

Compact flanged connections

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Foreword	2
Introduction	2
1 Scope	4
2 Normative and informative references	4
2.1 Normative references	4
2.2 Informative references	4
3 Terms, definitions and abbreviations	5
3.1 Definitions	5
3.2 Abbreviations	6
4 Fundamental design requirements	6
4.1 General	6
4.2 Materials	7
4.3 Strength	7
4.4 Corrosion resistance	8
4.5 Temperature	8
4.6 Leakage	8
4.7 Information requirements for supplier specific CFC	8
4.8 Designation and marking	8
5 Product standard	9
5.1 General	9
5.2 Normative references used in Clause 5	9
5.3 General description of flange design and features	10
5.4 Standard components	11
5.5 Designation	13
5.6 General requirements	13
5.7 Dimensions	14
5.8 Weights of flanges	14
5.9 Flange faces	15
5.10 Surface finish	15
5.11 Tolerances	16
5.12 Marking	16
5.13 IX seal ring	16
5.14 Handling, installation and assembly	18
Annex A (Normative) Flange dimensions and weights	27
Annex B (Normative) Seals dimensions and weights	59
Annex C (Normative) Bolt dimensions and weights	64
Annex D (Normative) Pressure temperature ratings	70
Annex E (Informative) Materials	72
Annex F (Informative) Metric bolting	74
Annex G (Informative) Statement of compliance	76
Annex H (Normative) Integral flange angle selection	77
Bibliography	86

Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as, possible intended to replace oil company specifications and serve as references in the authorities regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF), The Federation of Norwegian Industry, Norwegian Shipowners' Association and The Petroleum Safety Authority Norway.

NORSOK standards are administered and published by Standards Norway.

Attention is drawn to the possibility that some of the elements of this NORSOK standard may be the subject of patent rights. Queries about patent rights may be directed to Standards Norway.

This NORSOK standard is based on common principles utilized by VERAX¹⁾, Vector International AS and Off.N.Galperti SpA.

The CFC as described in Clause 5 is based upon the SPO¹⁾ compact flange developed by Vector International AS.

Annex A, B, C, D and H are normative for products according to Clause 5, whilst Annex E, F and G are informative.

Experience from the first edition of this NORSOK standard has revealed a need of the following improvements, which have been incorporated into the second edition:

- Requirements in order to improve documentation of mechanical properties in 4.2.
- Nickel alloys added for flanges, see 5.6.1.
- More specific guidelines to alignment in 5.14.7 including shear force capacity of seal ring.
- Improved design of blind flange in A.3 in order to improve sealing with a rigid interface.
- Design of integral flanges in A.4 in order to make them more feasible with all type of valves and equipment nozzle designs.
- Orifice spacers for monitoring of flow rate have been added to Clause 5, see A.7.
- Reducing threaded flanges for instrument connections have been added to Clause 5, see A.8.
- An informative bibliography has been added.

Introduction

This NORSOK standard is developed to provide an industry standard for a CFC which is an alternative to conventional flanges as specified in ASME standards, European Standard and International Standard, with reduced weight and smaller overall dimensions. In addition leak tightness reliability is increased by its inherent design features and make up procedures. The CFC may also be an alternative to other types of clamp and hub type mechanical connectors.

¹⁾ VERAX, SPO, CFS and GC - Compact Flanges are trade names of products supplied by VERAX, Vector International AS and Off.N.Galperti SpA. This information is given for the convenience of users of this NORSOK standard and does not constitute an endorsement by NORSOK of the products named. Equivalent products may be used if they can be shown to lead to the same results.

The use of load carrying sealing elements, traditionally referred to as "gaskets", will normally violate the fundamental requirements of this NORSOK standard.

It is claimed that compliance with this NORSOK standard may involve the use of a patent concerning the product given in Clause 5. However, the holder of this patent right – Patent no. NO177160 – has accepted free use of the flange configurations within the application limits contained in Clause 5.

1 Scope

This NORSOK standard provides general design and manufacturing requirements for CFCs used for joining equipment, valves, piping and other piping components. A specific and complete CFC product standard is included in Clause 5.

2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet the requirements of the referenced standards.

2.1 Normative references

ASME B1.1,	Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.5,	Pipe Flanges and Flanged Fittings
ASME B16.20,	Metallic Gaskets For Pipe Flanges: Ring Joint Spiral Wound And Jacketed
ASME B16.25,	Butt welding ends
ASME B16.34,	Valves - Flanged, Threaded and Welding End
ASME B18.2.2,	Square and Hex Nuts (Inch Series)
ASME B1.20.1	Pipe Threads, General Purpose (Inch)
ASME B31.3,	Process Piping
ASME B36.10M,	Welded and Seamless Wrought Steel Pipe
ASME B36.19M,	Stainless Steel Pipe
ASME VIII Div. 2,	Boiler and Pressure Vessel Code – Alternative Rules
ASTM A193,	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-temperature Service
EN 1092-1:2001,	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges
EN 1779:1999,	Non-destructive testing - Leak testing - Criteria for method and technique selection
EN 13480 (all parts),	Metallic industrial piping -
ISO 2768-1,	General tolerances - Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
ISO 4200,	Plain end steel tubes, welded and seamless. General tables of dimensions and masses per unit length.
ISO 4287,	Geometrical product specification (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters
ISO 4288,	Geometric Product Specification (GPS) — Surface texture — Profile method: Rules and procedures for the assessment of surface texture
ISO 5167-1,	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 1: General principles and requirements
ISO 5167-2,	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 2: Orifice plates
ISO 14313,	Petroleum and natural gas industries – Pipeline transportation systems – Pipeline valves

2.2 Informative references

API Spec 5L,	Specification for Line Pipe
ASTM A105,	Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A182,	Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A216,	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A240,	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A320,	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service
ASTM A350,	Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components

ASTM A351,	Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts
ASTM A352,	Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
ASTM 494,	Standard Specification for Castings, Nickel and Nickel Alloy
ASTM A516,	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A638,	Standard Specification for Precipitation Hardening Iron Base Superalloy Bars, Forgings, and Forging Stock for High-Temperature Service
ASTM A694,	Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service
ASTM A705,	Standard Specification for Age-Hardening Stainless Steel Forgings
ASTM A790,	Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
ASTM A928,	Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal
ASTM A995,	Standard Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts
ASTM B443,	Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219)* Plate, Sheet, and Strip
ASTM B564,	Standard Specification for Nickel Alloy Forgings
EN 1591-1,	Flanges and their joints - Design rules for gasketed circular flange connections - Part 1: Calculation method
EN 10025 (all parts),	Hot rolled products of structural steels -
NORSOK M-630,	Material data sheets for piping

3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1 Definitions

3.1.1

can

verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.2

class

CL

ASME pressure class (ASME B16.5 and ASME B16.34)

3.1.3

compact flanged connection

CFC

non-gasketed bolted static pipe connection including two flanges and where the bolt loads are transferred through metal to metal contact between the flange faces

3.1.4

gasket

barrier to prevent the passage of fluids, which does transmit all loads between flanges, as shown in EN 1591-1, Figure 3

3.1.5

may

verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.6

purchaser

individual or organisation that buys the pipe connection on behalf of the user and/or operator or for its own use

3.1.7**seal**

component providing a barrier to prevent the passage of fluids, transmitting no significant loads between the flanges

3.1.8**shall**

verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.9**should**

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.1.10**supplier**

individual or organisation that takes the responsibility for the supply of the pipe connection and its conformance with this NORSOK standard

3.2 Abbreviations

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BL	blind flange
CFC	compact flanged connection
CL	class
DN	nominal pipe diameter (mm)
EN	European Standard
ID	internal diameter
IF	integral flange (as part of some other equipment or component)
ISO	International Organisation for Standardisation
IX	special metallic seal ring applied in Clause 5
LB	line blinds (including PS and PB)
NCF5	NORSOK compact flange according to Clause 5
NPS	nominal pipe size (inch)
OD	outer diameter
OS	orifice spacer
PB	paddle blank
PN	nominal pressure (bar)
PS	paddle spacer
PTFE	polytetrafluoroethylene (Teflon®)
RI	rigid interface
RT	reducing threaded flange
WN	weld neck

4 Fundamental design requirements**4.1 General**

This clause specifies the minimum design requirements CFCs shall fulfil in order to be compliant with this NORSOK standard.

Supplier specific CFCs may refer to this NORSOK standard when additional requirements to the minimum requirements specified in this NORSOK standard are agreed between purchaser and supplier. The intention is to allow alternative designs to the products supplied in accordance with Clause 5.

A specific and complete CFC dimensional standard ranging from DN 15 to DN 1200 in pressure classes CL 150 to CL 2500 (maximum DN 600 for CL 2500) is included in Clause 5.

CFCs shall comply with the requirements in the piping or pressure vessel code agreed between the supplier and the purchaser.

CFCs shall

- be designed for face-to-face make-up for transfer of the bolt loading through the flange faces,
- be designed so that a static mode is maintained in the bolted joint up to a specified static mode pressure defined by the purchaser. Static mode is maintained as long as the difference between maximum and minimum nominal load sustained by the bolts in the joint does not exceed 5 % of minimum guaranteed yield load when measured from zero to static mode pressure at room temperature, and at minimum required bolt preload. The static mode pressure shall be at least equal to or greater than hydrostatic test pressure.

4.2 Materials

Flanges covered by this NORSOK standard shall be made from raw material products as listed in Table 1.

Forged bar material shall be certified with all required testing in position T/3 in both the longitudinal and the transverse direction (T = outside diameter).

The hot isostatic pressed process is an acceptable alternative to forging.

Cast flanges, integral or loose, shall be non-destructive tested to comply with casting factor used in calculations to determine performance.

Test samples for certification testing required by the material standard shall be taken from the flange ring transverse to the dominant grain flow direction or alternatively in both axial (weld neck) and tangential (flange ring) direction relative to internal bore.

No repair welding shall be permitted without prior approval of the purchaser.

Any welding shall be carried out in accordance with a written procedure.

4.3 Strength

CFCs shall generally have a level of structural safety that is comparable to that of the connecting pipe or piping component. CFCs shall be designed against the following possible modes of failure, as appropriate:

- gross plastic deformation (excessive yielding);
- leak tightness;
- fatigue failure.

Furthermore, considerations shall be given to maximum and minimum assembly bolt preload and possible loss of bolt preload during operation due to combination of minimum assembly bolt load, pressure, external loads and thermal effects. Minimum assembly bolt load shall be determined based on assessment of accuracy of bolt preload method, short-term and long-term bolt relaxation.

Sufficient resistance against the relevant failure modes shall be demonstrated by a calculation method, which has been validated by testing. This testing shall also verify the static mode as defined by 4.1, by applying a relevant pressure and external load test. When the internal pressure is gradually increased, it shall be demonstrated by measurement of force or elongation of the bolts, that the above requirement is met up to the specified strength pressure

The calculation methods or experimental testing method shall provide sufficient safety margins consistent, where applicable, with the requirements in the piping or pressure vessel code agreed between the supplier and the purchaser. Calculation or testing shall demonstrate that shakedown is achieved at a load level defined as the ultimate capacity. Two cycles of maximum tensile or bending load is sufficient for this purpose.

Calculations shall be made for design conditions that include pressure, external loads, assembly loads, thermal effects and tightness. Design conditions include assembly (bolt-up) condition, hydrostatic test condition and operating conditions. Calculations shall be performed using dimensions of the flange joint in

the corroded and the un-corroded condition, and the more severe case shall control. Corrosion shall be considered on all exposed surfaces.

Stresses resulting from bolt pre-loading shall be regarded as secondary stresses during testing and operation.

Nominal design stress for bolts shall be determined by the same rule as used for nominal design stress of flanges and shells, e.g. same safety factor on yield stress. Bolt materials shall be selected with due consideration to creep and relaxation.

4.4 Corrosion resistance

A CFC shall either be designed, or materials shall be selected, so that main sealing areas can not be subject to corrosion. Corrosion allowance on internally or externally exposed surfaces shall be specified by the purchaser.

4.5 Temperature

The purchaser shall specify the actual temperature range for the application.

4.6 Leakage

The maximum leakage for correctly assembled connections may be specified by the supplier according to EN 1779, and shall be expressed as leakage rate in units of gas throughput ($\text{Pa}\cdot\text{m}^3/\text{s}$) for a specific gas, i.e. helium at room temperature and at max working pressure conditions. The circumferential length for this leakage shall also be specified. It is the responsibility of the supplier to verify that this leakage is not exceeded for the specified design conditions.

Default testing method shall be according to EN 1779. The purchaser may specify other test methods.

4.7 Information requirements for supplier specific CFC

A supplier specific product standard shall be documented by the following items of information:

- general description of suppliers CFC design and features;
- necessary design and verification documentation required by applicable code reference;
- dimensions in mm:
 - overall dimensions;
 - welding neck configuration;
 - pipe wall thickness.
- weight of complete CFC in kg;
- temperature coverage;
- maximum allowable pressure at ambient temperature;
- pressure/temperature (P/T) dependency;
- maximum hydrostatic test pressure in bar;
- load carrying capacity:
 - bending moment in kNm;
 - axial load in kN;
 - static mode pressure at ambient temperature in bar.
- maximum guaranteed leakage rate;
- handling procedures;
- welding and assembly procedures;
- maintenance procedures.

4.8 Designation and marking

4.8.1 Designation

In line with EN 1092-1, the following shall designate the flanges in accordance with this NORSOK standard. The designation elements shall be separated by a slash. The number of characters is not fixed.

- NORSOK standard identification: NCF4 or NCF5 to identify clause in this NORSOK standard;
- flange type abbreviation according to Table 1;

- type of flange facing according to Clause 5 or supplier specific notation;
- nominal flange size;
- pressure class designation (PN, CL or rated pressure);
- pipe dimensions:
 - for standard pipes, the wall thickness in mm to one decimal accuracy;
 - for non-standard pipes, the pipe bore and wall thickness.
- material designation.

See 5.5 for typical examples.

4.8.2 Marking

All flanges, other than integral flanges shall be marked with the suppliers trade mark followed by the flange designation and material charge (cast) identification, see below. All elements shall be separated by a slash. The number of characters is not fixed. Flanges that are identical for several pressure classes shall be marked with the highest pressure class.

- Supplier's name or trade mark.
- Designation according to 4.8.1.
- Cast number of melt identification or suitable quality control number traceable to the cast number.

See 5.12 for typical examples.

5 Product standard

5.1 General

This clause gives a product standard for CFCs that meets the requirements of Clause 4. This product standard is in accordance with ASME VIII Div.2, Appendix 4 and Appendix 6, and has been developed for use in process piping, see ASME B31.3 and EN 13480 (all parts). Additional requirements may be relevant for other applications, e.g. subsea and pipeline risers in the oil and gas industry.

This clause specifies detailed manufacturing requirements for circular steel flanged connections in class designations CL 150 (PN 20) to CL 1500 (PN 260) for nominal sizes from DN 15 (NPS ½) to DN 1200 (NPS 48) and CL 2500 (PN 420) for nominal sizes from DN 15 (NPS ½) to DN 600 (NPS 24). NPS is in accordance with ASME B36.10M and ASME B36.19M.

This clause covers welding neck flanges, WN, blind flanges, BL, spacers, PS, and spacer blinds, PB, valve/equipment integral flanges, IF, orifice spacers, OS, reducing threaded flanges, RT and rigid interfaces, RI.

This clause covers the temperature range from -101 °C to +250 °C.

This clause contains

- flange dimensions and material requirements,
- seal ring dimensions and material requirements for steel seal rings,
- bolting dimensions and material requirements,
- weights of all flange standard components,
- structural capacity equations,
- installation and assembly instructions, maintenance,
- necessary information for manufacturing of flanges and seal components; tolerances, surface finishing and marking.

5.2 Normative references used in Clause 5

ASME B1.1,	Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1,	Pipe Threads, General Purpose (Inch)
ASME B16.5,	Pipe Flanges and Flanged Fittings
ASME B16.20,	Metallic Gaskets For Pipe Flanges: Ring Joint Spiral Wound And Jacketed
ASME B16.25,	Butt welding ends

ASME B16.34,	Valves - Flanged, Threaded and Welding End
ASME B18.2.2,	Square and Hex Nuts (Inch Series)
ASME B31.3,	Process Piping
ASME B36.10M,	Welded and Seamless Wrought Steel Pipe
ASME B36.19M,	Stainless Steel Pipe
ASME VIII Div. 2,	Boiler and Pressure Vessel Code – Alternative Rules
ASTM A193,	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-temperature Service
EN 13480 (all parts),	Metallic industrial piping
ISO 2768-1,	General tolerances - Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
ISO 4287,	Geometrical product specification (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters
ISO 4288,	Geometric Product Specification (GPS) — Surface texture — Profile method: Rules and procedures for the assessment of surface texture
ISO 4200,	Plain end steel tubes, welded and seamless. General tables of dimensions and masses per unit length.
ISO 5167-1,	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 1: General principles and requirements
ISO 5167-2,	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 2: Orifice plates
ISO 14313,	Petroleum and natural gas industries – Pipeline transportation systems – Pipeline valves

5.3 General description of flange design and features

Figure 1 shows the NCF5 and its seal system.

The flange face includes a slightly convex bevel with the highest point, called the heel, adjacent to the bore and a small outer wedge around the outer diameter of the flange. The NCF5 is made up by tightening/tensioning the flange bolting which pulls the two connector halves together.

