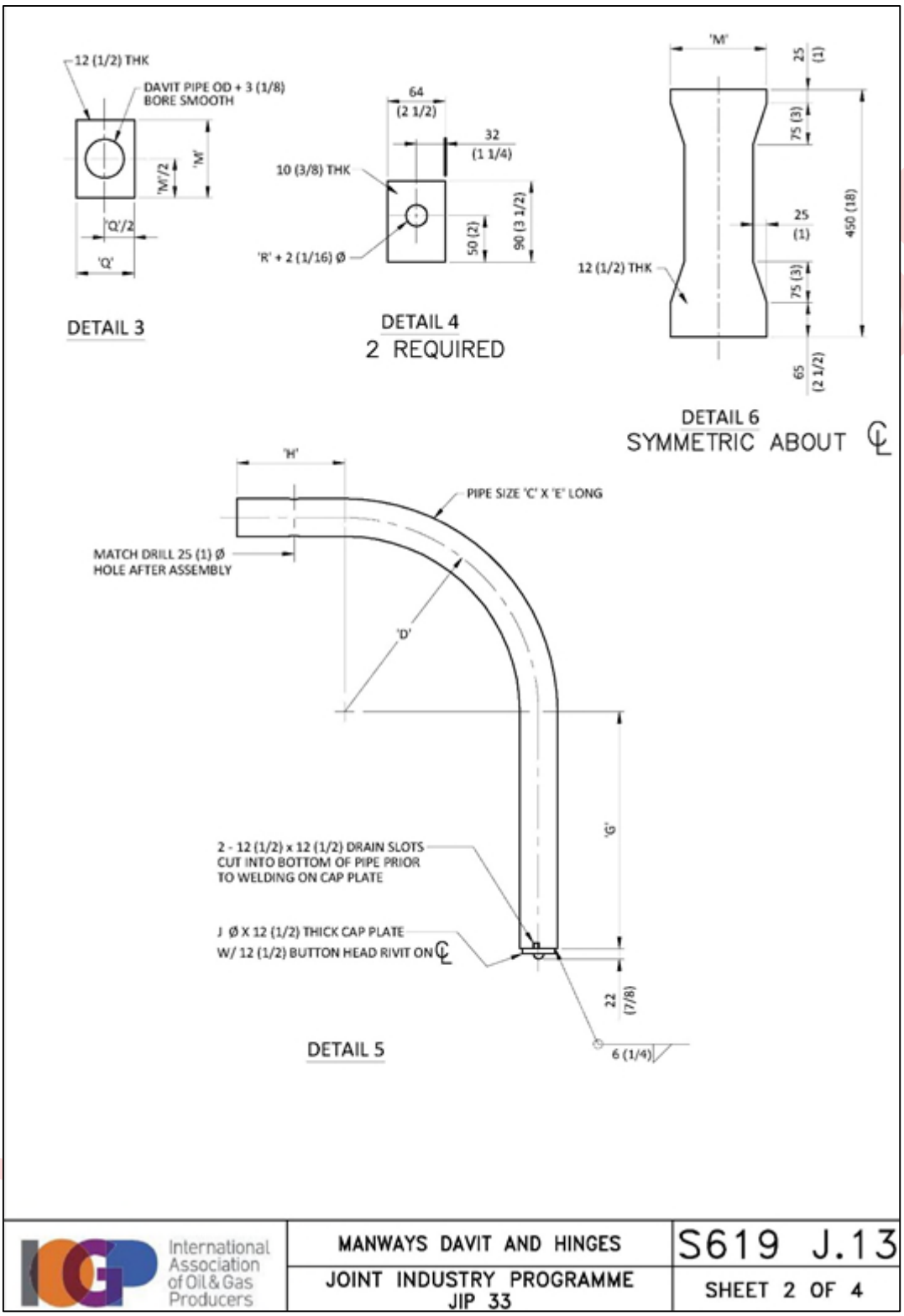

NOTES :-

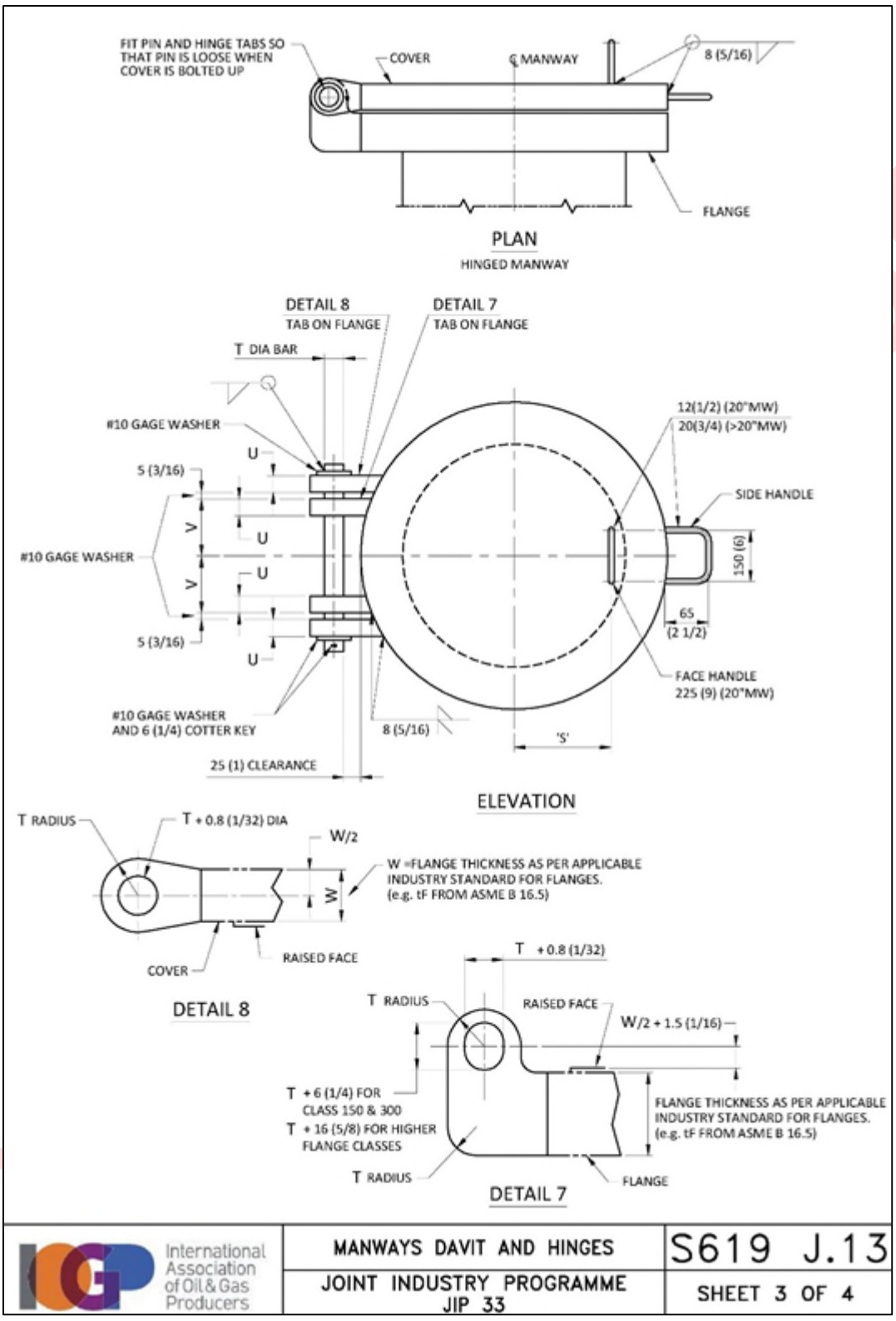
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. USE TEMPLATE FOR VERTICAL VESSEL WITH EIGHT (8) OR MORE ANCHOR BOLTS.
3. DRILL BOLT HOLES IN BASE PLATE AND FOUNDATION TEMPLATE PLATE TOGETHER.
4. DESIGN THE TEMPLATE COMPONENTS (SUCH AS ADDITIONAL BRACING SUPPORTS, NUMBER OF SEGMENTS, REQUIREMENT OF GUSSET PLATES) TO AVOID DEFORMATION DURING TRANSPORTATION AND HANDLING AT SITE. BRACING, SEGMENT SEPARATION AND GUSSET PLATES SHOWN IN DRAWING ARE INDICATIVE.
5. TRIAL FIT / ASSEMBLE ALL SEGMENT PRIOR TO DISPATCH.
6. MARK 0°, 90°, 180°,270°, "NORTH" (SAME AS VESSEL ORIENTATION), VESSEL TAG NUMBER AND WORD "TOP" ON TEMPLATE PLATE WITH WELD BEAD LETTERING NO LESS THAN 25 (1) HIGH.
7. DIMENSION 'H' IS EQUAL TO THE HEIGHT OF THE GUSSET PLATE PLUS THICKNESS OF SKIRT BASE PLATE PLUS THICKNESS OF COMPRESSION RING PLUS WASHER THICKNESS.
8. BRACING SHOULD BE ON THE TOP OF THE TEMPLATE.
9. BOTTOM OF TEMPLATE SHOULD BE FLUSH.

| International Association of Oil & Gas Producers | FOUNDATION TEMPLATE FOR SKIRT SUPPORTED VESSELS<br>JOINT INDUSTRY PROGRAMME JIP 33 | S619 J.12<br>SHEET 1 OF 1 |
|---|---|---|

## J.13 Manway davit




12 (1/2) THK
DAVIT PIPE OD + 3 (1/8)
BORE SMOOTH
'M'/2
'M'
'Q'/2
'Q'
DETAIL 3
64
(2 1/2)
32
(1 1/4)
10 (3/8) THK
'R' + 2 (1/16) Ø
50 (2)
90 (3 1/2)
DETAIL 4
2 REQUIRED
'M'