For the IX seal ring, axial forces are exerted on the taper of the metal seal ring and translated into a radial sealing force. Furthermore with increased pre-load, the bevel is closed and face to face contact is achieved at the outer wedge while most of the bolt pre-load is transferred as compressive forces between the flange faces at the heel, see Figure 1. The arrows in the figure indicate the applied forces/pressure and the contact forces after make-up and during normal operation.

The principle design of the flange face includes two independent seals. The first seal is created by application of seal seating stress at the flange heel. However, an undamaged flange heel may not seal at any extreme load condition, but the heel contact will be maintained for pressure values up to 1,8 times the flange rating at room temperature. This requirement is only applicable when the WN thickness fulfils the code requirement for minimum pipe wall thickness for the actual material. This pressure will also represent the static mode pressure. The flange also remains in contact along its outer circumference at the flange faces for all allowable load levels. The main seal is the IX seal ring. The seal ring force is provided by the elastic stored energy in the stressed seal ring. Any heel leakage will give internal pressure acting on the seal ring inside intensifying the sealing action.

The design aims at preventing exposure to oxygen and other corrosive agents. Thus, this prevents corrosion of the flange faces, the stressed length of the bolts and the seal ring.

The back face of the flange in the made-up position is parallel to the flange face in order to prevent bending of the bolts in the assembled condition.

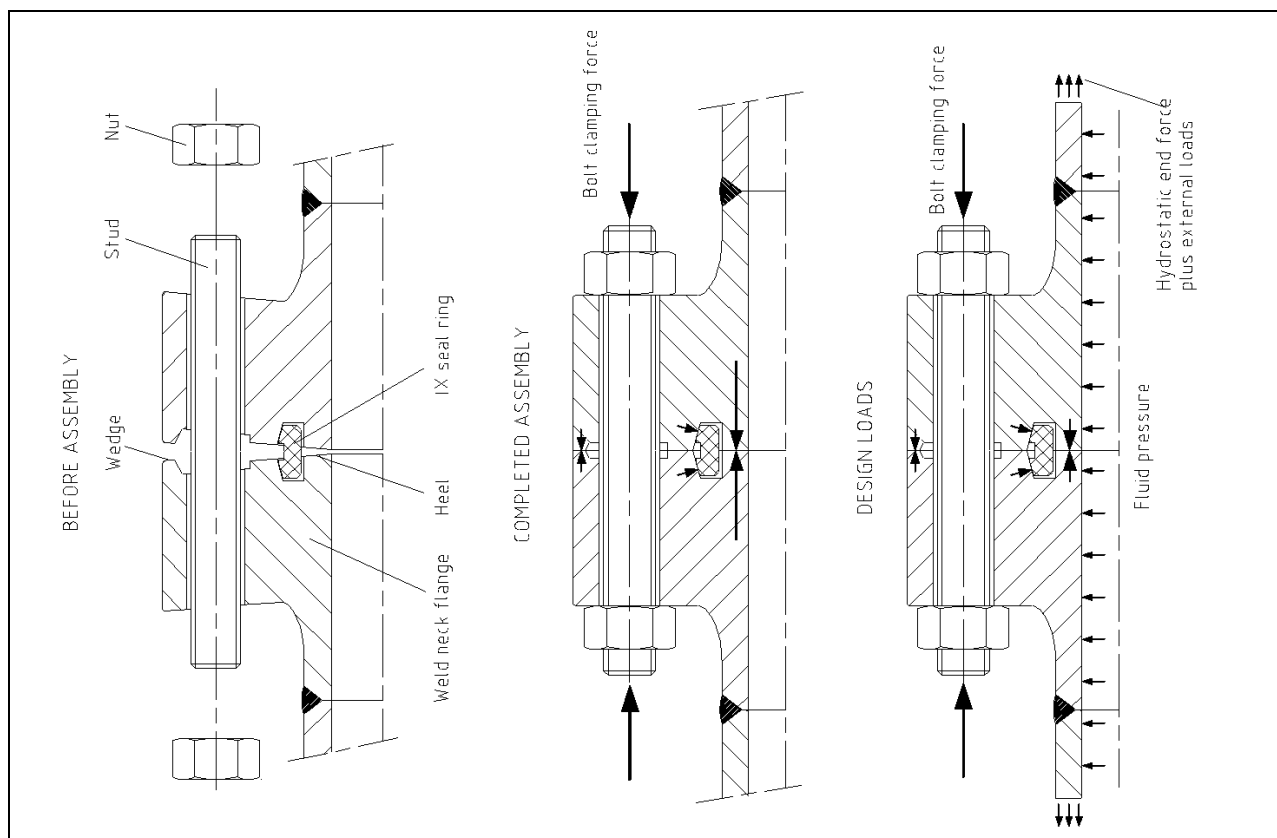


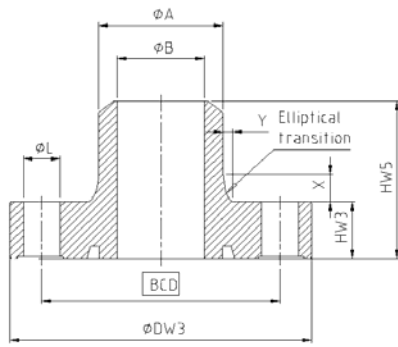
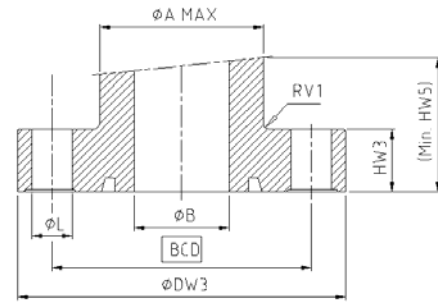
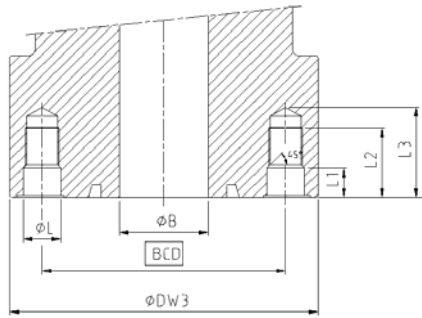
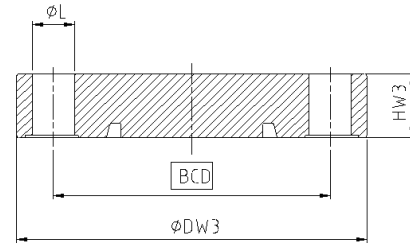
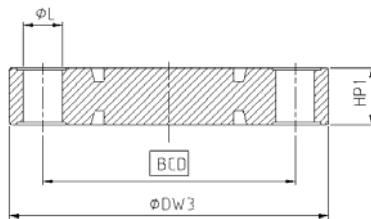
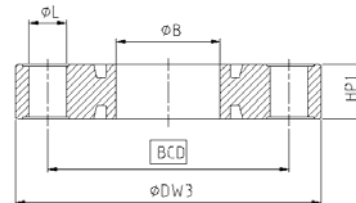
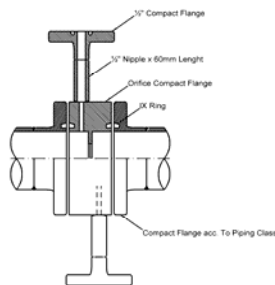
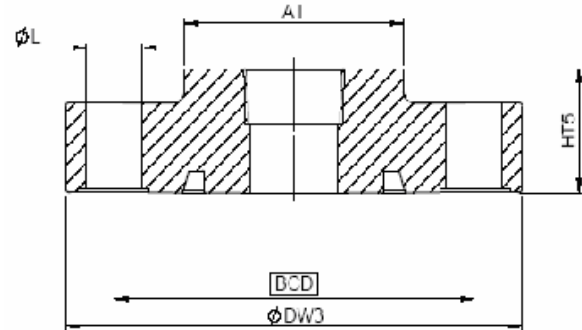
Figure 1 – How the NCF5 works

5.4 Standard components

The types of flanges specified in this subclause are given in Table 1 and Figure 2 showing the flange types with the relevant designations.

Table 1 – Types of flanges and accepted raw material forms for manufacture

Type abbreviation	Description	Raw material product forms
WN	Weld neck flange	Forging or Forged bar
BL	Blind flange	Plate, Forging or Forged bar
IF	Integral flange as part of some other equipment or component	Forging, Forged bar or Casting
RI	Rigid interface as part of some other equipment or component	Plate, Forging or Casting
PB	Paddle blank	Plate, Forging or Forged bar
PS	Paddle spacer	Plate, Forging or Forged bar
OS	Orifice spacer	Plate, Forging or Forged bar
RT	Reducing threaded flange	Forging or Forged bar

**WELD NECK****INTEGRAL****RIGID INTERFACE****BLIND****PADDLE BLANK****PADDLE SPACER****ORIFICE SPACER****REDUCING THREADED****Figure 2 – Components in the NCF5 standard**

5.5 Designation

The flange designations shall be according to 4.8.1.

Examples of designation are given below:

Example 1

Designation of WN flange in CL 600 with IX groove, nominal size DN 250 with pipe schedule 40S, i.e. 9,3 mm wall thickness and material A182F51 (duplex):

NCF5/WN/IX/DN250/CL600/9.3/A182F51

Example 2

For designation of a BL flange in CL 2500 with IX groove, nominal size DN 200 and with material A516 grade 70 (low temperature carbon steel):

NCF5/BL/IX/DN200/CL2500/A516gr70

Example 3

Designation of a RT flange in CL900 with IX groove, nominal size DN 25, threaded outlet not specified (DN 15 NPT is default, see A.8), and with material A182F316 (stainless steel):

NCF5/RT/IX/DN25/CL900/DN15NPT/A182F316

5.6 General requirements

Requirements herein are additional to those listed in 4.2.

5.6.1 Flange material

The NCF5 covers flanges made of steel and nickel alloys. It is assumed that the flange material has a Young's modulus in the range 190 000 MPa to 210 000 MPa at room temperature. Minimum specified yield strength for flanges to this NORSOK standard is at room temperature 205 MPa. For lower strength materials, the flange size, the bolt pre-tension force and flange face angle shall be determined based on the actual design requirements. The principles of Clause 4 shall then be utilised.

Stainless steel overlay welding of flange faces and seal groove is not considered necessary when interfacing carbon steel and stainless steel flanges.

Annex E gives references to material standards for forged flanges listed by ASME B31.3.

5.6.2 Bolting

It is a design requirement to use bolts of the minimum strength as to ASTM A193 gr.B7.

Imperial standard bolts threaded at both ends or full length may be used. Heavy hex nuts (ASME B18.2.2) shall be used. Threads shall be coarse series, CL 2A (ASME B1.1), and nuts shall be coarse series, CL 2B. The specified tolerances shall be met after galvanising or other surface treatment. Nominal diameters of 1 in and smaller shall be coarse thread series (UNC); nominal diameters of 1½ in and larger shall be of the 8 thread series (8 UN).

Metric bolting may be used if specified by the purchaser. This may affect assembly and bolt preloading procedures. Annex F describes which metric bolts to choose for replacing the listed imperial bolts.

5.6.3 Bolt dimensions and weights

Dimensions and weights of bolts and nuts can be found in Annex C. This annex also describes dimensions of washers/sleeves where this should be used in order to control bolting load during assembly.

5.6.4 Seals

The NCF5 uses a steel seal ring (IX).

The IX seal ring dimensions, design characteristics and typical materials used are given in 5.13.

5.6.5 Pressure/temperature ratings

Generally flanges covered by NCF5 shall be designated as one of the given classes in Table 2

Table 2 – Pressure class designation and ASME rating ceiling values to ASME B16.5

Pressure class		Class abbreviation	Nominal pressure		ASME pressure rating ceiling values	
					psig	barg
Class	150	CL 150	PN	20	290	20,0
Class	300	CL 300	PN	50	750	51,7
Class	600	CL 600	PN	110	1500	103,4
Class	900	CL 900	PN	150	2250	155,2
Class	1500	CL 1500	PN	260	3750	258,6
Class	2500	CL 2500	PN	420	6250	431,0

Flanges covered by a class of Clause 5 will stand the maximum rating of the corresponding ASME B16.5 class over the temperature range covered by NCF5. This corresponds to a utilization factor of 0,5 according to Annex D, which gives a method for determining the external load capacity for flanged connections.

For integral cast flanges also some design codes use the concept of “casting factors”. The yield strength should in such cases be multiplied by the relevant casting factor before used in the capacity equations

5.7 Dimensions

5.7.1 Range of nominal sizes

A summary of the DN's applicable to each rating class is given in Table 3.

5.7.2 Weld neck (WN) dimensions

The minimum outside diameter of the WN of WN flange is equal to the nominal outside diameter of the pipe. The maximum bore is equal to the specified nominal bore. This assures that the minimum WN thickness is equal to or larger than the wall thickness of the connected pipe.

5.7.3 Flange dimensions

Dimensions of the flanges shall be in accordance with the information given in Annex A (see Table 3 for an overview).

5.7.4 Welding end preparation

Details for the weld preparation for WN flanges are given in ASME B16.25. Other welding end preparations can be agreed between supplier and purchaser.

5.7.5 Bolt holes

All bolt holes shall be equally spaced on the bolt circle diameter. Bolt holes on integral flanges shall straddle the horizontal or vertical lines, see Figure 8.

5.8 Weights of flanges

Calculated weights of flanges are based on nominal dimensions given in Annex A and density equal to 7,85 kg/dm³.

NOTE The SI unit system specifies “N” (Newton) as unit for force (weight is a force). However, in this NORSOK standard “kg” is used as unit for weight.

Table 3 – Overview of sizes and rating class (CL)

DN	NPS	CL 150	CL 300	CL 600	CL 900	CL 1500	CL 2500
15	½	Equal to CL 300	•	Equal to CL 2500	Equal to CL 2500	Equal to CL 2500	•
20	¾		•				•
25	1		•				•
40	1 ½		•				•
50	2		•	Equal to CL 1500	Equal to CL 1500	•	•
65	2 ½		•			•	•
80	3		•	Equal to CL 900	•	•	•
100	4		•		•	•	•
125	5		•		•	•	•
150	6		•		•	•	•
200	8	•	•	•	•	•	•
250	10	•	•	•	•	•	•
300	12	•	•	•	•	•	•
350	14	•	•	•	•	•	•
400	16	•	•	•	•	•	•
450	18	•	•	•	•	•	•
500	20	•	•	•	•	•	•
550	22	•	•	•	•	•	•
600	24	•	•	•	•	•	•
650	26	•	•	•	•	•	
700	28	•	•	•	•	•	
750	30	•	•	•	•	•	
800	32	•	•	•	•	•	
850	34	•	•	•	•	•	
900	36	•	•	•	•	•	
950	38	•	•	•	•	•	
1000	40	•	•	•	•	•	
1050	42	•	•	•	•	•	
1100	44	•	•	•	•	•	
1150	46	•	•	•	•	•	
1200	48	•	•	•	•	•	

NOTE "Equal to CL xxxx" means that the dimensions are equal for the referred pressure class, the flange shall then be marked with the higher pressure class, see 5.12.

5.9 Flange faces

This clause includes grooves for IX-type flange facings. Flange face dimensions are given together with all other flange dimensions in Annex A.

5.10 Surface finish

The flange surfaces shall be machined to comply with the requirements of Table 4 below, see ISO 4287. A sample of at least 10 % of the batch shall be checked by methods defined in ISO 4288.

Table 4 – Surface finish for flanges

Location	R _a min. µm	R _a max. µm
OD surface of IX groove	-	0,8
Flange heel face	-	0,8
Flange face general and IX groove	-	1,6
Bolt holes	-	12,5
All other surfaces	-	6,3

5.11 Tolerances

Tolerances on dimensions of flanges shall be as given in Annex A, Table A.12. Medium tolerances to ISO 2768-1 shall be used for non specified tolerances.

5.12 Marking

5.12.1 General

The flange marking shall be according to 4.8.2.

The example below is for a DN 250 WN flange CL 600 for a pipe wall thickness of 9,3 mm. The material is ASTM A182 F51 (duplex SS) and the heat number is F1245.

Example for a supplier by the name of XXX:

XXX/NCF5/WN/IX/DN250/CL600/9.3/A182F51/F1245

5.12.2 Stamping

Where steel stamps are used, the marking shall be positioned on the rim of the flange. Care should be taken to ensure that steel stamp markings are not liable to cause cracks in the flange material, i.e. use soft nose stamps.

5.13 IX seal ring

The IX seal ring design exists in one size per DN covering all pressure classes in Clause 5.

5.13.1 Designation

The IX seal ring is designated as described below. The designation elements shall be separated by "/" (slash). The number of characters is not fixed.

- Standard identification - NCF5.
- Type - and ring size - IX and the appropriate DN.
- Material designation.

Example:

Designation of an IX seal ring for DN 250 and material A182F51 (Duplex):

NCF5/IX250/A182F51

5.13.2 Typical seal ring materials

Typical minimum yield stress and ultimate stress for the seal ring material shall at maximum design temperature be 300 MPa and 360 MPa, respectively, in order to allow for reasonably elastic spring-back.

Lower strength may be used, but is not recommended. The user is responsible for selecting a seal ring material which is suitable for the service medium and the design temperature conditions. Seal ring materials are commonly chosen to be compatible with the flange material, i.e. duplex seal ring in duplex flange.

For in service use, Table 5 gives a guideline for seal ring selection.

Annex E gives references to seal ring material specifications that may be used.

5.13.3 Dimensions

Metallic IX seal rings shall have dimensions and tolerances as specified in Annex B. Medium tolerances to ISO 2768-1 shall be used for non specified tolerances. Figure B.2 gives nomenclature used in Table B.2 and Table B.3.

5.13.4 Weights

Annex B gives calculated weights of seal rings based on nominal dimensions and density equal to 7,85 kg/dm³.

Table 5 – Seal ring selection

Flange material	Service temperature	Seal ring material	Seal ring PTFE colour
Carbon steel	-50°C to +250°C	Carbon steel CS360LT or low alloy steels, e.g. AISI 4140	Blue
Stainless steel	-50°C to +250°C	22Cr Duplex	Yellow
Stainless steel	-50°C to +250°C	17/4-PH	Orange
Stainless steel	-101°C to +250°C	Nickel alloys such as Alloy 625 or similar	Black

NOTE 1 For testing purposes at ambient temperature, a carbon steel ring can be used for all flange materials.

NOTE 2 Listed seal ring materials may be less resistant to corrosion than the stainless steel of the flanges, and this is justified by the low probability of corrosion due to the stressed contact between heel areas of the mating flanges, and due to the seal at the outer circumference of the flanges preventing ingress of moisture and water.

5.13.5 Surface finish

All seal ring surfaces shall be machined finished with maximum surface roughness in accordance with Table 6, see ISO 4287.

Table 6 – Surface finish for seal rings

Location	R _a max. µm
Sealing faces	0,8
All other surfaces	6,3

5.13.6 Inspection and testing

No special requirements regarding hardness are required for the IX seal ring as opposed to standard ring-joint gaskets to ASME B16.20.

There is no requirement for Charpy impact testing of seal ring materials.

5.13.7 Coating

Seal rings shall be coated with 10 µm to 30 µm PTFE coating. The colour of the coating shall follow the requirements of Table 5.

5.13.8 Marking

5.13.8.1 General

All seal rings shall be marked with the suppliers trade mark followed by the seal ring designation and material charge (cast) identification, i.e. as follows:

1. suppliers name;
2. designation;
3. cast number of melt identification or suitable quality control number traceable to the cast number, e.g. F1245.

Example (XXX supplier):

XXX NCF5/IX250/A182F51/F1245

Stamping or other suitable marking shall be positioned on inner diameter of the ring.

5.13.8.2 Stamping

Where steel stamps are used, care should be taken to ensure that the sealing faces are not damaged.

5.14 Handling, installation and assembly

5.14.1 General

This information serves as a guide during handling, welding and assembly of NCF5. In addition, it contains procedures for preload qualification.

NOTE: All NCF5 products shall be supplied without any damages and scratches, i.e. 5.14.7 applies to damages occurred on sites for fabrication and installation of piping only.

5.14.2 Protection

Flanges shall be supplied with suitable protection of the flange face, such as plywood boards or plastic caps. They should not be removed prior to field assembly to minimise the likelihood of accidental damage - except for inspection, welding and stress relieving of the weld area. Seal rings should be stored in its original packing until final installation. Careful handling is of the utmost importance.

5.14.3 Flange handling

Flanges shall not be lifted by slinging through the bore of the flange, as this may damage the seal surface and the bevelled end. It is preferable to lift using the bolt holes or other suitable lifting points.

5.14.4 Welding

Protect the flange sealing faces with an inhibitor to prevent oxidation during pre-heating and stress relieving.

Ensure that the sealing faces are protected from scratching and weld splatter. The alignment tolerances are similar as for conventional ASME/ANSI flanges. If flanges welded to the pipe spools are not to be assembled immediately, coat the sealing faces with grease or another type of preservative.

5.14.5 Painting

If the flange is to be shot-blasted and painted, then it is imperative that the plywood board or protective cap is left on preferably also sealed off by strong adhesive tape to prevent damage to the sealing faces. No contact areas should be painted in order to avoid loss of bolt preload. This includes flange faces and nut bearing areas.

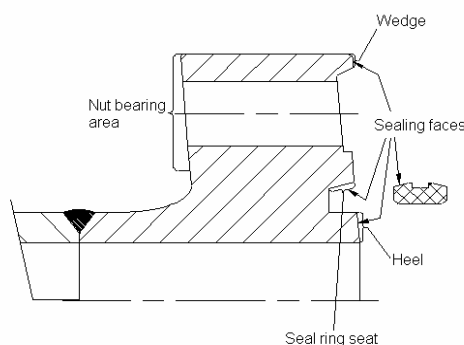


Figure 3 – Flange areas to be protected

5.14.6 Procedure personnel and equipment for assembly

For flanged connections, which rely on axial compression to activate the seal and to ensure a static mode of action, the capacity depends directly on the bolt pre-stress achieved. Bolt preloading procedures and personnel shall be qualified according to 5.14.11. Ensure use of skilled workmen and correct equipment. Final preload tools should be well maintained and should have accuracy within $\pm 2\%$ of the torque or tension to be applied, see Table 8.

5.14.7 Preparation before final preloading

Clean and check

Use a nonabrasive soft cloth to clean all components with solvent to remove grease, preservation and dirt. Special care should be taken on sealing faces and contact areas. Check that all components are of correct material and size.

Inspection and repair, see Figure 3 and Figure 4, and Table 7

Examine all sealing surfaces for mechanical damage and rust. The sealing faces rely on a good surface finish. These surfaces should therefore be free from leak path scratches, damage marks and other surface irregularities. Use a suitable light source and run the fingertip over seal surfaces to detect dents and gouges. Polish off any small scratches on the heel, seal ring and seal ring seat with fine emery cloth in the circumferential direction only. Polish at least one third of the circumference to ensure a uniform blending of the re-work area. Lateral polishing is unacceptable. Larger flange damages may require flange face re-machining.

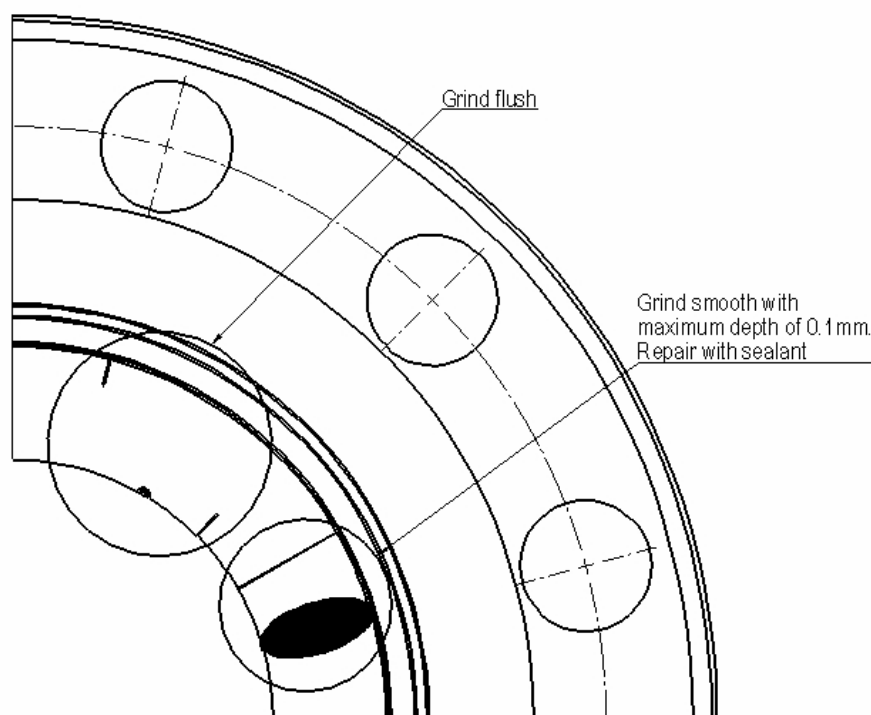


Figure 4 – Repair of heel

Table 7 – Damage repair guide

Damage and location	Remedy
Scratch or dent at the heel, covering less than $\frac{3}{4}$ of the heel width.	Grind with fine emery paper to the required depth. Finish with emery paper grade 240.
Scratch or dent at the heel, covering $\frac{3}{4}$ or more of the heel width.	Grind with fine emery paper to the required depth. Finish with emery paper grade 240. The depth after grinding should be maximum 0,1 mm. "Repair" large scratches with a suitable sealant (gasket eliminator).
Small scratch in seal ring seat location.	Grind with fine emery paper. Finish with emery paper grade 240.
Outer wedge.	Remove any burr standing proud of the surface by grinding/filing.
Seal ring sealing faces.	Replace seal ring.

Inspect bolt threads and nut bearing area to verify that there is no evidence of galling or other damage. The surface shall be completely intact. If any sign of damage, discard and replace.

IX seal ring – Installation and check for stand-off

When the seal ring is placed in the groove by hand, it should rock slightly in the groove, i.e. the ring should be unable to firmly contact the groove bottom. If this is not the case the seal will need replacing.

Use a pull up cord as shown on Figure 7 when installing the IX ring between flanges in horizontal piping, and remove the cord when the ring has entered the flange grooves on each side.

Use of lubrication and sealant

Assembly of compact flanges does not require use of lubricants or sealants if flange sealing surfaces are undamaged. On repeated assembling operations it is recommended to lubricate sealing surfaces by applying a layer of thin oil. If flange sealing surfaces have been damaged, a layer of a suitable sealant should be applied to ensure tightness, see Figure 4 and Table 7.

Lubricate

The nut thread and nut bearing surfaces on the flange should be lubricated in accordance to the qualified procedure when torque is used to achieve the final preload.

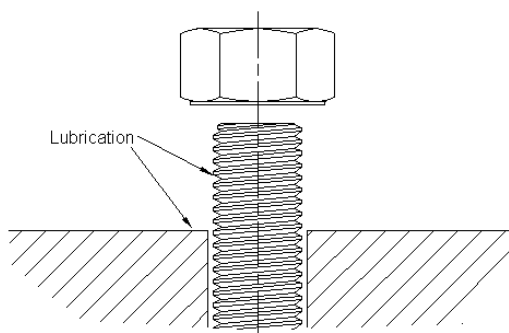
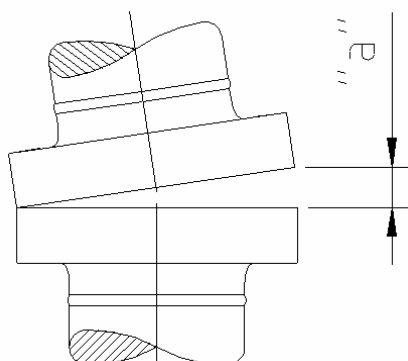


Figure 5 – Thread lubrication



Alignment of facings, "a", shall not be more than 3mm or 10mm per meter flange diameter, whichever is the greater.

Figure 6 – Flange assembly alignment

Alignment

With the seal ring in the groove of one of the flanges (parallel standoff), bring the other flange into alignment, see Figure 6. The load to bring into alignment shall not exceed the maximum load given in the section below. The shear load capacity of the IX seal ring is given in Annex B.3. The bolt holes should be positioned so that the bolts can be moved easily.

Fitting

The stud shall protrude one to two threads from the nut on the side where the tool is not used. Loosely assemble the studs and nuts. As the flanges are drawn together by the tightening of the bolts, the IX ring will provide the final alignment of the flange prior to full make-up of the joint.

Tighten the bolts using a spanner in a criss-cross pattern, such that the seal ring standoff is closed and there is face-to-face contact at the heel. Typically 10 % of final bolt tightening torque should be sufficient, see Table 8 for non-restrained pipe-work. However, if misalignment will require a higher load in order to bring the flange heels together, do as follows:

Step 1: Pull flanges together without the seal ring, and measure applied force when flange heels are touching around the whole circumference. Acceptance limit: No bolt shall be loaded more than 15 % of the target preload in Table 8.

Step 2: Release and insert the seal ring. Pull flanges together. If closing of the gap between the flanges at the outer rim is impossible within the target preload values of Table 8, this is cause to reject the alignment.

If final preload is not applied immediately, it is preferably to seal off the flange faces with adhesive tape to avoid foreign particles to enter the gap between the flange faces.

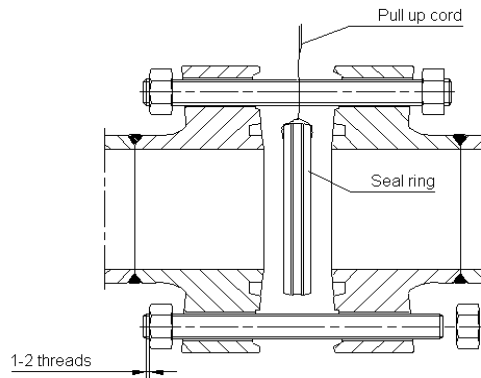


Figure 7 – Seal ring installation

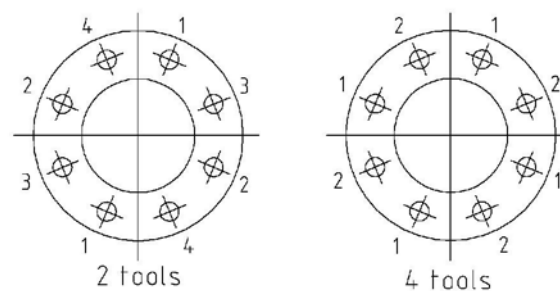


Figure 8 – Bolt pre-loading sequence

5.14.8 Final pre-loading procedure

Tighten bolts in a diagonal sequence as illustrated in Figure 8. The bolt preload shall be applied in suitable steps. Especially when using only one tool the preload used in the first step shall not be greater than 30 % of the total preload. Start with the bolt where the flanges have the largest gap.

Tighten bolts to 100 % of the applied tension or torque values given in Table 8 for imperial standard bolting, and see Annex F for metric bolts. The flanges are stronger than the bolts and can not be overloaded by the bolts. Continue torque or tensioning the bolts until the nuts can not be turned with the preset max load value from the tool. Check that the flange gap at the flange outside diameter is closed all around the circumference of the connection.

If closing of the gap at the outer rim was just achieved at the target value of Table 8 due to misalignment, it is recommended to increase the final pre-load to 5 % above the target value of Table 8.

5.14.9 Maintenance

NCF5 connections do not require special maintenance if correctly assembled. Seal ring may be reused if they have sufficient standoff, see 5.14.7, and are free from defects. Minor rust, burrs or scratches on sealing faces shall be removed, see 5.14.7, *Inspection and repair*.

5.14.10 Disassembly

Before disassembling compact flanged connections, verify that all pressure has been bled from the line. As a safeguard, the bolting should be slackened (1/6 turn first time) gradually in a criss-cross sequence enabling a controlled release of fluid. Then remove the bolting completely. Once the flange is fully disassembled and inspected, it is advisable to re-apply suitable surface protection and protection on the flange faces and seal ring.

When disassembling the flanges, great care should be exercised to avoid damaging the outer diameter seal. Hence, the use of standard flange spreaders should be avoided. However, such tools may be used if suitable jacking brackets are welded to the flange diameter. Spreader tools designed for use in the bolt holes may be used.

Table 8 – Final bolt tension and torque values

Stud bolt size in	Target residual preload ^{a c} kN	Applied tension with tension tool ^{b c} kN	Applied torque with torque tool and lubricant $\mu=0,12^d$ Nm
1/2-UNC	44		98
5/8-UNC	71		192
3/4-UNC	106	134	341
7/8-UNC	147	186	544
1-UNC	193	244	816
1 1/8-8UN	255	323	1194
1 1/4-8UN	325	412	1671
1 3/8-8UN	405	512	2261
1 1/2-8UN	492	623	2989
1 5/8-8UN	589	745	3840
1 3/4-8UN	693	878	4859
1 7/8-8UN	807	1022	6020
2-8UN	929	1177	7351
2 1/4-8UN	1199	1519	10610
2 1/2-8UN	1503	1904	14665
2 3/4-8UN	1667	2111	17766
3-8UN	2004	2539	23240
3 1/4-8UN	2373	3006	29736
3 1/2-8UN	2773	3512	37258
3 3/4-8UN	3204	4058	46046
4-8UN	3666	4643	56008
NOTE Bolting material: ASTM A193 gr.B7, ASTM A193 gr.B16 and ASTM A320, gr.L7 and gr.L43			
^a	Target minimum pre-stress is 75 % of yield such that a minimum of 70 % is achieved due to uncertainties in the make-up procedure. Bolt root diameter used.		
^b	The applied tension is equivalent to 95 % of yield in bolt in order to ensure that a minimum of 75 % of yield (target residual value) is left when preload is transferred from the tension tool to nut.		
^c	Washers may be necessary for some flanges to achieve sufficient residual bolt load with tension tool.		
^d	Torque tests with a specified lubrication procedure shall be performed to determine the appropriate coefficient of friction. Full filling of threads with lubricant is recommended.		