25
(1)
75 (3)
25
(1)
75 (3)
450 (18)
12 (1/2) THK
65
(2 1/2)
DETAIL 6
SYMMETRIC ABOUT
'H'
PIPE SIZE 'C' X 'E' LONG
MATCH DRILL 25 (1) Ø
HOLE AFTER ASSEMBLY
'D'
'G'
2 - 12 (1/2) x 12 (1/2) DRAIN SLOTS
CUT INTO BOTTOM OF PIPE PRIOR
TO WELDING ON CAP PLATE
J Ø X 12 (1/2) THICK CAP PLATE
W/ 12 (1/2) BUTTON HEAD RIVIT ON
22
(7/8)
6 (1/4)
DETAIL 5
International Association of Oil & Gas Producers
MANWAYS DAVIT AND HINGES
JOINT INDUSTRY PROGRAMME
JIP 33
S619 J.13
SHEET 2 OF 4


FIT PIN AND HINGE TABS SO THAT PIN IS LOOSE WHEN COVER IS BOLTED UP
COVER
℄ MANWAY
8 (5/16)
FLANGE
PLAN
HINGED MANWAY
DETAIL 8
TAB ON FLANGE
DETAIL 7
TAB ON FLANGE
T DIA BAR
#10 GAGE WASHER
5 (3/16)
U
V
#10 GAGE WASHER
5 (3/16)
#10 GAGE WASHER AND 6 (1/4) COTTER KEY
25 (1) CLEARANCE
8 (5/16)
'S'
12(1/2) (20°MW)
20(3/4) (>20°MW)
SIDE HANDLE
150 (6)
65
(2 1/2)
FACE HANDLE
225 (9) (20°MW)
ELEVATION
T RADIUS
T + 0.8 (1/32) DIA
W/2
W
W =FLANGE THICKNESS AS PER APPLICABLE INDUSTRY STANDARD FOR FLANGES. (e.g. tF FROM ASME B 16.5)
COVER
RAISED FACE
DETAIL 8
T + 0.8 (1/32)
T RADIUS
RAISED FACE
W/2 + 1.5 (1/16)
T + 6 (1/4) FOR CLASS 150 & 300
T + 16 (5/8) FOR HIGHER FLANGE CLASSES
FLANGE THICKNESS AS PER APPLICABLE INDUSTRY STANDARD FOR FLANGES. (e.g. tF FROM ASME B 16.5)
T RADIUS
FLANGE
DETAIL 7
International Association of Oil & Gas Producers
MANWAYS DAVIT AND HINGES
JOINT INDUSTRY PROGRAMME JIP 33
S619 J.13
SHEET 3 OF 4

| MANWAY | | DAVIT PIPE | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DIAMETER DN (NPS) | CLASS RATING | NOMINAL SIZE | BEND | LENGTH | OFFSET | VERT LEN | HORIZ LEN | CAP DIA |
| | | C | D | E | F | G | H | J |
| 500 (20) | 150 | DN 50 (NPS 2) SCH 160 | 380 (15) | 1305.8 (51.41) | 438.2 (17.25) | 529.6 (20.85) | 175 (7) | 48 (1.875) |
| 500 (20) | 300 | DN 50 (NPS 2) SCH 160 | 405 (16) | 1383.8 (54.48) | 476.3 (18.75) | 542.3 (21.35) | 200 (8) | 48 (1.875) |
| 500 (20) | 600 | DN 80 (NPS 3) SCH 80 | 405 (16) | 1453.6 (57.23) | 520.7 (20.5 ) | 561.3 (22.10) | 250 (10) | 76 (3) |
| 500 (20) | 900 | DN 80 (NPS 3) SCH 160 | 460 (18) | 1479.6 (58.25) | 543 (21.375) | 532.9 (20.98) | 225 (9) | 76 (3) |
| 600 (24) | 150 | DN 65 (NPS 2 1/2) SCH 160 | 405 (16) | 1453.6 (57.23) | 520.7 (20.5) | 561.3 (22.10) | 250 (10) | 60 (2.375) |
| 600 (24) | 300 | DN 80 (NPS 3) SCH 80 | 460 (18) | 1533.4(60.37) | 571.5 (22.5) | 561.3 (22.10) | 250 (10) | 76 (3) |
| 600 (24) | 600 | DN 100 (NPS 4) SCH 160 | 460 (18) | 1596.9(62.87) | 596.9 (23.5) | 574 (22.60) | 300 (12) | 76 (3) |
| 600 (24) | 900 | DN 100 (NPS 4) SCH 160 | 530 (21) | 1666.0 (65.59) | 647.7 (25.5) | 548.6 (21.60) | 275 (11) | 76 (3) |
| 750 (30) | 150 | DN 80 (NPS 3) SCH 80 | 460 (18) | 1520.0 (59.84) | 558 (21.97) | 547.9 (21.57) | 250 (10) | 76 (3) |
| 750 (30) | 300 | DN 100 (NPS 4) SCH 160 | 530 (21) | 1615.2(63.59) | 622.3 (24.5) | 523.2 (20.60) | 250 (10) | 102 (4) |
| 750 (30) | 600 | DN 100 (NPS 4) SCH 160 | 530 (21) | 1656.3 (65.21) | 638.2 (25.125) | 539.2 (21.23) | 275 (11) | 102 (4) |
| 900 (36) | 150 | DN 100 (NPS 4) SCH 80 | 530 (21) | 1673.9(65.90) | 655.6 (25.81) | 556.5 (21.91) | 275 (11) | 102 (4) |
| 900 (36) | 300 | DN 100 (NPS 4) SCH 160 | 610 (24) | 1749.0(68.86) | 712.7 (28.06) | 537.5 (21.16) | 250 (10) | 102 (4) |

| DETAIL D1 | | | DETAIL D2 | DETAIL D3 | ELEVATION | | NON-DAVIT DESIGN | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | BOLT DIA | HANDHOLD | PIN DIA | TAB THK | HINGE DIM |
| K | L | M | P | Q | R | S | T | U | V |
| 250.2 (9.85) | 75 (3) | 125 (5) | 110.5 (4.35) | 100 (4) | 22 (0.875) | 225 (9) | 25 (1) | 25 (1) | 150 (6) |
| 239.8 (9.44) | 75 (3) | 125 (5) | 100.1 (3.94) | 100 (4) | 22 (0.875) | 225 (9) | 25 (1) | 25 (1) | 150 (6) |
| 286.3 (11.27) | 100 (4) | 150 (6) | 95.8 (3.77) | 150 (6) | 22 (0.875) | 225 (9) | 32 (1.25) | 25 (1) | 150 (6) |
| 282 (11.10) | 100 (4) | 175 (7) | 91.4 (3.60) | 150 (6) | 22 (0.875) | 225 (9) | 38 (1.5) | 25 (1) | 150 (6) |
| 286.3 (11.27) | 100 (4) | 150 (6) | 95.8 (3.77) | 150 (6) | 22 (0.875) | 275 (11) | 38 (1.5) | 32 (1.25) | 190 (7.5) |
| 277.1 (10.91) | 100 (4) | 175 (7) | 86.6 (3.41) | 150 (6) | 22 (0.875) | 275 (11) | 38 (1.5) | 32 (1.25) | 190 (7.5) |
| 300.8 (11.84) | 115 (4.5) | 200 (8) | 84.8 (3.34) | 175 (7) | 22 (0.875) | 275 (11) | 38 (1.5) | 32 (1.25) | 190 (7.5) |
| 294.1 (11.58) | 115 (4.5) | 200 (8) | 78.2 (3.08) | 175 (7) | 25 (1) | 275 (11) | 50 (2) | 32 (1.25) | 190 (7.5) |
| 279.4 (11.00 ) | 100 (4) | 162.5 (6.5) | 88.9 (3.50) | 150 (6) | 22 (0.875) | 350 (14) | 38 (1.5) | 38 (1.5) | 225 (9) |
| 297.2 (11.70) | 115 (4.5) | 200 (8) | 81.3 (3.20) | 175 (7) | 22 (0.875) | 350 (14) | 38 (1.5) | 38 (1.5) | 225 (9) |
| 295.1 (11.62) | 115 (4.5) | 200 (8) | 79.2 (3.12) | 175 (7) | 25 (1) | 350 (14) | 45 (1.75) | 38 (1.5) | 225 (9) |
| 293.4 (11.55 | 115 (4.5) | 200 (8) | 77.5 (3.05) | 175 (7) | 22 (0.875) | 425 (17) | 38 (1.5) | 38 (1.5) | 225 (9) |
| 287.8 (11.33) | 115 (4.5) | 200 (8) | 71.9 (2.83) | 175 (7) | 25 (1) | 425 (17) | 45 (1.75) | 38 (1.5) | 275 (11) |