5.14.11 Bolt tensioning qualification procedure

5.14.11.1 General

This clause describes procedures for qualification of bolt preloading with hydraulic tensioning or hydraulic torque methods. The target minimum prestress should be 75 % of yield such that a minimum of 70 % prestress is achieved after losses due to time dependent strains (relaxation). However, the target value should be lower for bolts of higher strength than required in 5.6.2, and also lower for some metric bolts, see Annex F. This procedure applies to bolt sizes above 1/2 in or M12. Standard spanners used by trained

personnel may be used for smaller sizes, i.e. no special procedure is necessary. However, the personnel shall be trained to recognize suitable torque according to yield strength properties of the bolts, and the requirements of 5.14.7 apply.

The requirement for skilled operators is a very important aspect, which often is neglected. The complete assembly of tool and torque/tension measurement instrument shall be calibrated together and have a calibration traceable to a recognised international standard. Finally in order to achieve good accuracy and repeatability operators shall be technically qualified and experienced in assessing surface conditions, lubricant application and tool performance.

5.14.11.2 Torque preloading

5.14.11.2.1 Background

Preloading by torque is achieved by applying a measured torque to a bolt and nut with a controlled lubrication. For bolts of moderate length the required torque is with good accuracy given by the following expression:

$$T = \frac{F_p}{2} \left(\mu_n \times d_n + 1.155 \times \mu_t \times d_t + \frac{p}{\pi} \right)$$

where	T	=	torque applied to the bolt
	F _p	=	required bolt preload
	μ _n	=	coefficient of friction of nut bearing surface
	d _n	=	effective contact diameter of nut face (average between width of cross flats and diameter of bolt hole)
	μ _t	=	coefficient of friction of threads
	d _t	=	effective (mean) contact diameter of threads
	p	=	thread pitch

The nut and thread friction is set equal to μ in Table 8, i.e. μ = μ_n = μ_t. It is seen that the coefficients of friction are of dominant importance to the achieved preload. The coefficients of friction are sensitive to a number of factors:

- bolt/nut material;
- bolt surface coating;
- type;
- amount;
- condition;
- method of application;
- contamination;
- temperature of the lubrication of the bolt threads and nut bearing surface;
- hardness of all parts;
- surface finish;
- speed with which the nut is tightened;
- the fit between threads and thread tolerances.

Consistent application of bolt lubrication is vital in maintaining the consistency of induced bolt stresses at assembly with torque methods. Change of lubrication will change friction coefficient and hence the required torque.

5.14.11.2.2 Equipment

Use the following equipment:

1. a torque wrench with a current calibration certificate or, a hydraulic torque tool with a pressure gauge of class 1.6 or with better accuracy and with a calibration certificate;
2. a hollow load cell with a capacity at least equal to the yield strength of the bolt. The capacity should desirably not exceed twice the yield capacity of the bolt. The load cell shall have a valid (not more than 12

month old) calibration certificate traceable to a recognised national standard from an accredited laboratory;

3. two solid steel backing plates with one hole in each to suit the bolts;
4. suitable bolt lubricant such as a MoS₂ lubricant supplied in a closed container such as an aerosol or a tube or box;
5. five sets of bolts with nuts for calibration test.

5.14.11.2.3 Calibration and qualification

The following procedure shall be followed:

1. place load cell between reaction plates, enter bolt and nuts and pull hand tight after lubricating according to lubrication procedure. Centre the bolt on the load cell;
2. apply specified torque value;
3. record bolt force achieved;
4. repeat steps 2. and 3. with the remaining bolt sets;
5. calculate the mean tensile load achieved;
6. calculate the standard deviation of the tensile load achieved;
7. calculate the minimum bolt tension as the mean value less one standard deviation and check to see that this exceeds the minimum bolt load specified;
8. calculate the maximum bolt load as the mean plus one standard deviation and the corresponding axial bolt stress as well as the shear stress due to the applied torque. Check that the equivalent von Mises stress does not exceed the yield strength of the bolts;
9. if the checks in 7. or 8. are not satisfied revise the specified bolt torque or the lubrication procedure or chose a new lubricant and repeat the same procedure using new bolts and nuts until satisfied.

5.14.11.2.4 Lubrication procedure

The purpose of this lubrication procedure is to apply bolt lubrication as consistently as possible without contaminating the lubricant. Apply lubricant in a manner that can easily be repeated giving a consistent amount of lubricant. To achieve this it is recommended that the threads shall be filled with lubricant.

5.14.11.3 Hydraulic tension preloading**5.14.11.3.1 Background**

Any bolt tensioner exhibits a load transfer loss as the bolt load is transferred from the bolt tensioner to the nuts. The bolt load loss is a direct loss of stud elongation, this due to many different factors, such as thread deflections, radial expansion of the nut and "Bedding in" of the nut into the flange. Extra load shall be applied so the bolt will relax down to the required load on load transfer. The load transfer loss can be calculated as:

$$\Delta = 0,9 \, d/l$$

where Δ = fraction of the initially applied pre stress lost in transfer
 d = nominal bolt diameter
 l = clear bolt length between engaged threads

If the bearing surface is flexible this shall be allowed for by calculating the equivalent effective bolt length. The d/l ratio should not exceed 0,222 which corresponds to a load transfer loss of 0,20. The bolt length may have to be increased by using washers for some flanges. Refer to tables in Annex C for details.

5.14.11.3.2 Equipment

The following equipment is required:

- a hydraulic tensioner;
- an electronic load cell with a valid calibration from an accredited laboratory traceable to a recognised national standard;
- two solid steel backing plates;
- five bolts with nuts.

5.14.11.3.3 Qualification and calibration

The following procedure shall be followed:

1. place the load cell between the reaction plates, insert bolt and attach nuts;
2. install bolt tensioner and apply estimated initial tensile load;
3. make transfer and record achieved pre-load;
4. repeat step 1. to step 3. for all five bolts;
5. calculate the mean tensile load achieved;

6. calculate the standard deviation of the tensile load achieved;
7. calculate the minimum bolt tension as the mean value less one standard deviation and check to see that this exceeds the minimum bolt load specified;
8. calculate the maximum bolt tension as the mean value plus one standard deviation and check to see that this is lower than the maximum bolt load specified.

Annex A (Normative)

Flange dimensions and weights

A.1 Symbols

A	=	outside diameter of neck
$A_{\max}$	=	the maximum outer diameter to accommodate standard tools
$A_{\min}$	=	minimum neck outer diameter listed in Table A.1 to Table A.6
$Area_{0.15}$	=	the cross section area of the neck/pipe calculated from $t_{0.15}$.
$Area_{\text{eqv}}$	=	the cross section area of a special flange neck geometry calculated from t_{eqv} .
B	=	bore diameter, the bore should not exceed the maximum listed bore in this NORSOK standard
$B_{\max}$	=	maximum listed bore diameter.
$B_{\min}$	=	the minimum bore diameter for which the face angles are valid
B_1	=	minimum bore diameter for flange to be blinded. Also start diameter for blind and reducing threaded flange face angle.
Da1	=	ID of groove
Da3	=	OD of groove
d_B	=	bolt size
BCD	=	bolt circle diameter
DW1	=	inner recess diameter
DW2	=	outer recess diameter
DW3	=	outside diameter of flange
DW4	=	flange to neck fillet OD
E1	=	depth of groove
E2	=	depth of recess
E3	=	depth of recess for gasket
HC2	=	swivel collar thickness
HP1	=	thickness of PB, PS and OS
HW3	=	flange thickness
HW5, HT5	=	overall length
L	=	bolt hole diameter
L1,L2,L3	=	bolt hole depths
n_B	=	number of bolts
R1	=	radius
R2	=	radius
R3	=	radius (maximum value tabulated)
RV1	=	neck to flange ring radius on integral flanges
t	=	pipe wall thickness
$t_{\min}$	=	minimum neck thickness that can be used which is defined by the standard pipe outer diameter, A, and maximum listed bore diameter, $B_{\max}$.
$t_{\max}$	=	the maximum neck thickness that can be used which is defined by $A_{\max}$ and the minimum listed bore diameter
$t_{0.15}$	=	the wall thickness giving the smallest possible face angle (0,15°).
t_{eqv}	=	the wall thickness calculated from a special flange neck geometry.
X	=	half major ellipse axis
Y	=	half minor ellipse axis
$\alpha A2$	=	groove angle
$\alpha B1$	=	flange face bevel angle
$\alpha B2$	=	effective face angle/rear face bevel angle

A.2 Weld neck flanges

Dimensions of WN flanges are defined in Figure A.1. Given variations of wall thickness of connected pipe (t) in Table A.1 to Table A.6 are according to standard wall thicknesses in ASME B36.10M, ASME B36.19M and ISO 4200. WN flanges are neither designed for welding to rigid equipment nor to heavy wall pipes outside the pipe wall thickness range given in the tables below. Annex A.4 Integral flanges should then be used. It is recommended to use a higher pressure rating WN flange if the selected pipe wall thickness is above the range specified in Tables A.1 to A.6.

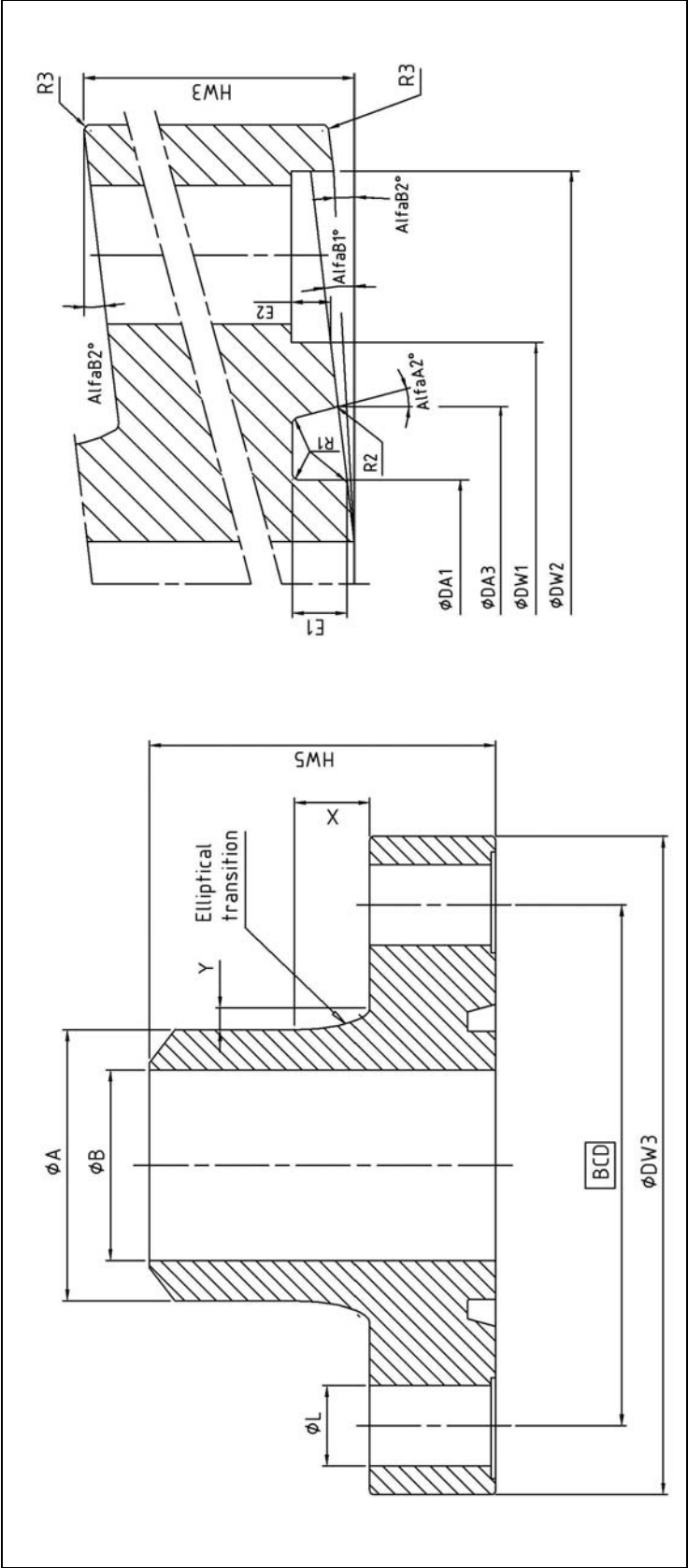


Figure A.1 – Nomenclatures for weld neck (WN) flanges

Table A.1 - Dimensions of CL 150 weld neck (WN) flanges

DN	NPS	t	A	B	DW1	DW2	DW3	BCD	DA1	DA3	αA2	E1	E2	αB1	αB2	HW3	HW5	X	Y	R1	R2	R3	L	n	d _B
15	½	2.11-4.78	21.3	17.1-11.7	49.1	87.0	93.0	67.3	20.8	30.88	15.2	5.30	1.0	0.27	0.18	15.0	40.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
20	¾	2.11-5.56	26.7	22.5-15.6	54.4	92.0	98.0	72.7	25.8	35.88	15.2	5.30	1.0	0.30	0.20	15.0	40.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
25	1	2.77-6.35	33.4	27.9-20.7	61.2	99.0	105.0	79.4	32.8	42.87	15.2	5.30	1.0	0.32	0.22	15.0	40.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
40	1½	2.77-5.08	48.3	42.8-38.1	76.0	114.0	120.0	94.3	47.8	58.88	15.3	5.58	1.0	0.41	0.27	15.0	41.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
50	2	2.77-5.54	60.3	54.8-49.2	88.1	126.0	132.0	106.3	59.8	71.88	15.3	6.19	1.0	0.45	0.30	15.0	42.0	10.5	3.0	0.4	0.6	1.0	15.0	4	½
65	2½	3.05-5.16	73.0	66.9-62.7	100.8	139.0	145.0	119.0	72.8	85.86	15.3	6.79	1.0	0.41	0.27	16.0	43.0	10.5	3.0	0.4	0.6	1.0	15.0	4	½
80	3	3.05-5.49	88.9	82.8-77.9	116.7	155.0	161.0	134.9	87.8	101.96	15.6	7.42	1.0	0.88	0.59	18.0	46.0	10.5	3.0	0.4	0.7	1.0	15.0	8	½
100	4	3.05-6.02	114.3	108.2-102.3	141.7	180.0	186.0	160.3	113.8	129.91	15.4	8.40	1.0	0.59	0.40	22.0	51.0	10.5	3.0	0.5	0.8	1.0	15.0	8	½
125	5	3.40-6.55	141.3	134.5-128.2	168.7	207.0	213.0	187.3	139.8	157.90	15.5	9.27	1.0	0.76	0.50	25.0	55.0	10.5	3.0	0.5	0.9	1.0	15.0	12	½
150	6	3.40-7.11	168.3	161.5-154.1	195.7	234.0	240.0	214.3	167.7	187.86	15.4	10.12	1.0	0.62	0.41	28.0	60.0	10.5	3.0	0.6	1.0	1.0	15.0	12	½
200	8	3.76-6.35	219.1	211.6-206.4	249.4	288.0	294.0	268.1	217.7	239.91	15.6	11.48	1.0	0.94	0.63	26.0	53.0	10.5	3.0	0.7	1.1	1.5	15.0	12	½
250	10	4.19-6.35	273.1	264.7-260.4	310.6	349.0	355.0	329.3	271.7	299.92	15.6	12.90	1.0	0.93	0.62	32.0	60.0	10.5	3.0	0.8	1.3	1.5	15.0	16	½
300	12	4.57-6.35	323.9	314.8-311.2	358.1	397.0	403.0	376.7	321.7	348.95	15.7	13.97	1.0	1.01	0.67	35.0	64.0	10.5	3.0	0.8	1.4	1.5	15.0	20	½
350	14	4.78-7.92	355.6	346.0-339.8	392.3	431.0	437.0	411.5	353.7	381.89	15.6	14.63	1.0	0.85	0.57	38.0	67.0	10.5	3.0	0.8	1.4	1.5	15.0	20	½
400	16	4.78-7.92	406.4	396.8-390.6	451.2	497.0	505.0	473.4	405.7	436.06	15.8	15.63	1.0	1.20	0.80	42.0	73.0	10.5	3.0	0.9	1.5	2.0	18.0	20	¾
450	18	4.78-7.92	457.2	447.6-441.4	498.7	545.0	552.0	520.9	455.7	487.97	15.7	16.54	1.0	1.01	0.67	46.0	77.0	10.5	3.0	1.0	1.6	2.0	18.0	20	¾
500	20	5.54-9.53	508.0	496.9-488.9	552.5	599.0	606.0	574.7	507.7	540.99	15.7	17.63	1.0	1.02	0.68	50.0	82.0	10.5	3.0	1.0	1.7	2.0	18.0	24	¾
550	22	5.54-9.53	558.8	547.7-539.7	606.9	653.0	661.0	629.1	557.7	593.03	15.7	18.45	1.0	1.08	0.72	54.0	87.0	10.5	3.0	1.1	1.8	2.0	18.0	28	¾
600	24	6.35-9.53	609.6	596.9-590.5	666.3	722.0	730.0	693.0	607.7	644.13	15.8	19.23	1.0	1.19	0.79	59.0	93.0	10.5	3.0	1.1	1.9	3.0	22.0	24	¾
650	26	7.92-9.53	660.4	644.6-641.3	720.2	776.0	784.0	746.8	659.5	696.97	15.7	20.00	1.0	1.00	0.67	64.0	98.0	10.5	3.0	1.1	1.9	3.0	22.0	24	¾
700	28	7.92-9.53	711.2	695.4-692.1	774.5	830.0	839.0	801.2	709.5	749.04	15.7	20.92	1.0	1.08	0.72	68.0	103.0	10.5	3.0	1.2	2.0	3.0	22.0	28	¾
750	30	7.92-12.70	762.0	746.2-736.6	828.9	884.0	893.0	855.5	761.5	802.05	15.7	21.65	1.0	1.08	0.72	72.0	108.0	10.9	3.1	1.3	2.1	3.0	22.0	32	¾
800	32	7.92-12.70	812.8	797.0-787.4	881.3	937.0	945.0	908.0	811.5	853.02	15.7	22.32	1.0	1.03	0.69	76.0	113.0	11.3	3.2	1.3	2.2	3.0	22.0	36	¾
850	34	7.92-12.70	863.6	847.8-838.2	933.9	989.0	998.0	960.5	861.5	904.16	15.8	22.97	1.0	1.18	0.79	79.0	118.0	11.8	3.4	1.3	2.2	3.0	22.0	40	¾
900	36	7.92-12.70	914.4	898.6-889.0	986.1	1050.0	1059.0	1016.6	913.5	958.16	15.8	23.82	1.0	1.15	0.77	84.0	123.0	12.3	3.5	1.4	2.3	3.0	25.0	32	¾
950	38	9.53-12.70	965.2	946.1-939.8	1041.2	1105.0	1114.0	1071.6	963.5	1009.22	15.8	24.44	1.0	1.20	0.80	88.0	128.0	12.7	3.6	1.4	2.3	3.0	25.0	36	¾
1000	40	9.53-12.70	1016.0	996.9-990.6	1098.7	1162.0	1172.0	1129.2	1015.5	1062.30	15.8	25.06	1.0	1.26	0.84	92.0	133.0	13.2	3.8	1.4	2.4	3.0	25.0	40	¾
1050	42	9.53-12.70	1066.8	1047.7-1041.4	1145.8	1209.0	1219.0	1176.2	1065.5	1113.36	15.9	25.65	1.0	1.31	0.87	95.0	137.0	13.8	3.9	1.5	2.5	3.0	25.0	44	¾
1100	44	9.53-12.70	1117.6	1098.5-1092.2	1197.8	1261.0	1271.0	1228.3	1115.5	1164.28	15.8	26.42	1.0	1.22	0.81	99.0	141.0	14.1	4.1	1.5	2.5	3.0	25.0	44	¾
1150	46	9.53-12.70	1168.4	1149.3-1143.0	1249.9	1313.0	1323.0	1280.3	1167.5	1217.35	15.9	27.00	1.0	1.28	0.85	102.0	146.0	14.7	4.2	1.6	2.6	3.0	25.0	48	¾
1200	48	9.53-12.70	1219.2	1200.1-1193.8	1302.4	1366.0	1376.0	1332.9	1217.5	1268.39	15.9	27.54	1.0	1.30	0.87	106.0	150.0	15.2	4.3	1.6	2.6	3.0	25.0	52	¾