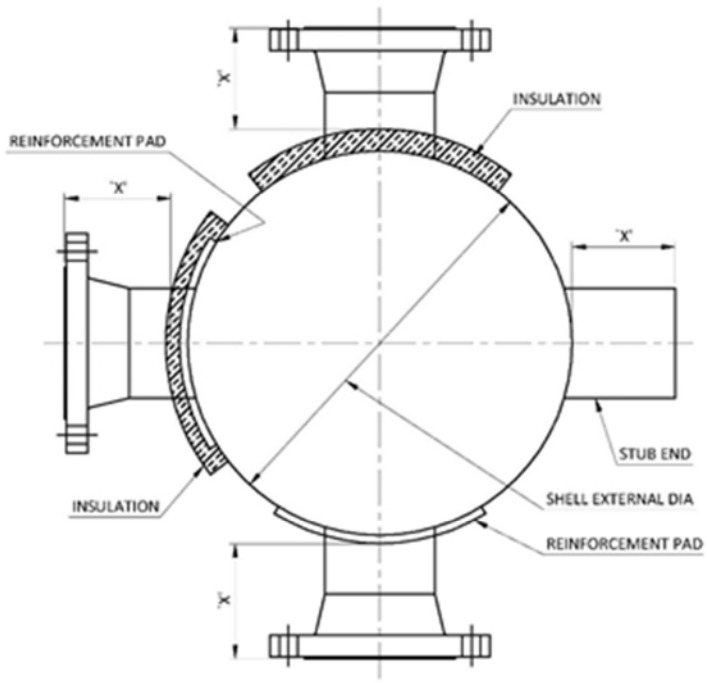
## NOTES :-

1. UNLESS SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETERS (INCHES).
2. VERIFY FUNCTIONALITY OF DAVIT ASSEMBLY IN SHOP
3. PLATE AND BAR TO BE ASTM A36 OR A516 . PIPE TO BE ASTM A53 GRADE B OR A106M PLATE AND BAR TO BE ASTM A36 OR A516. PIPE TO BE ASTM A53 GRADE B OR A106M.
4. 22(7/8) DIA. FORGED EYEBOLT FOR APPLICATIONS WARMER THAN 20°F (-7°C) MAT'L SHALL BE ASTM A489. FOR APPLICATIONS WARMER THAN -40°F(-40°C) MAT'L SHALL BE ASTM F541. EYEBOLT SHALL BE SUFFICIENTLY LONG TO ALLOW FIVE THREADS TO SHOW ABOVE NUTS WHEN MANWAY COVER IS CLOSED.
5. WELDS TO BE 6(1/4) MINIMUM. DOUBLE FILLET WELDS U.N.O.

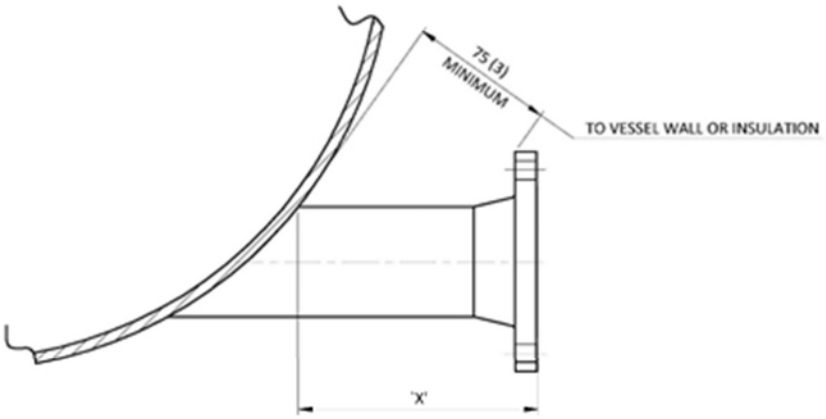
| International Association of Oil & Gas Producers | MANWAYS DAVIT AND HINGES<br>JOINT INDUSTRY PROGRAMME<br>JIP 33 | S619 J.13<br>SHEET 4 OF 4 |
|---|---|---|

## J.14 Nozzle standout

SOURCE : EQUINOR TR 1053, V.9.01, 2016, Fig. 1




RADIAL NOZZLE STANDOUT LENGTH 'X'




OFFSET NOZZLE STANDOUT LENGTH 'X'

| International Association of Oil & Gas Producers | NOZZLE STANDOUT<br>JOINT INDUSTRY PROGRAMME JIP 33 | S619 J.14<br>SHEET 1 OF 2 |
|---|---|---|

SOURCE : EQUINOR TR 1053, V.9.01, 2016, TABLE 2

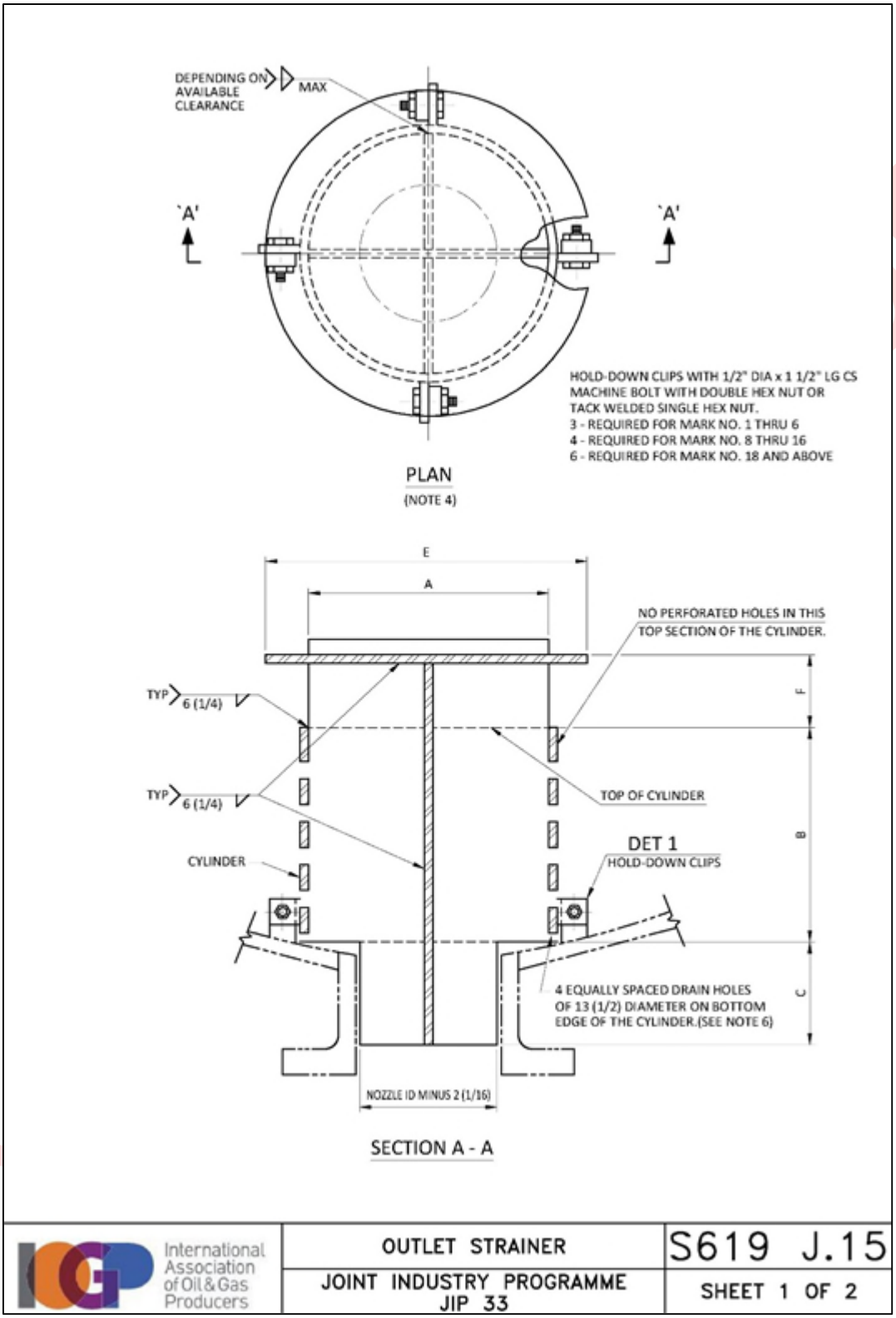
| FLANGE CLASS | MINIMUM NOZZLE STANDOUT LENGTH 'X' | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DN 40 AND DN 50 | DN 80 | DN 100 | DN 150 | DN 200 | DN 250 | DN 300 | DN 350 | DN 400 | DN 450 | DN 500 | DN 600 |
| | NPS 1 1/2 AND NPS 2 | NPS 3 | NPS 4 | NPS 6 | NPS 8 | NPS 10 | NPS 12 | NPS 14 | NPS 16 | NPS 18 | NPS 20 | NPS 24 |
| CL-150 | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 320 (13) |
| CL-300 | 200 (8) | 200 (8) | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 220 (9) | 320 (13) |
| CL-600 | 200 (8) | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 220 (9) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 320 (13) |
| CL-900 | 200 (8) | 200 (8) | 220 (9) | 220 (9) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 320 (13) |
| CL-1500 | 220 (9) | 220 (9) | 260 (10 1/2) | 260 (10 1/2) | 260 (10 1/2) | 320 (13) | 320 (13) | 320 (13) | 320 (13) | 400 (16) | 400 (16) | 400 (16) |
| CL-2500 | 260 (10 1/2) | 260 (10 1/2) | 320 (13) | 320 (13) | 320 (13) | 400 (16) | 400 (16) | | | | | |

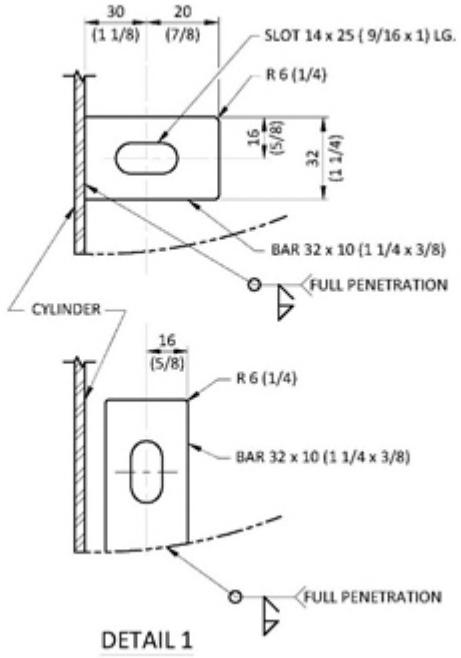
NOTES :-

1. UNLESS SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).

| | | |
|---|---|---|
| International Association of Oil & Gas Producers | NOZZLE STANDOUT | S619 J.14 |
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 2 OF 2 |