Table A.2 – Dimensions of CL 300 weld neck (WN) flanges

DN	NPS	t	A	B	Dw1	Dw2	Dw3	BCD	DA1	DA3	αA2°	E1	E2	αB1°	αB2°	Hw3	Hw5	X	Y	R1	R2	R3	L	n	d _b in
15	½	2.11-4.78	21.3	17.1-11.7	49.1	87.0	93.0	67.3	20.8	30.88	15.2	5.30	1.0	0.27	0.18	15.0	40.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
20	¾	2.11-5.56	26.7	22.5-15.6	54.4	92.0	98.0	72.7	25.8	35.88	15.2	5.30	1.0	0.30	0.20	15.0	40.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
25	1	2.77-6.35	33.4	27.9-20.7	61.2	99.0	105.0	79.4	32.8	42.87	15.2	5.30	1.0	0.32	0.22	15.0	40.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
40	1½	2.77-5.08	48.3	42.8-38.1	76.0	114.0	120.0	94.3	47.8	58.88	15.3	5.58	1.0	0.41	0.27	15.0	41.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
50	2	2.77-5.54	60.3	54.8-49.2	88.1	126.0	132.0	106.3	59.8	71.88	15.3	6.19	1.0	0.45	0.30	15.0	42.0	10.5	3.0	0.4	0.6	1.0	15.0	4	½
65	2½	3.05-5.16	73.0	66.9-62.7	100.8	139.0	145.0	119.0	72.8	85.86	15.3	6.79	1.0	0.41	0.27	16.0	43.0	10.5	3.0	0.4	0.6	1.0	15.0	4	½
80	3	3.05-5.49	88.9	82.8-77.9	116.7	155.0	161.0	134.9	87.8	101.96	15.6	7.42	1.0	0.88	0.59	18.0	46.0	10.5	3.0	0.4	0.7	1.0	15.0	8	½
100	4	3.05-6.02	114.3	108.2-102.3	141.7	180.0	186.0	160.3	113.8	129.91	15.4	8.40	1.0	0.59	0.40	22.0	51.0	10.5	3.0	0.5	0.8	1.0	15.0	8	½
125	5	3.40-6.55	141.3	134.5-128.2	168.7	207.0	213.0	187.3	139.8	157.90	15.5	9.27	1.0	0.76	0.50	25.0	55.0	10.5	3.0	0.5	0.9	1.0	15.0	12	½
150	6	3.40-7.11	168.3	161.5-154.1	195.7	234.0	240.0	214.3	167.7	187.86	15.4	10.12	1.0	0.62	0.41	28.0	60.0	10.5	3.0	0.6	1.0	1.0	15.0	12	½
200	8	3.76-8.18	219.1	211.6-202.7	252.9	299.0	306.0	274.6	217.7	239.89	15.4	11.48	1.0	0.66	0.44	35.0	69.0	10.5	3.0	0.7	1.1	1.5	18.0	12	¾
250	10	4.19-9.27	273.1	264.7-254.6	307.8	353.0	361.0	329.4	271.7	299.97	15.5	12.90	1.0	0.80	0.54	42.0	78.0	10.5	3.0	0.8	1.3	1.5	18.0	20	¾
300	12	4.57-10.31	323.9	314.8-303.3	361.6	407.0	415.0	383.2	321.7	348.91	15.4	13.97	1.0	0.67	0.45	47.0	85.0	11.4	3.3	0.8	1.4	1.5	18.0	20	¾
350	14	4.78-11.13	355.6	346.0-333.3	395.8	442.0	450.0	418.0	353.7	381.94	15.5	14.63	1.0	0.74	0.49	50.0	90.0	12.3	3.5	0.8	1.4	1.5	18.0	24	¾
400	16	4.78-12.70	406.4	396.8-381.0	455.8	511.0	519.0	482.4	405.7	436.04	15.6	15.63	1.0	0.84	0.56	58.0	100.0	13.5	3.9	0.9	1.5	2.0	22.0	24	¾
450	18	6.35-14.27	457.2	444.5-428.7	503.3	559.0	567.0	529.9	455.7	488.03	15.5	16.54	1.0	0.81	0.54	63.0	107.0	14.7	4.2	1.0	1.6	2.0	22.0	28	¾
500	20	6.35-15.09	508.0	495.3-477.8	558.1	621.0	631.0	587.7	507.7	541.04	15.5	17.63	1.0	0.81	0.54	69.0	116.0	16.0	4.6	1.0	1.7	2.0	25.0	24	¾
550	22	9.53-22.23	558.8	539.7-514.3	612.5	675.0	685.0	642.1	557.7	593.00	15.5	18.45	1.0	0.75	0.50	74.0	121.0	17.3	4.9	1.1	1.8	2.0	25.0	28	¾
600	24	9.53-17.48	609.6	590.5-574.6	668.3	740.0	750.0	702.0	607.7	644.18	15.6	19.23	1.5	0.91	0.61	81.0	128.0	18.4	5.3	1.1	1.9	3.0	29.0	28	1
650	26	7.92-16.00	660.4	644.6-628.4	722.2	794.0	804.0	755.8	659.5	697.22	15.7	20.00	1.5	0.99	0.66	86.0	134.0	19.7	5.6	1.1	1.9	3.0	29.0	32	1
700	28	7.92-15.88	711.2	695.4-679.4	776.5	848.0	859.0	810.2	709.5	749.16	15.6	20.92	1.5	0.92	0.61	91.0	140.0	21.0	6.0	1.2	2.0	3.0	29.0	32	1
750	30	7.92-17.50	762.0	746.2-727.0	837.9	917.0	928.0	874.5	761.5	802.35	15.7	21.65	1.5	1.06	0.71	98.0	147.0	22.2	6.3	1.3	2.1	3.0	32.0	32	1½
800	32	9.53-17.48	812.8	793.7-777.8	890.3	969.0	981.0	927.0	811.5	853.26	15.6	22.32	1.5	0.97	0.64	103.0	152.0	23.5	6.7	1.3	2.2	3.0	32.0	32	1½
850	34	9.53-20.00	863.6	844.5-823.6	945.9	1032.0	1045.0	985.5	861.5	904.45	15.7	22.97	1.5	1.09	0.72	109.0	159.0	24.7	7.1	1.3	2.2	3.0	35.0	32	1½
900	36	9.53-22.20	914.4	895.3-870.0	997.1	1084.0	1097.0	1037.6	913.5	958.34	15.7	23.82	1.5	0.99	0.66	114.0	164.0	25.9	7.4	1.4	2.3	3.0	35.0	32	1½
950	38	12.70-20.00	965.2	939.8-925.2	1052.2	1139.0	1152.0	1092.6	963.5	1009.45	15.7	24.44	1.5	1.05	0.70	119.0	170.0	27.2	7.8	1.4	2.3	3.0	35.0	36	1½
1000	40	12.70-22.20	1016.0	990.6-971.6	1109.7	1196.0	1210.0	1150.2	1015.5	1062.48	15.7	25.06	1.5	1.05	0.70	126.0	177.0	28.5	8.1	1.4	2.4	3.0	35.0	40	1½
1050	42	12.70-22.20	1066.8	1041.4-1022.4	1162.8	1257.0	1271.0	1206.2	1065.5	1113.57	15.7	25.65	1.5	1.09	0.73	131.0	184.0	29.6	8.5	1.5	2.5	3.0	38.0	40	1½
1100	44	12.70-25.00	1117.6	1092.2-1067.6	1214.8	1309.0	1323.0	1258.3	1115.5	1164.66	15.8	26.42	1.5	1.14	0.76	135.0	190.0	30.9	8.8	1.5	2.5	3.0	38.0	40	1½
1150	46	12.70-25.0	1168.4	1143.0-1118.4	1266.9	1370.0	1385.0	1314.3	1167.5	1217.68	15.7	27.00	1.5	1.12	0.74	142.0	198.0	32.2	9.2	1.6	2.6	3.0	42.0	36	1½
1200	48	12.70-25.0	1219.2	1193.8-1169.2	1319.4	1422.0	1437.0	1366.9	1217.5	1288.63	15.7	27.54	1.5	1.08	0.72	146.0	204.0	33.5	9.6	1.6	2.6	3.0	42.0	36	1½

Table A.3 – Dimensions of CL 600 weld neck (WN) flanges

DN	NPS	t	A	B	Dw1	Dw2	Dw3	BCD	DA1	DA3	αA2	E1	E2	αB1	αB2	Hw3	Hw5	X	Y	R1	R2	R3	L	n	d _b
15	½	2.77-4.78	21.3	15.8-11.7	49.1	87.0	93.0	67.3	20.8	30.86	15.1	5.30	1.0	0.15	0.10	20.0	51.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
20	¾	2.87-5.56	26.7	21.0-15.6	54.4	92.0	98.0	72.7	25.8	35.86	15.1	5.30	1.0	0.15	0.10	20.0	53.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
25	1	2.77-6.35	33.4	27.9-20.7	61.2	99.0	105.0	79.4	32.8	42.85	15.1	5.30	1.0	0.15	0.10	20.0	56.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
40	1½	2.77-7.14	48.3	42.8-34.0	77.1	115.0	121.0	95.3	47.8	58.88	15.2	5.58	1.0	0.29	0.19	23.0	64.0	12.4	3.5	0.3	0.5	1.0	15.0	8	½
50	2	2.77-8.74	60.3	54.8-42.8	91.7	130.0	136.0	110.0	59.8	71.89	15.2	6.19	1.0	0.33	0.22	23.0	60.0	10.5	3.0	0.4	0.6	1.0	15.0	8	½
65	2½	3.05-7.01	73.0	66.9-59.0	104.8	143.0	149.0	123.1	72.8	85.92	15.3	6.79	1.0	0.44	0.29	26.0	66.0	12.0	3.4	0.4	0.6	1.0	15.0	12	½
80	3	3.05-7.62	88.9	82.8-73.7	116.7	155.0	161.0	134.9	87.8	101.93	15.4	7.42	1.0	0.53	0.35	25.0	61.0	10.5	3.0	0.4	0.7	1.0	15.0	12	½
100	4	3.05-8.56	114.3	108.2-97.2	150.0	196.0	203.0	171.7	113.8	129.97	15.4	8.40	1.0	0.59	0.39	31.0	70.0	11.7	3.3	0.5	0.8	1.0	18.0	12	¾
125	5	3.40-9.53	141.3	134.5-122.2	177.0	223.0	230.0	198.6	139.8	157.88	15.3	9.27	1.0	0.48	0.32	35.0	78.0	13.7	3.9	0.5	0.9	1.0	18.0	12	¾
150	6	7.11-10.97	168.3	154.1-146.4	205.2	251.0	258.0	226.8	167.7	187.85	15.3	10.12	1.0	0.46	0.31	36.0	75.0	11.7	3.3	0.6	1.0	1.0	18.0	12	¾
200	8	6.35-12.70	219.1	206.4-193.7	258.7	304.0	312.0	280.4	217.7	239.92	15.4	11.48	1.0	0.60	0.40	43.0	87.0	14.1	4.0	0.7	1.1	1.5	18.0	20	¾
250	10	6.35-15.09	273.1	260.4-242.9	318.7	374.0	382.0	344.8	271.7	299.95	15.4	12.90	1.0	0.61	0.40	53.0	102.0	16.7	4.8	0.8	1.3	1.5	22.0	20	¾
300	12	8.38-17.48	323.9	307.1-288.9	378.0	441.0	450.0	407.7	321.7	349.01	15.5	13.97	1.0	0.68	0.45	60.0	108.0	19.1	5.5	0.8	1.4	1.5	25.0	20	¾
350	14	7.92-19.05	355.6	339.8-317.5	409.5	472.0	482.0	439.2	353.7	382.05	15.5	14.63	1.0	0.72	0.48	64.0	113.0	20.7	5.9	0.8	1.4	1.5	25.0	24	¾
400	16	9.53-21.44	406.4	387.3-363.5	465.4	537.0	547.0	499.0	405.7	436.09	15.5	15.63	1.5	0.72	0.48	73.0	122.0	23.2	6.6	0.9	1.5	2.0	29.0	24	1
450	18	9.53-23.83	457.2	438.1-409.5	523.4	602.0	614.0	560.1	455.7	488.19	15.5	16.54	1.5	0.81	0.54	80.0	131.0	25.7	7.3	1.0	1.6	2.0	32.0	24	1½
500	20	12.70-26.19	508.0	482.6-455.6	574.0	653.0	664.0	610.6	507.7	541.20	15.5	17.63	1.5	0.81	0.54	86.0	139.0	28.1	8.0	1.0	1.7	2.0	32.0	28	1½
550	22	12.70-28.58	558.8	533.4-501.6	631.1	717.0	730.0	670.7	557.7	593.17	15.5	18.45	1.5	0.75	0.50	94.0	149.0	30.6	8.7	1.1	1.8	2.0	35.0	24	1½
600	24	12.70-30.96	609.6	584.2-547.7	685.9	772.0	785.0	725.6	607.7	644.23	15.5	19.23	1.5	0.79	0.52	100.0	158.0	33.0	9.4	1.1	1.9	3.0	35.0	28	1½
650	26	14.2-28.00	660.4	632.0-604.4	736.0	822.0	835.0	775.6	659.5	697.27	15.6	20.00	1.5	0.85	0.57	105.0	166.0	35.5	10.1	1.1	1.9	3.0	35.0	32	1½
700	28	15.88-28.00	711.2	679.4-655.2	792.5	886.0	900.0	835.2	709.5	749.42	15.6	20.92	1.5	0.95	0.63	112.0	176.0	37.9	10.8	1.2	2.0	3.0	38.0	32	1¾
750	30	15.88-30.00	762.0	730.2-702.0	847.1	940.0	955.0	889.8	761.5	802.49	15.7	21.65	1.5	0.98	0.65	118.0	185.0	40.4	11.5	1.3	2.1	3.0	38.0	36	1¾
800	32	17.48-30.00	812.8	777.8-752.8	899.0	1001.0	1016.0	945.7	811.5	853.46	15.6	22.32	1.5	0.92	0.62	126.0	195.0	42.8	12.2	1.3	2.2	3.0	42.0	32	1½
850	34	17.48-32.00	863.6	828.6-799.6	954.3	1064.0	1081.0	1004.8	861.5	904.61	15.7	22.97	1.5	1.00	0.67	133.0	205.0	45.3	12.9	1.3	2.2	3.0	45.0	32	1¾
900	36	19.05-36.00	914.4	876.3-842.4	1007.9	1118.0	1134.0	1058.4	913.5	958.39	15.5	23.82	1.5	0.81	0.54	145.0	214.0	47.3	13.5	1.4	2.3	3.0	45.0	32	1¾
950	38	20.00-36.00	965.2	925.2-893.2	1060.5	1179.0	1196.0	1115.0	963.5	1009.62	15.6	24.44	1.5	0.95	0.64	147.0	223.0	49.0	14.0	1.4	2.3	3.0	49.0	32	1¾
1000	40	20.00-40.00	1016.0	976.0-936.0	1115.1	1234.0	1251.0	1169.6	1015.5	1062.71	15.7	25.06	1.5	0.99	0.66	153.0	232.0	50.8	14.5	1.4	2.4	3.0	49.0	36	1¾
1050	42	22.20-40.00	1066.8	1022.4-986.8	1167.7	1294.0	1312.0	1225.2	1065.5	1113.56	15.6	25.65	1.5	0.86	0.57	165.0	241.0	52.5	15.0	1.5	2.5	3.0	52.0	32	1¾
1100	44	22.20-45.00	1117.6	1073.2-1027.6	1221.0	1347.0	1365.0	1278.5	1115.5	1164.67	15.6	26.42	1.5	0.91	0.60	170.0	249.0	54.3	15.5	1.5	2.5	3.0	52.0	36	1¾
1150	46	22.20-45.00	1168.4	1124.0-1078.4	1285.4	1419.0	1438.0	1345.9	1167.5	1217.95	15.7	27.00	2.0	1.05	0.70	174.0	262.0	56.0	16.0	1.6	2.6	3.0	55.0	36	2
1200	48	25.0-45.00	1219.2	1169.2-1129.2	1337.0	1470.0	1490.0	1397.4	1217.5	1268.69	15.6	27.54	2.0	0.86	0.57	189.0	270.0	57.8	16.5	1.6	2.6	3.0	55.0	36	2

Table A.4 – Dimensions of CL 900 weld neck (WN) flanges

DN	NPS	t mm	A mm	B mm	Dw1 mm	Dw2 mm	Dw3 mm	BCD Mm	DA1 mm	DA3 mm	αA2 °	E1 mm	E2 mm	αB1 °	αB2 °	Hw3 mm	Hw5 mm	X mm	Y mm	R1 mm	R2 mm	R3 mm	L mm	n	d _b in
15	½	2.77-4.78	21.3	15.8-11.7	49.1	87.0	93.0	67.3	20.8	30.86	15.1	5.30	1.0	0.15	0.10	20.0	51.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
20	¾	2.87-5.66	26.7	21.0-15.6	54.4	92.0	98.0	72.7	25.8	35.86	15.1	5.30	1.0	0.15	0.10	20.0	53.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
25	1	3.38-6.35	33.4	26.6-20.7	61.2	99.0	105.0	79.4	32.8	42.85	15.1	5.30	1.0	0.15	0.10	20.0	56.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
40	1½	2.77-7.14	48.3	42.8-34.0	77.1	115.0	121.0	95.3	42.8	58.88	15.2	5.58	1.0	0.29	0.19	23.0	64.0	12.4	3.5	0.3	0.5	1.0	15.0	8	½
50	2	2.77-8.74	60.3	54.8-42.8	91.7	130.0	136.0	110.0	59.8	71.89	15.2	6.19	1.0	0.33	0.22	23.0	60.0	10.5	3.0	0.4	0.6	1.0	15.0	8	½
65	2½	3.05-9.53	73.0	66.9-53.9	104.8	143.0	149.0	123.1	72.8	85.91	15.3	6.79	1.0	0.41	0.28	26.0	66.0	12.0	3.4	0.4	0.6	1.0	15.0	12	½
80	3	3.05-11.13	88.9	82.8-66.6	116.7	155.0	161.0	134.9	87.8	101.91	15.3	7.42	1.0	0.48	0.32	25.0	61.0	10.5	3.0	0.4	0.7	1.0	15.0	12	½
100	4	3.05-11.13	114.3	108.2-92.0	150.0	196.0	203.0	171.7	113.8	129.96	15.4	8.40	1.0	0.56	0.37	31.0	70.0	11.7	3.3	0.5	0.8	1.0	18.0	12	¾
125	5	6.55-12.70	141.3	128.2-115.9	177.0	223.0	230.0	198.6	139.8	157.86	15.3	9.27	1.0	0.43	0.29	35.0	78.0	13.7	3.9	0.5	0.9	1.0	18.0	12	¾
150	6	7.11-14.27	168.3	154.1-139.8	210.0	256.0	263.0	231.6	167.7	187.88	15.3	10.12	1.0	0.47	0.31	40.0	87.0	15.5	4.4	0.6	1.0	1.0	18.0	16	¾
200	8	6.35-18.26	219.1	206.4-182.6	267.2	322.0	330.0	293.2	217.7	239.96	15.4	11.48	1.0	0.58	0.39	50.0	98.0	19.1	5.5	0.7	1.1	1.5	22.0	20	¾
250	10	7.80-21.44	273.1	257.5-230.2	325.8	388.0	397.0	354.8	271.7	299.97	15.4	12.90	1.0	0.56	0.38	60.0	110.0	23.1	6.6	0.8	1.3	1.5	25.0	20	¾
300	12	8.36-25.4	323.9	307.1-273.1	380.3	452.0	462.0	413.9	321.7	349.00	15.4	13.97	1.5	0.58	0.39	68.0	119.0	26.7	7.6	0.8	1.4	1.5	29.0	20	1
350	14	9.53-27.79	355.6	336.5-300.0	415.6	487.0	497.0	449.3	353.7	382.03	15.4	14.63	1.5	0.61	0.41	73.0	127.0	28.9	8.3	0.8	1.4	1.5	29.0	24	1
400	16	12.70-30.96	406.4	381.0-344.5	477.2	556.0	567.0	513.8	405.7	436.09	15.4	15.63	1.5	0.65	0.43	82.0	140.0	32.6	9.3	0.9	1.5	2.0	32.0	24	1½
450	18	11.13-29.36	457.2	434.9-398.5	534.3	620.0	633.0	574.0	455.7	488.21	15.5	16.54	1.5	0.74	0.49	90.0	153.0	36.3	10.4	1.0	1.6	2.0	35.0	24	1½
500	20	12.70-32.54	508.0	482.6-442.9	592.9	686.0	700.0	635.5	507.7	541.27	15.5	17.63	1.5	0.76	0.51	99.0	166.0	39.9	11.4	1.0	1.7	2.0	38.0	24	1¾
550	22	22.23-34.93	558.8	514.3-488.9	647.0	749.0	764.0	693.6	557.7	593.28	15.5	18.45	1.5	0.75	0.50	107.0	179.0	43.5	12.4	1.1	1.8	2.0	42.0	24	1½
600	24	14.27-38.89	609.6	581.1-531.8	704.6	814.0	830.0	754.2	607.7	644.42	15.5	19.23	1.5	0.82	0.55	115.0	191.0	47.1	13.5	1.1	1.9	3.0	45.0	24	1¾
650	26	20.00-36.0	660.4	620.4-588.4	759.2	877.0	894.0	812.8	659.5	697.44	15.6	20.00	1.5	0.84	0.56	124.0	204.0	50.8	14.5	1.1	1.9	3.0	49.0	24	1¾
700	28	22.20-40.00	711.2	666.8-631.2	812.8	931.0	948.0	866.4	709.5	749.20	15.4	20.92	1.5	0.62	0.41	141.0	214.0	52.5	15.0	1.2	2.0	3.0	49.0	24	1¾
750	30	17.50-45.00	762.0	727.0-672.0	870.2	995.0	1014.0	926.9	761.5	802.29	15.4	21.65	1.5	0.66	0.44	149.0	227.0	56.0	16.0	1.3	2.1	3.0	52.0	24	1¾
800	32	25.00-45.00	812.8	762.8-722.8	928.8	1061.0	1081.0	988.4	811.5	853.35	15.5	22.32	2.0	0.68	0.45	157.0	239.0	59.5	17.0	1.3	2.2	3.0	55.0	24	2
850	34	25.00-50.00	863.6	813.6-763.6	989.0	1139.0	1160.0	1057.1	861.5	904.71	15.6	22.97	2.0	0.89	0.60	158.0	254.0	63.0	18.0	1.3	2.2	3.0	62.0	24	2¼
900	36	22.20-50.00	914.4	870.0-814.4	1042.7	1193.0	1214.0	1110.7	913.5	958.50	15.5	23.82	2.0	0.72	0.48	176.0	265.0	64.8	18.5	1.4	2.3	3.0	62.0	24	2¼
950	38	30.00-55.00	965.2	905.2-855.2	1102.8	1267.0	1291.0	1176.8	963.5	1009.85	15.6	24.44	2.0	0.92	0.61	174.0	279.0	66.5	19.0	1.4	2.3	3.0	68.0	24	2½
1000	40	30.00-55.00	1016.0	956.0-906.0	1155.9	1320.0	1344.0	1230.0	1015.5	1062.64	15.5	25.06	2.0	0.77	0.51	190.0	290.0	68.3	19.5	1.4	2.4	3.0	68.0	24	2½
1050	42	25.00-60.00	1066.8	1016.8-946.8	1208.1	1372.0	1396.0	1282.1	1065.5	1113.93	15.6	25.65	2.0	0.90	0.60	192.0	300.0	70.0	20.0	1.5	2.5	3.0	68.0	28	2½
1100	44	32.00-60.00	1117.6	1053.6-997.6	1262.7	1427.0	1451.0	1336.8	1115.5	1164.64	15.5	26.42	2.0	0.72	0.48	211.0	310.0	71.8	20.5	1.5	2.5	3.0	68.0	28	2½
1150	46	36.00-65.00	1168.4	1096.4-1038.4	1321.3	1501.0	1527.0	1401.9	1167.5	1217.69	15.5	27.00	2.0	0.73	0.49	219.0	324.0	73.5	21.0	1.6	2.6	3.0	74.0	28	2¾
1200	48	36.00-65.00	1219.2	1147.2-1089.2	1394.4	1590.0	1618.0	1482.0	1217.5	1269.20	15.6	27.54	2.5	0.95	0.63	218.0	342.0	75.3	21.5	1.6	2.6	3.0	81.0	28	3

Table A.5 – Dimensions of CL 1500 weld neck (WN) flanges

DN	NPS	t	A	B	Dw1	Dw2	Dw3	BCD	DA1	DA3	αA2	E1	E2	αB1	αB2	Hw3	Hw5	X	Y	R1	R2	R3	L	n	d _b
15	½	2.77-7.47	21.3	15.8-6.4	49.1	87.0	93.0	67.3	20.8	30.86	15.1	5.30	1.0	0.15	0.10	20.0	51.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
20	¾	2.87-7.82	26.7	21.0-11.1	54.4	92.0	98.0	72.7	25.8	35.86	15.1	5.30	1.0	0.15	0.10	20.0	53.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
25	1	3.38-9.09	33.4	26.6-15.2	61.2	99.0	105.0	79.4	32.8	42.85	15.1	5.30	1.0	0.15	0.10	20.0	56.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
40	1½	3.68-10.15	48.3	40.9-28.0	77.1	115.0	121.0	95.3	47.8	58.89	15.2	5.58	1.0	0.30	0.20	23.0	64.0	12.4	3.5	0.3	0.5	1.0	15.0	8	½
50	2	3.91-11.07	60.3	52.5-38.2	91.7	130.0	136.0	110.0	59.8	71.88	15.2	6.19	1.0	0.30	0.20	23.0	60.0	10.5	3.0	0.4	0.6	1.0	15.0	8	½
65	2½	5.16-14.02	73.0	62.7-45.0	104.8	143.0	149.0	123.1	72.8	85.92	15.3	6.79	1.0	0.45	0.30	26.0	66.0	12.0	3.4	0.4	0.6	1.0	15.0	12	½
80	3	5.49-15.24	88.9	77.9-58.4	126.7	172.0	180.0	148.3	87.8	101.93	15.3	7.42	1.0	0.45	0.30	30.0	73.0	13.8	3.9	0.4	0.7	1.0	18.0	12	¾
100	4	6.02-17.12	114.3	102.3-80.1	161.0	216.0	224.0	187.0	113.8	129.96	15.3	8.40	1.0	0.49	0.33	37.0	86.0	16.8	4.8	0.5	0.8	1.0	22.0	12	¾
125	5	9.53-19.05	141.3	122.2-103.2	189.6	252.0	261.0	218.6	139.8	157.93	15.3	9.27	1.0	0.49	0.33	43.0	92.0	19.8	5.7	0.5	0.9	1.0	25.0	12	¾
150	6	10.97-21.95	168.3	146.4-124.4	225.7	297.0	307.0	258.8	167.7	187.94	15.3	10.12	1.5	0.49	0.33	50.0	101.0	23.0	6.6	0.6	1.0	1.0	29.0	12	1
200	8	12.70-25.00	219.1	193.7-169.1	284.4	355.0	365.0	317.4	217.7	239.96	15.3	11.48	1.5	0.49	0.33	60.0	115.0	28.9	8.3	0.7	1.1	1.5	29.0	16	1
250	10	12.70-28.58	273.1	247.7-215.9	354.6	440.0	453.0	393.6	271.7	300.06	15.4	12.90	1.5	0.55	0.37	75.0	136.0	35.1	10.0	0.8	1.3	1.5	35.0	16	1¼
300	12	14.27-33.32	323.9	295.4-257.3	409.3	495.0	508.0	449.0	321.7	349.10	15.4	13.97	1.5	0.58	0.38	83.0	151.0	41.1	11.7	0.8	1.4	1.5	35.0	20	1¼
350	14	19.05-35.71	355.6	317.5-284.2	450.4	544.0	558.0	493.1	353.7	382.15	15.4	14.63	1.5	0.62	0.41	89.0	162.0	44.7	12.8	0.8	1.4	1.5	38.0	20	1½
400	16	21.44-40.49	406.4	363.5-325.4	508.6	611.0	626.0	555.2	405.7	436.12	15.4	15.63	1.5	0.53	0.35	105.0	180.0	50.6	14.5	0.9	1.5	2.0	42.0	20	1½
450	18	23.83-45.24	457.2	409.5-366.7	568.6	687.0	704.0	622.3	455.7	488.31	15.5	16.54	1.5	0.68	0.45	111.0	198.0	56.5	16.1	1.0	1.6	2.0	49.0	20	1¾
500	20	26.19-50.01	508.0	455.6-408.0	634.1	759.0	778.0	690.7	507.7	541.29	15.4	17.63	1.5	0.61	0.41	126.0	217.0	62.4	17.8	1.0	1.7	2.0	52.0	20	1¾
550	22	34.93-53.98	558.8	488.9-450.8	698.3	831.0	850.0	757.9	557.7	593.24	15.4	18.45	2.0	0.53	0.36	142.0	234.0	68.3	19.5	1.1	1.8	2.0	55.0	20	2
600	24	30.96-59.54	609.6	547.7-490.5	762.1	911.0	933.0	829.3	607.7	644.50	15.5	19.23	2.0	0.69	0.46	146.0	253.0	74.2	21.2	1.1	1.9	3.0	62.0	20	2¼
650	26	32.00-60.00	660.4	596.4-540.4	819.7	969.0	990.0	887.0	659.5	697.20	15.3	20.00	2.0	0.49	0.33	172.0	269.0	75.2	21.5	1.1	1.9	3.0	62.0	20	2¼
700	28	36.00-60.00	711.2	639.2-591.2	879.9	1029.0	1051.0	947.2	709.5	749.32	15.4	20.92	2.0	0.54	0.36	182.0	285.0	78.8	22.5	1.2	2.0	3.0	62.0	24	2¼
750	30	36.00-65.00	762.0	690.0-632.0	943.5	1108.0	1132.0	1017.5	761.5	802.59	15.4	21.65	2.0	0.67	0.44	186.0	304.0	82.3	23.5	1.3	2.1	3.0	68.0	24	2½
800	32	40.00-70.00	812.8	732.8-672.8	966.8	1131.0	1155.0	1040.8	811.5	853.32	15.3	22.32	2.0	0.52	0.35	202.0	311.0	85.8	24.5	1.3	2.2	3.0	68.0	24	2½
850	34	40.00-75.00	863.6	783.6-713.6	1026.4	1206.0	1232.0	1107.1	861.5	904.35	15.3	22.97	2.0	0.51	0.34	214.0	328.0	89.3	25.5	1.3	2.2	3.0	74.0	24	2¾
900	36	45.00-80.00	914.4	824.4-754.4	1096.6	1308.0	1339.0	1191.3	913.5	958.50	15.4	23.82	2.5	0.57	0.38	222.0	352.0	92.8	26.5	1.4	2.3	3.0	88.0	20	3¼
950	38	50.00-80.00	965.2	865.2-805.2	1156.9	1383.0	1416.0	1257.5	963.5	1009.72	15.4	24.44	2.5	0.66	0.44	226.0	369.0	96.3	27.5	1.4	2.3	3.0	94.0	20	3½
1000	40	50.00-85.00	1016.0	916.0-846.0	1210.4	1422.0	1452.0	1305.0	1015.5	1062.52	15.4	25.06	2.5	0.54	0.36	250.0	382.0	99.8	28.5	1.4	2.4	3.0	88.0	24	3¼
1050	42	50.00-90.00	1066.8	966.8-886.8	1271.9	1514.0	1549.0	1379.5	1065.5	1113.65	15.4	25.65	2.5	0.58	0.39	257.0	402.0	103.3	29.5	1.5	2.5	3.0	101.0	20	3¾
1100	44	55.00-95.00	1117.6	1007.6-927.6	1323.6	1550.0	1583.0	1424.2	1115.5	1164.52	15.3	26.42	2.5	0.51	0.34	275.0	413.0	106.8	30.5	1.5	2.5	3.0	94.0	24	3¾
1150	46	60.00-110.0	1168.4	1048.4-948.4	1388.9	1631.0	1666.0	1496.5	1167.5	1217.65	15.4	27.00	2.5	0.56	0.37	281.0	433.0	110.3	31.5	1.6	2.6	3.0	101.0	24	3¾
1200	48	60.00-115.0	1219.2	1099.2-989.2	1437.0	1679.0	1714.0	1544.7	1217.5	1268.44	15.3	27.54	2.5	0.47	0.31	303.0	445.0	110.3	31.5	1.6	2.6	3.0	101.0	24	3¾