## J.15 Outlet strainer






DETAIL 1

| NOZZLE SIZE DN (NPS) | 40 (1 1/2) | 50 (2) | 80 (3) | 100 (4) | 150 (6) | 200 (8) | 250 (10) | 300 (12) | 350 (14) | 400 (16) | 450 (18) | 500 (20) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 75 (3) | 100 (4) | 125 (5) | 150 (6) | 200 (8) | 300 (12) | 350 (14) | 400 (16) | 450 (18) | 500 (20) | 600 (24) | 675 (27) |
| B | 75 (3) | 100 (4) | 125 (5) | 150 (6) | 150 (6) | 150 (6) | 200 (8) | 250 (10) | 275 (11) | 350 (14) | 350 (14) | 400 (16) |
| C | 100 (4) | 100 (4) | 100 (4) | 100 (4) | 100 (4) | 125 (5) | 125 (5) | 125 (5) | 150 (6) | 150 (6) | 150 (6) | 150 (6) |
| E | 100 (4) | 125 (5) | 150 (6) | 190 (7 1/2) | 250 (10) | 370 (14 1/2) | 455 (17 1/2) | 500 (20) | 575 (23) | 650 (26) | 750 (30) | 825 (33) |
| F | 19 (3/4) | 25 (1) | 32 (1 1/4) | 38 ( 1 1/2) | 50 (2) | 75 (3) | 90 (3 1/2) | 100 (4) | 100 (4) | 125 (5) | 150 (6) | 175 (7) |

NOTES :-

1. ALL DIMENSIONS ARE IN MILIMETRES (INCHES).
2. ENTIRE SURFACE OF CYLINDER SHALL BE PERFORATED WITH 10 (3/8) DIAMETER HOLES AT 12 (1/2) CENTERS ON TRIANGULAR PITCH.
3. ALL COMPONENTS TO HAVE A MINIMUM CORRODED THICKNESS OF 3 (1/8).
4. TWO CROSS MEMBERS AS SHOWN FOR ALL MARK NO'S, BUT FOR NO'S 1 THRU 3 TERMINATE ONE CROSS MEMBER AT BOTTOM OF DIMENSION "B".
5. NOTE THAT FOR NOZZLES 10 INCH. AND LARGER, THESE STRAINERS MAY NOT FIT THROUGH A MANWAY AND MUST BE INSTALLED BEFORE CLOSING UP THE VESSEL, OR FABRICATED IN TWO PARTS AND WELDED TOGETHER INSIDE THE VESSEL.
6. LOCATE DRAIN HOLES AWAY FROM HOLD DOWN CLIP WELD AND CROSS PLATE WELDS AREA TO AVOID INTERFERENCE.

| International Association of Oil & Gas Producers | OUTLET STRAINER | S619 J.15 |
|---|---|---|
| | JOINT INDUSTRY PROGRAMME JIP 33 | SHEET 2 OF 2 |

# Annex K
(normative)
# Allowable nozzle loads for nozzle sizes DN 650 (NPS 24) to DN 1500 (NPS 60)

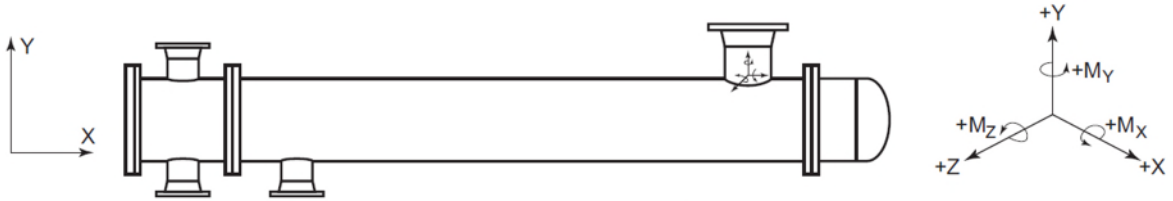



**Figure K.1 — Directions of moments and forces on nozzles**

**Table K.1 — Allowable nozzle loads (for nozzle sizes NPS 650 (24 in) to NPS 1500 (60 in)**

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 650 | 26 | 150 | 18,950 | 13,980 | 28,430 | 20,970 | 24,070 | 17,750 | 30,200 | 6,790 | 24,200 | 5,440 | 30,200 | 6,790 |
| | | 300 | 18,950 | 13,980 | 28,430 | 20,970 | 24,070 | 17,750 | 37,320 | 8,390 | 29,890 | 6,720 | 37,320 | 8,390 |
| | | 600 | 39,670 | 29,260 | 59,510 | 43,890 | 50,380 | 37,160 | 55,070 | 12,380 | 44,080 | 9,910 | 55,070 | 12,380 |
| | | 900 | 60,310 | 44,480 | 90,470 | 66,730 | 76,590 | 56,490 | 74,600 | 16,770 | 59,740 | 13,430 | 74,600 | 16,770 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Table K.1** *(continued)*

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 700 | 28 | 150 | 23,820 | 17,570 | 35,730 | 26,350 | 30,250 | 22,310 | 33,670 | 7,570 | 27,000 | 6,070 | 33,670 | 7,570 |
| | | 300 | 23,820 | 17,570 | 35,730 | 26,350 | 30,250 | 22,310 | 37,230 | 8,370 | 29,850 | 6,710 | 37,230 | 8,370 |
| | | 600 | 49,410 | 36,440 | 74,120 | 54,670 | 62,750 | 46,280 | 56,710 | 12,750 | 45,460 | 10,220 | 56,710 | 12,750 |
| | | 900 | 74,650 | 55,060 | 111,980 | 82,590 | 94,810 | 69,930 | 79,760 | 17,930 | 63,970 | 14,380 | 79,760 | 17,930 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 750 | 30 | 150 | 30,280 | 22,330 | 45,420 | 33,500 | 38,460 | 28,370 | 37,190 | 8,360 | 29,800 | 6,700 | 37,190 | 8,360 |
| | | 300 | 30,280 | 22,330 | 45,420 | 33,500 | 38,460 | 28,370 | 37,190 | 8,360 | 29,800 | 6,700 | 37,190 | 8,360 |
| | | 600 | 62,150 | 45,840 | 93,230 | 68,760 | 78,940 | 58,220 | 58,410 | 13,130 | 46,840 | 10,530 | 58,410 | 13,130 |
| | | 900 | 93,520 | 68,980 | 140,290 | 103,470 | 118,770 | 87,600 | 84,960 | 19,100 | 68,150 | 15,320 | 84,960 | 19,100 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 800 | 32 | 150 | 37,330 | 27,530 | 56,000 | 41,300 | 47,410 | 34,970 | 39,630 | 8,910 | 31,800 | 7,150 | 39,630 | 8,910 |
| | | 300 | 37,330 | 27,530 | 56,000 | 41,300 | 47,410 | 34,970 | 39,630 | 8,910 | 31,800 | 7,150 | 39,630 | 8,910 |
| | | 600 | 76,580 | 56,480 | 114,860 | 84,720 | 97,270 | 71,740 | 62,320 | 14,010 | 50,000 | 11,240 | 62,320 | 14,010 |
| | | 900 | 115,240 | 85,000 | 172,850 | 127,490 | 146,350 | 107,940 | 90,610 | 20,370 | 72,680 | 16,340 | 90,610 | 20,370 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Table K.1** *(continued)*