Table A.6 – Dimensions of CL 2500 weld neck (WN) flanges

DN	NPS	t mm	A mm	B mm	Dw1 mm	Dw2 mm	Dw3 mm	BCD mm	DA1 mm	DA3 mm	αA2 °	E1 mm	E2 mm	αB1 °	αB2 °	Hw3 mm	Hw5 mm	X mm	Y mm	R1 mm	R2 mm	R3 mm	L mm	n	d _b In
15	½	2.77-7.47	21.3	15.8-6.4	49.1	87.0	93.0	67.3	20.8	30.86	15.1	5.30	1.0	0.15	0.10	20.0	51.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
20	¾	2.87-7.82	26.7	21.0-11.1	54.4	92.0	98.0	72.7	25.8	35.86	15.1	5.30	1.0	0.15	0.10	20.0	53.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
25	1	3.38-9.09	33.4	26.6-15.2	61.2	99.0	105.0	79.4	32.8	42.85	15.1	5.30	1.0	0.15	0.10	20.0	56.0	10.5	3.0	0.3	0.5	1.0	15.0	4	½
40	1½	3.68-12.50	48.3	40.9-23.3	77.1	115.0	121.0	95.3	47.8	58.87	15.2	5.58	1.0	0.25	0.17	23.0	64.0	12.4	3.5	0.3	0.5	1.0	15.0	8	½
50	2	3.91-14.20	60.3	52.5-31.9	94.9	140.0	147.0	116.2	59.8	71.89	15.2	6.19	1.0	0.31	0.21	27.0	72.0	14.7	4.2	0.4	0.6	1.0	18.0	8	¾
65	2½	7.01-16.00	73.0	59.0-41.0	115.9	170.0	179.0	141.6	72.8	85.91	15.2	6.79	1.0	0.33	0.22	32.0	81.0	17.0	4.9	0.4	0.6	1.0	22.0	8	¾
80	3	5.49-17.50	88.9	77.9-53.9	137.3	199.0	209.0	166.3	87.8	101.94	15.3	7.42	1.0	0.40	0.27	36.0	85.0	20.0	5.7	0.4	0.7	1.0	25.0	8	¾
100	4	8.56-22.20	114.3	97.2-69.9	167.3	238.0	248.0	200.4	113.8	129.93	15.2	8.40	1.5	0.34	0.23	44.0	95.0	24.6	7.0	0.5	0.8	1.0	29.0	8	1
125	5	15.88-25.0	141.3	109.5-91.3	197.2	268.0	278.0	230.2	139.8	157.91	15.3	9.27	1.5	0.39	0.26	50.0	106.0	29.6	8.5	0.5	0.9	1.0	29.0	12	1
150	6	10.97-30.0	168.3	146.4-108.3	232.7	311.0	322.0	268.8	167.7	187.94	15.3	10.12	1.5	0.41	0.28	58.0	120.0	34.5	9.9	0.6	1.0	1.0	32.0	12	1½
200	8	15.09-36.0	219.1	188.9-147.1	301.6	394.0	408.0	343.7	217.7	239.99	15.3	11.48	1.5	0.44	0.29	72.0	145.0	44.0	12.6	0.7	1.1	1.5	38.0	12	1¾
250	10	15.09-45.0	273.1	242.9-183.1	368.4	470.0	485.0	415.0	271.7	300.08	15.3	12.90	1.5	0.49	0.33	88.0	172.0	53.9	15.4	0.8	1.3	1.5	42.0	16	1½
300	12	17.48-55.0	323.9	288.9-213.9	429.6	548.0	564.0	483.2	321.7	349.17	15.4	13.97	1.5	0.55	0.37	99.0	195.0	63.4	18.1	0.8	1.4	1.5	49.0	16	1¾
350	14	19.05-55.0	355.6	317.5-245.6	474.6	600.0	618.0	531.2	353.7	382.22	15.4	14.63	1.5	0.56	0.37	108.0	211.0	69.2	19.8	0.8	1.4	1.5	52.0	16	1¾
400	16	21.44-65.0	406.4	363.5-276.4	547.8	697.0	718.0	615.1	405.7	436.37	15.4	15.63	2.0	0.62	0.41	125.0	238.0	78.5	22.4	0.9	1.5	2.0	62.0	16	2¼
450	18	23.88-70.0	457.2	409.4-317.2	609.0	758.0	780.0	676.3	455.7	488.28	15.4	16.54	2.0	0.53	0.36	136.0	260.0	88.0	25.1	1.0	1.6	2.0	62.0	16	2¼
500	20	26.19-80.0	508.0	455.6-348.0	661.8	825.0	849.0	735.0	507.7	541.35	15.4	17.63	2.0	0.56	0.37	147.0	282.0	97.3	27.8	1.0	1.7	2.0	68.0	16	2½
550	22	53.98-85.0	558.8	450.8-388.8	735.0	930.0	958.0	821.8	557.7	593.39	15.4	18.45	2.5	0.54	0.36	163.0	310.0	106.8	30.5	1.1	1.8	2.0	81.0	16	3
600	24	52.37-95.0	609.6	504.9-419.6	797.4	1008.0	1039.0	891.3	607.7	644.47	15.4	19.23	2.5	0.56	0.38	176.0	334.0	116.1	33.2	1.1	1.9	3.0	88.0	16	3¼

A.3 Blind flanges

Dimensions specific to the blind flanges are given in this clause and are defined in the drawing below. All other dimensions are found in Table A.1 to Table A.6 for the WN flanges.

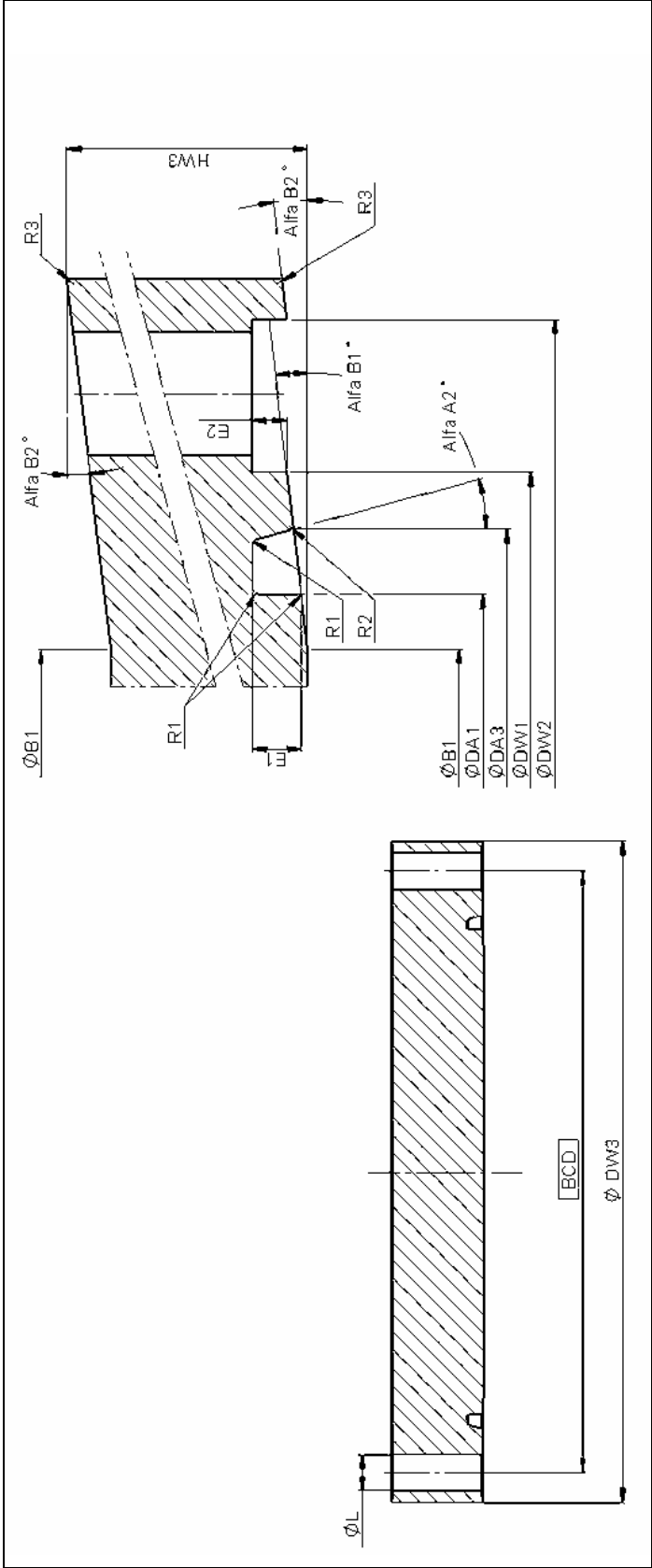


Figure A.2 – Nomenclatures for blind flanges (BL)

Table A.7 – Dimensions for CL 150, CL 300 and CL 600 blind flanges

		CL 150					CL 300					CL 600				
DN	NPS	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °
15	½	9.0	30.87	15.2	0.27	0.18	9.0	30.87	15.2	0.27	0.18	2.0	30.85	15.1	0.15	0.10
20	¾	13.0	35.87	15.2	0.27	0.18	14.0	35.87	15.2	0.27	0.18	3.0	35.85	15.1	0.15	0.10
25	1	19.0	42.87	15.2	0.27	0.18	19.0	42.87	15.2	0.27	0.18	7.0	42.85	15.1	0.15	0.10
40	1½	31.0	58.85	15.2	0.28	0.18	31.0	58.85	15.2	0.28	0.18	14.0	58.86	15.1	0.20	0.13
50	2	41.0	71.84	15.2	0.27	0.18	41.0	71.84	15.2	0.27	0.18	27.0	71.85	15.1	0.22	0.14
65	2½	49.0	85.83	15.2	0.22	0.15	49.0	85.83	15.2	0.22	0.15	36.0	85.86	15.2	0.25	0.16
80	3	63.0	101.87	15.3	0.44	0.30	63.0	101.87	15.3	0.44	0.30	53.0	101.85	15.2	0.27	0.18
100	4	83.0	129.82	15.2	0.25	0.16	83.0	129.82	15.2	0.25	0.16	71.0	129.85	15.2	0.28	0.18
125	5	104.0	157.76	15.2	0.28	0.19	104.0	157.76	15.2	0.28	0.19	90.0	157.76	15.1	0.20	0.13
150	6	126.0	187.70	15.1	0.15	0.10	126.0	187.72	15.1	0.20	0.13	117.0	187.74	15.1	0.19	0.12
200	8	173.0	239.70	15.2	0.27	0.18	167.0	239.70	15.1	0.20	0.13	155.0	239.72	15.1	0.21	0.14
250	10	218.0	299.66	15.2	0.23	0.15	209.0	299.68	15.1	0.21	0.14	196.0	299.70	15.1	0.20	0.13
300	12	260.0	348.63	15.2	0.22	0.15	250.0	348.63	15.1	0.16	0.11	233.0	348.69	15.2	0.22	0.15
350	14	287.0	381.59	15.1	0.18	0.12	275.0	381.61	15.1	0.17	0.11	257.0	381.68	15.2	0.22	0.15
400	16	328.0	435.60	15.2	0.25	0.17	315.0	435.61	15.1	0.20	0.13	294.0	435.66	15.1	0.22	0.14
450	18	371.0	487.53	15.1	0.19	0.12	355.0	487.56	15.1	0.18	0.12	332.0	487.66	15.2	0.24	0.16
500	20	413.0	540.50	15.1	0.18	0.12	396.0	540.53	15.1	0.17	0.11	369.0	540.62	15.2	0.23	0.15
550	22	456.0	592.47	15.1	0.18	0.12	437.0	592.50	15.1	0.17	0.11	406.0	592.58	15.1	0.21	0.14
600	24	496.0	643.46	15.1	0.21	0.14	478.0	643.50	15.1	0.19	0.13	445.0	643.56	15.1	0.21	0.14
650	26	539.0	696.35	15.1	0.17	0.11	517.0	696.42	15.1	0.19	0.13	483.0	696.48	15.1	0.21	0.14
700	28	581.0	748.32	15.1	0.17	0.12	558.0	748.36	15.1	0.17	0.11	520.0	748.49	15.2	0.23	0.15
750	30	624.0	801.29	15.1	0.17	0.12	598.0	801.37	15.1	0.20	0.13	558.0	801.46	15.2	0.23	0.15
800	32	665.0	852.26	15.1	0.17	0.11	639.0	852.32	15.1	0.17	0.12	595.0	852.42	15.1	0.21	0.14
850	34	707.0	903.23	15.1	0.18	0.12	678.0	903.33	15.1	0.20	0.13	634.0	903.43	15.2	0.23	0.15
900	36	750.0	957.19	15.1	0.17	0.11	719.0	957.26	15.1	0.18	0.12	672.0	957.33	15.1	0.18	0.12
950	38	792.0	1008.17	15.1	0.17	0.12	760.0	1008.24	15.1	0.18	0.12	709.0	1008.36	15.1	0.21	0.14
1000	40	835.0	1061.14	15.1	0.18	0.12	801.0	1061.21	15.1	0.18	0.12	746.0	1061.34	15.2	0.22	0.15
1050	42	876.0	1112.10	15.1	0.17	0.12	840.0	1112.20	15.1	0.19	0.12	784.0	1112.27	15.1	0.19	0.12
1100	44	918.0	1163.05	15.1	0.16	0.10	881.0	1163.18	15.1	0.19	0.13	823.0	1163.26	15.1	0.20	0.13
1150	46	961.0	1216.02	15.1	0.16	0.10	921.0	1216.14	15.1	0.19	0.12	860.0	1216.30	15.2	0.23	0.15
1200	48	1003.0	1266.99	15.1	0.16	0.10	962.0	1267.09	15.1	0.17	0.12	898.0	1267.19	15.1	0.18	0.12

Table A.8 – Dimensions for CL 900, CL 1500 and CL 2500 blind flanges

		CL 900					CL 1500					CL 2500				
DN	NPS	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °
15	½	2.0	30.85	15.1	0.15	0.10	2.0	30.85	15.1	0.15	0.10	2.0	30.85	15.1	0.15	0.10
20	¾	3.0	35.85	15.1	0.15	0.10	3.0	35.85	15.1	0.15	0.10	3.0	35.85	15.1	0.15	0.10
25	1	7.0	42.85	15.1	0.15	0.10	7.0	42.85	15.1	0.15	0.10	7.0	42.85	15.1	0.15	0.10
40	1½	14.0	58.86	15.1	0.20	0.13	14.0	58.86	15.1	0.20	0.13	14.0	58.86	15.1	0.20	0.13
50	2	27.0	71.85	15.1	0.22	0.14	27.0	71.85	15.1	0.22	0.14	19.0	71.87	15.2	0.24	0.16
65	2½	36.0	85.86	15.2	0.25	0.16	36.0	85.86	15.2	0.25	0.16	26.0	85.88	15.2	0.26	0.17
80	3	53.0	101.85	15.2	0.27	0.18	44.0	101.88	15.2	0.31	0.21	32.0	101.90	15.2	0.29	0.20
100	4	71.0	129.85	15.2	0.28	0.18	60.0	129.88	15.2	0.30	0.20	43.0	129.88	15.2	0.24	0.16
125	5	90.0	157.76	15.1	0.20	0.13	77.0	157.83	15.2	0.29	0.19	56.0	157.84	15.2	0.28	0.18
150	6	109.0	187.75	15.1	0.20	0.13	92.0	187.82	15.2	0.28	0.19	68.0	187.84	15.2	0.26	0.17
200	8	143.0	239.76	15.2	0.24	0.16	122.0	239.80	15.2	0.25	0.17	90.0	239.85	15.2	0.27	0.18
250	10	180.0	299.72	15.1	0.21	0.14	155.0	299.81	15.2	0.26	0.18	114.0	299.87	15.2	0.29	0.19
300	12	216.0	348.71	15.1	0.21	0.14	185.0	348.79	15.2	0.26	0.17	138.0	348.91	15.2	0.32	0.21
350	14	238.0	381.70	15.1	0.22	0.14	204.0	381.81	15.2	0.29	0.19	151.0	381.91	15.2	0.32	0.21
400	16	274.0	435.69	15.2	0.23	0.15	235.0	435.76	15.2	0.23	0.15	175.0	435.99	15.2	0.36	0.24
450	18	308.0	487.69	15.2	0.24	0.16	265.0	487.83	15.2	0.31	0.21	197.0	487.90	15.2	0.29	0.20
500	20	343.0	540.68	15.2	0.25	0.16	294.0	540.79	15.2	0.27	0.18	219.0	540.91	15.2	0.30	0.20
550	22	379.0	592.67	15.2	0.25	0.17	325.0	592.75	15.2	0.24	0.16	243.0	593.00	15.2	0.34	0.23
600	24	413.0	643.67	15.2	0.26	0.17	355.0	643.85	15.2	0.31	0.21	265.0	644.03	15.2	0.35	0.23
650	26	449.0	696.60	15.2	0.26	0.17	386.0	696.62	15.1	0.20	0.13					
700	28	485.0	748.48	15.1	0.18	0.12	417.0	748.63	15.1	0.21	0.14					
750	30	519.0	801.47	15.1	0.19	0.13	445.0	801.72	15.2	0.27	0.18					
800	32	554.0	852.47	15.1	0.20	0.13	476.0	852.56	15.1	0.19	0.13					
850	34	590.0	903.58	15.2	0.28	0.18	507.0	903.54	15.1	0.19	0.13					
900	36	626.0	957.44	15.1	0.20	0.13	537.0	957.61	15.2	0.23	0.15					
950	38	660.0	1008.56	15.2	0.28	0.19	568.0	1008.68	15.2	0.26	0.18					
1000	40	695.0	1061.44	15.2	0.22	0.15	597.0	1061.53	15.1	0.20	0.13					
1050	42	731.0	1112.48	15.2	0.25	0.17	627.0	1112.57	15.2	0.22	0.15					
1100	44	765.0	1163.35	15.1	0.20	0.13	658.0	1163.47	15.1	0.19	0.13					
1150	46	801.0	1216.36	15.1	0.21	0.14	689.0	1216.54	15.1	0.22	0.14					
1200	48	836.0	1267.51	15.2	0.28	0.19	719.0	1267.40	15.1	0.17	0.12					

A.4 Integral flanges

Dimensions specific to the integral flanges are given in this clause and are defined in the drawing below. All other dimensions are found in Tables A.1 to A.6 for WN flanges. Dimensions shall comply with requirements in ASME B16.34 and ISO 14313. The face angles for the integral flanges are based on the stiffness of flange ring and flange neck. For each flange size, two face angles are listed. One for the minimum neck thickness that can be used, $t_{\min}$ and the other angle is valid for the maximum neck thickness that can be used, $t_{\max}$.