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 900 | 36 | 150 | 53,090 | 39,160 | 79,640 | 58,740 | 67,420 | 49,730 | 44,620 | 10,030 | 35,760 | 8,040 | 44,620 | 10,030 |
| | | 300 | 53,090 | 39,160 | 79,640 | 58,740 | 67,420 | 49,730 | 44,620 | 10,030 | 35,760 | 8,040 | 44,620 | 10,030 |
| | | 600 | 108,530 | 80,050 | 162,810 | 120,080 | 137,830 | 101,660 | 70,100 | 15,760 | 56,230 | 12,640 | 70,100 | 15,760 |
| | | 900 | 164,810 | 121,560 | 247,220 | 182,340 | 209,310 | 154,380 | 101,950 | 22,920 | 81,800 | 18,390 | 101,950 | 22,920 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 950 | 38 | 150 | 55,520 | 40,950 | 83,270 | 61,420 | 70,520 | 52,010 | 47,060 | 10,580 | 37,770 | 8,490 | 47,060 | 10,580 |
| | | 300 | 55,520 | 40,950 | 83,270 | 61,420 | 70,520 | 52,010 | 47,060 | 10,580 | 37,770 | 8,490 | 47,060 | 10,580 |
| | | 600 | 120,610 | 88,960 | 180,920 | 133,440 | 153,170 | 112,970 | 73,970 | 16,630 | 59,340 | 13,340 | 73,970 | 16,630 |
| | | 900 | 207,510 | 153,050 | 311,270 | 229,580 | 263,540 | 194,380 | 107,600 | 24,190 | 86,340 | 19,410 | 107,600 | 24,190 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1000 | 40 | 150 | 63,990 | 47,200 | 95,990 | 70,800 | 81,270 | 59,940 | 53,110 | 11,940 | 42,610 | 9,580 | 53,110 | 11,940 |
| | | 300 | 63,990 | 47,200 | 95,990 | 70,800 | 81,270 | 59,940 | 53,110 | 11,940 | 42,610 | 9,580 | 53,110 | 11,940 |
| | | 600 | 141,330 | 104,240 | 212,000 | 156,360 | 179,500 | 132,390 | 88,520 | 19,900 | 70,990 | 15,960 | 88,520 | 19,900 |
| | | 900 | 248,100 | 182,990 | 372,140 | 274,480 | 315,090 | 232,400 | 113,300 | 25,470 | 90,880 | 20,430 | 113,300 | 25,470 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Table K.1** *(continued)*

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 1050 | 42 | 150 | 74,230 | 54,750 | 111,350 | 82,130 | 94,270 | 69,530 | 55,740 | 12,530 | 44,750 | 10,060 | 55,740 | 12,530 |
| | | 300 | 74,230 | 54,750 | 111,350 | 82,130 | 94,270 | 69,530 | 55,740 | 12,530 | 44,750 | 10,060 | 55,740 | 12,530 |
| | | 600 | 165,910 | 122,370 | 248,870 | 183,560 | 210,710 | 155,410 | 92,920 | 20,890 | 74,550 | 16,760 | 92,920 | 20,890 |
| | | 900 | 284,000 | 209,470 | 426,000 | 314,200 | 360,670 | 266,020 | 118,950 | 26,740 | 95,410 | 21,450 | 118,950 | 26,740 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1100 | 44 | 150 | 87,230 | 64,340 | 130,850 | 96,510 | 110,780 | 81,710 | 58,410 | 13,130 | 46,840 | 10,530 | 58,410 | 13,130 |
| | | 300 | 87,230 | 64,340 | 130,850 | 96,510 | 110,780 | 81,710 | 58,410 | 13,130 | 46,840 | 10,530 | 58,410 | 13,130 |
| | | 600 | 193,160 | 142,470 | 289,740 | 213,700 | 245,310 | 180,930 | 97,370 | 21,890 | 78,110 | 17,560 | 97,370 | 21,890 |
| | | 900 | 309,760 | 228,470 | 464,640 | 342,700 | 393,400 | 290,160 | 124,590 | 28,010 | 99,950 | 22,470 | 124,590 | 28,010 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1150 | 46 | 150 | 98,890 | 72,940 | 148,340 | 109,410 | 125,590 | 92,630 | 61,070 | 13,730 | 48,970 | 11,010 | 61,070 | 13,730 |
| | | 300 | 98,890 | 72,940 | 148,340 | 109,410 | 125,590 | 92,630 | 61,070 | 13,730 | 48,970 | 11,010 | 61,070 | 13,730 |
| | | 600 | 219,670 | 162,020 | 329,500 | 243,030 | 278,990 | 205,770 | 101,780 | 22,880 | 81,670 | 18,360 | 101,780 | 22,880 |
| | | 900 | 338,560 | 249,710 | 507,840 | 374,560 | 429,970 | 317,130 | 130,290 | 29,290 | 104,530 | 23,500 | 130,290 | 29,290 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Table K.1** *(continued)*

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 1200 | 48 | 150 | 114,160 | 84,200 | 171,240 | 126,300 | 144,980 | 106,930 | 63,700 | 14,320 | 51,110 | 11,490 | 63,700 | 14,320 |
| | | 300 | 114,160 | 84,200 | 171,240 | 126,300 | 144,980 | 106,930 | 63,700 | 14,320 | 51,110 | 11,490 | 63,700 | 14,320 |
| | | 600 | 252,300 | 186,090 | 378,450 | 279,130 | 320,420 | 236,330 | 106,180 | 23,870 | 85,180 | 19,150 | 106,180 | 23,870 |
| | | 900 | 368,630 | 271,890 | 552,960 | 407,840 | 468,160 | 345,300 | 135,940 | 30,560 | 109,070 | 24,520 | 135,940 | 30,560 |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1250 | 50 | 150 | 131,850 | 97,250 | 197,790 | 145,880 | 167,440 | 123,500 | 66,370 | 14,920 | 53,250 | 11,970 | 66,370 | 14,920 |
| | | 300 | 131,850 | 97,250 | 197,790 | 145,880 | 167,440 | 123,500 | 66,370 | 14,920 | 53,250 | 11,970 | 66,370 | 14,920 |
| | | 600 | 283,840 | 209,350 | 425,750 | 314,020 | 360,480 | 265,880 | 110,630 | 24,870 | 88,740 | 19,950 | 110,630 | 24,870 |
| | | 900 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1300 | 52 | 150 | 148,120 | 109,250 | 222,180 | 163,870 | 188,110 | 138,740 | 69,040 | 15,520 | 55,380 | 12,450 | 69,040 | 15,520 |
| | | 300 | 148,120 | 109,250 | 222,180 | 163,870 | 188,110 | 138,740 | 69,040 | 15,520 | 55,380 | 12,450 | 69,040 | 15,520 |
| | | 600 | 317,980 | 234,530 | 476,980 | 351,800 | 403,830 | 297,850 | 115,030 | 25,860 | 92,300 | 20,750 | 115,030 | 25,860 |
| | | 900 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Table K.1** *(continued)*

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 1350 | 54 | 150 | 168,000 | 123,910 | 252,010 | 185,870 | 213,370 | 157,370 | 71,710 | 16,120 | 57,520 | 12,930 | 71,710 | 16,120 |
| | | 300 | 168,000 | 123,910 | 252,010 | 185,870 | 213,370 | 157,370 | 71,710 | 16,120 | 57,520 | 12,930 | 71,710 | 16,120 |
| | | 600 | 359,500 | 265,150 | 539,250 | 397,730 | 456,570 | 336,750 | 119,480 | 26,860 | 95,860 | 21,550 | 119,480 | 26,860 |
| | | 900 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1400 | 56 | 150 | 187,050 | 137,960 | 280,590 | 206,950 | 237,550 | 175,210 | 74,330 | 16,710 | 59,650 | 13,410 | 74,330 | 16,710 |
| | | 300 | 187,050 | 137,960 | 280,590 | 206,950 | 237,550 | 175,210 | 74,330 | 16,710 | 59,650 | 13,410 | 74,330 | 16,710 |
| | | 600 | 399,330 | 294,530 | 599,000 | 441,800 | 507,140 | 374,050 | 123,880 | 27,850 | 99,420 | 22,350 | 123,880 | 27,850 |
| | | 900 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1450 | 58 | 150 | 210,190 | 155,030 | 315,300 | 232,550 | 266,930 | 196,880 | 77,000 | 17,310 | 61,790 | 13,890 | 77,000 | 17,310 |
| | | 300 | 210,190 | 155,030 | 315,300 | 232,550 | 266,930 | 196,880 | 77,000 | 17,310 | 61,790 | 13,890 | 77,000 | 17,310 |
| | | 600 | 420,490 | 310,140 | 630,750 | 465,220 | 534,040 | 393,890 | 128,330 | 28,850 | 102,930 | 23,140 | 128,330 | 28,850 |
| | | 900 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Table K.1** *(continued)*

| DN | NPS | Flange rating | Mx | | My | | Mz | | Fx | | Fy | | Fz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N-m) | (lbf·ft) | (N) | (lbs) | (N) | (lbs) | (N) | (lbs) |
| 1500 | 60 | 150 | 232,250 | 171,300 | 348,380 | 256,950 | 294,960 | 217,550 | 79,670 | 17,910 | 63,920 | 14,370 | 79,670 | 17,910 |
| | | 300 | 232,250 | 171,300 | 348,380 | 256,950 | 294,960 | 217,550 | 79,670 | 17,910 | 63,920 | 14,370 | 79,670 | 17,910 |
| | | 600 | 450,000 | 331,900 | 674,990 | 497,850 | 571,500 | 421,520 | 132,730 | 29,840 | 106,490 | 23,940 | 132,730 | 29,840 |
| | | 900 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 1500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2500 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

# Bibliography

[1] ~~The Case for MACA: The Optimization of Corrosion Allowance –~~ASME 2016 Pressure Vessels and Piping Conference, PVP2016-63074, *The Case for MACA: The Optimization of Corrosion Allowance*

[2] ~~Guidelines for MACA: The Optimization of Corrosion Allowance –~~ASME 2016 Pressure Vessels and Piping Conference, PVP2016-63075, *Guidelines for MACA: The Optimization of Corrosion Allowance*

**Registered Office**
City Tower
Level 14
40 Basinghall Street
London EC2V 5DE
United Kingdom

T +44 (0)20 3763 9700
reception@iogp.org

**Brussels Office**
Avenue de Tervuren 188A
B-1150 Brussels
Belgium

T +32 (0)2 790 7762
reception-europe@iogp.org

**Houston Office**
15377 Memorial Drive
Suite 250
Houston, TX 77079
USA

T +1 (713) 261 0411
reception-americas@iogp.org

www.iogp.org