For all integral flanges the face dimensions shall be interpolated between their listed values at maximum and minimum neck thickness. Calculating methods and examples are included in Annex H. The minimum value for flange face angle α_{B1} is set to $0,15^\circ$. Any calculation resulting in smaller angles than $0,15^\circ$ shall select angles and dimension corresponding to $0,15^\circ$.

For all use of the integral flange design it is an imperative requirement that the external transition between the flange ring and the neck has a smooth curvature, with no rapid diametrical steps, notches or other imperfections. The radius 'RV1' tabulated in table A.9 to A.14 shall be adhered to. This is to prevent local high stress areas at the transition.

Some types of equipment and valves may use an internal nozzle at flange ends, e.g. a corrosion resistant nozzle at inlet of a Pressure Safety Valve. It is then recommended to design this inlet nozzle and the supporting body flange as a rigid construction with no flange angle ($\alpha_{B1} = 0^\circ$). The thickness of the inlet nozzle and the supporting body flange shall then be minimum $2,5 \times HW3$. The nozzle flange shall have the same external diameter, $DW3$, as the mating WN flange, or an external forged ring shall provide full closure at the external flange diameter in order to protect bolting from environmental moist etc.

Dimensions and angles in A.4 and Annex H might not cover equipment body designs with special flange configuration, e.g. funnel-shaped flange neck design differing considerably from a cylindrical design as specified in this standard. It is the equipment supplier's responsibility to verify that their design is in accordance with the general requirements described in this NORSOK standard.

Standard bore diameter within a pressure class may be used if accepted by the purchaser. The standard bore should be selected within the given bore range for the actual size and pressure class. Smaller bore diameters may be accepted if the flange face angle is adjusted according to the actual flange warping stiffness. The flange functionality will not be affected by a bore diameter step at the mating faces between an integral flange and another flange component to this NORSOK standard. However, other functional requirements such as effect on flow patterns, and pigging requirements may limit the step change at the mating faces.

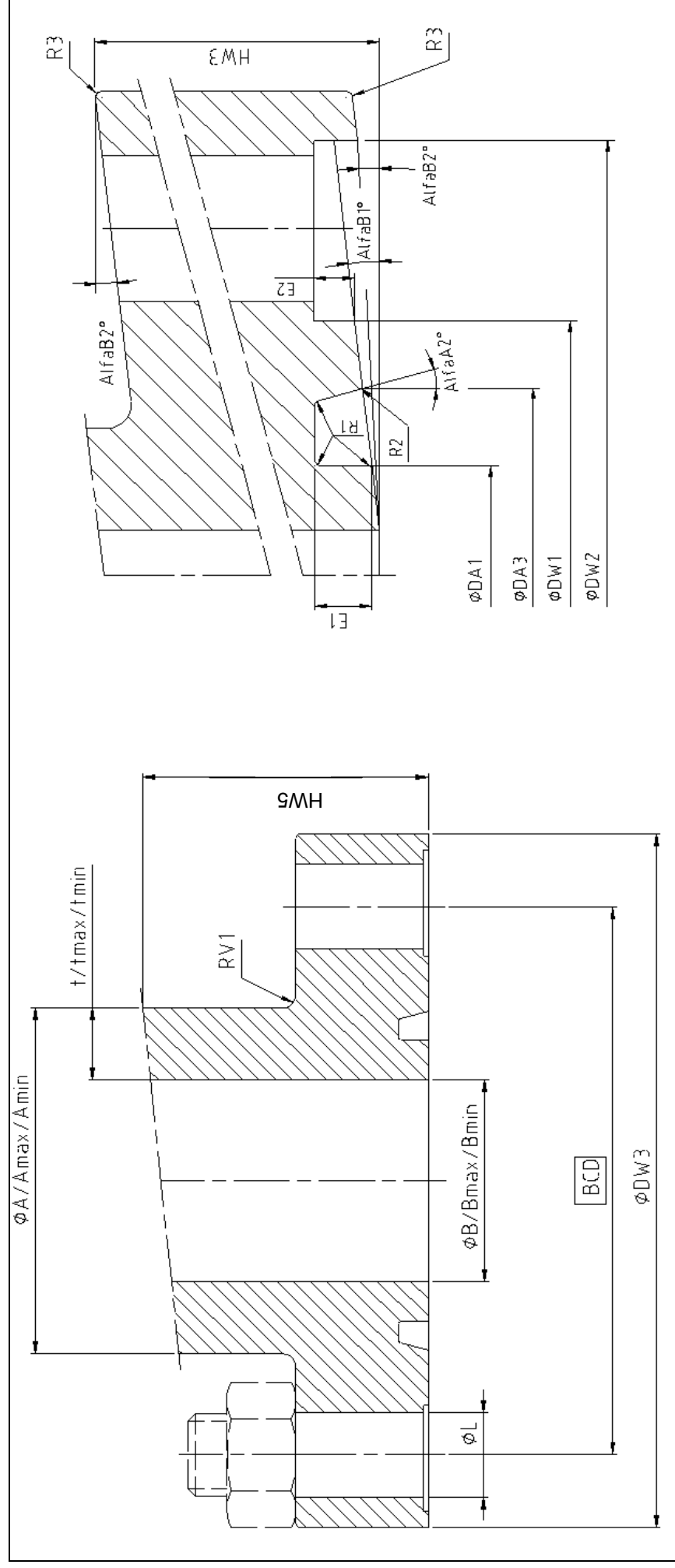


Table A.9 – Dimensions for CL 150 integral flanges

CL 150									
NPS	DN	t _{min} /t _{max} mm	A _{min} A _{max} mm	B _{max} B _{min} mm	DA3 mm	αA2 °	αB1 °	αB2 °	Rv1 mm
½	15	2.11	21.3	17.1	30.88	15.2	0.30	0.20	3.0
½	15	5.15	22.0	11.7	30.87	15.2	0.24	0.16	3.0
¾	20	2.11	26.7	22.5	35.88	15.2	0.32	0.21	3.0
¾	20	7.70	31.0	15.6	35.86	15.2	0.22	0.15	3.0
1	25	2.77	33.4	27.9	42.88	15.2	0.34	0.23	3.0
1	25	9.15	39.0	20.7	42.85	15.1	0.21	0.14	3.0
1½	40	2.77	48.3	42.8	58.88	15.3	0.42	0.28	3.0
1½	40	6.95	52.0	38.1	58.86	15.2	0.30	0.20	3.0
2	50	2.77	60.3	54.8	71.88	15.3	0.45	0.30	3.0
2	50	8.90	67.0	49.2	71.84	15.2	0.25	0.17	3.0
2½	65	3.05	73.0	66.9	85.86	15.3	0.40	0.27	4.0
2½	65	8.65	80.0	62.7	85.83	15.2	0.23	0.15	4.0
3	80	3.05	88.9	82.8	101.96	15.6	0.90	0.60	4.0
3	80	8.05	94.0	77.9	101.90	15.4	0.58	0.39	4.0
4	100	3.05	114.3	108.2	129.90	15.4	0.59	0.39	4.0
4	100	9.85	122.0	102.3	129.84	15.2	0.35	0.23	4.0
5	125	3.40	141.3	134.5	157.90	15.5	0.75	0.50	4.0
5	125	10.40	149.0	128.2	157.82	15.3	0.46	0.31	4.0
6	150	3.40	168.3	161.5	187.86	15.4	0.61	0.41	4.0
6	150	11.95	178.0	154.1	187.77	15.2	0.35	0.23	4.0
8	200	3.76	219.1	211.6	239.89	15.6	0.90	0.60	4.0
8	200	12.80	232.0	206.4	239.74	15.3	0.38	0.25	4.0
10	250	4.19	273.1	264.7	299.88	15.6	0.82	0.55	6.0
10	250	16.30	293.0	260.4	299.69	15.2	0.30	0.20	6.0
12	300	4.57	323.9	314.8	348.91	15.6	0.91	0.60	6.0
12	300	14.40	340.0	311.2	348.70	15.3	0.40	0.27	6.0
14	350	4.78	355.6	346.0	381.86	15.5	0.78	0.52	6.0
14	350	17.60	375.0	339.8	381.64	15.2	0.28	0.19	6.0
16	400	4.78	406.4	396.8	435.99	15.7	1.07	0.71	6.0
16	400	19.70	430.0	390.6	435.65	15.2	0.37	0.24	6.0
18	450	4.78	457.2	447.6	487.92	15.6	0.91	0.60	6.0
18	450	18.30	478.0	441.4	487.64	15.3	0.38	0.25	6.0
20	500	5.54	508.0	496.9	540.93	15.6	0.93	0.62	6.0
20	500	21.55	532.0	488.9	540.59	15.2	0.34	0.22	6.0
22	550	5.54	558.8	547.7	592.95	15.6	0.95	0.63	6.0
22	550	23.15	586.0	539.7	592.56	15.2	0.33	0.22	6.0
24	600	6.35	609.6	596.9	644.02	15.7	1.03	0.69	6.0
24	600	25.25	641.0	590.5	643.57	15.3	0.37	0.25	6.0
26	650	7.92	660.4	644.6	696.85	15.6	0.84	0.56	6.0
26	650	26.85	695.0	641.3	696.46	15.2	0.31	0.21	6.0
28	700	7.92	711.2	695.4	748.89	15.6	0.89	0.59	6.0
28	700	28.45	749.0	692.1	748.44	15.2	0.31	0.21	6.0
30	750	7.92	762.0	746.2	801.92	15.6	0.92	0.61	6.0
30	750	33.70	804.0	736.6	801.37	15.2	0.27	0.18	6.0
32	800	7.92	812.8	797.0	852.95	15.6	0.95	0.63	6.0
32	800	34.30	856.0	787.4	852.36	15.2	0.28	0.19	6.0
34	850	7.92	863.6	847.8	903.98	15.7	1.00	0.66	6.0
34	850	35.40	909.0	838.2	903.34	15.2	0.29	0.19	6.0
36	900	7.92	914.4	898.6	958.01	15.7	1.00	0.67	6.0
36	900	33.00	955.0	889.0	957.38	15.2	0.36	0.24	6.0
38	950	9.53	965.2	946.1	1009.02	15.7	1.01	0.67	6.0
38	950	35.10	1010.0	939.8	1008.35	15.2	0.36	0.24	6.0
40	1000	9.53	1016.0	996.9	1062.06	15.7	1.03	0.69	6.0
40	1000	38.20	1067.0	990.6	1061.30	15.2	0.33	0.22	6.0
42	1050	9.53	1066.8	1047.7	1113.11	15.7	1.09	0.72	6.0
42	1050	36.30	1114.0	1041.4	1112.33	15.3	0.38	0.25	6.0
44	1100	9.53	1117.6	1098.5	1164.03	15.7	1.01	0.67	8.0
44	1100	36.90	1166.0	1092.2	1163.28	15.2	0.36	0.24	8.0
46	1150	9.53	1168.4	1149.3	1217.08	15.7	1.05	0.70	8.0
46	1150	37.50	1218.0	1143.0	1216.27	15.3	0.37	0.25	8.0
48	1200	9.53	1219.2	1200.1	1268.10	15.7	1.06	0.71	8.0
48	1200	38.60	1271.0	1193.8	1267.26	15.3	0.37	0.25	8.0

Table A.10 – Dimensions for CL 300 integral flanges

CL 300									
NPS	DN	t _{min} /t _{max}	A _{min} A _{max}	B _{max} B _{min}	DA3	αA2	αB1	αB2	Rv1
		mm	mm	mm	mm	°	°	°	mm
½	15	2.11	21.3	17.1	30.88	15.2	0.30	0.20	3.0
½	15	5.15	22.0	11.7	30.87	15.2	0.24	0.16	3.0
¾	20	2.11	26.7	22.5	35.88	15.2	0.32	0.21	3.0
¾	20	7.70	31.0	15.6	35.86	15.2	0.22	0.15	3.0
1	25	2.77	33.4	27.9	42.88	15.2	0.34	0.23	3.0
1	25	9.15	39.0	20.7	42.85	15.1	0.21	0.14	3.0
1½	40	2.77	48.3	42.8	58.88	15.3	0.42	0.28	3.0
1½	40	6.95	52.0	38.1	58.86	15.2	0.30	0.20	3.0
2	50	2.77	60.3	54.8	71.88	15.3	0.45	0.30	3.0
2	50	8.90	67.0	49.2	71.84	15.2	0.25	0.17	3.0
2½	65	3.05	73.0	66.9	85.86	15.3	0.40	0.27	4.0
2½	65	8.65	80.0	62.7	85.83	15.2	0.23	0.15	4.0
3	80	3.05	88.9	82.8	101.96	15.6	0.90	0.60	4.0
3	80	8.05	94.0	77.9	101.90	15.4	0.58	0.39	4.0
4	100	3.05	114.3	108.2	129.90	15.4	0.59	0.39	4.0
4	100	9.85	122.0	102.3	129.84	15.2	0.35	0.23	4.0
5	125	3.40	141.3	134.5	157.90	15.5	0.75	0.50	4.0
5	125	10.40	149.0	128.2	157.82	15.3	0.46	0.31	4.0
6	150	3.40	168.3	161.5	187.86	15.4	0.61	0.41	4.0
6	150	11.95	178.0	154.1	187.77	15.2	0.35	0.23	4.0
8	200	3.76	219.1	211.6	239.88	15.4	0.64	0.42	4.0
8	200	14.65	232.0	202.7	239.77	15.2	0.36	0.24	4.0
10	250	4.19	273.1	264.7	299.96	15.5	0.78	0.52	6.0
10	250	15.70	286.0	254.6	299.80	15.3	0.45	0.30	6.0
12	300	4.57	323.9	314.8	348.89	15.4	0.64	0.43	6.0
12	300	18.35	340.0	303.3	348.72	15.2	0.34	0.23	6.0
14	350	4.78	355.6	346.0	381.92	15.5	0.70	0.47	6.0
14	350	20.85	375.0	333.3	381.71	15.2	0.34	0.22	6.0
16	400	4.78	406.4	396.8	436.01	15.5	0.79	0.53	6.0
16	400	24.50	430.0	381.0	435.72	15.3	0.37	0.25	6.0
18	450	6.35	457.2	444.5	488.01	15.5	0.79	0.52	6.0
18	450	24.65	478.0	428.7	487.72	15.3	0.40	0.26	6.0
20	500	6.35	508.0	495.3	541.04	15.5	0.80	0.54	6.0
20	500	24.10	526.0	477.8	540.76	15.3	0.46	0.30	6.0
22	550	9.53	558.8	539.7	593.04	15.5	0.79	0.53	6.0
22	550	32.85	580.0	514.3	592.65	15.2	0.35	0.23	6.0
24	600	9.53	609.6	590.5	644.14	15.6	0.88	0.58	6.0
24	600	29.70	634.0	574.6	643.76	15.3	0.47	0.31	6.0
26	650	7.92	660.4	644.6	697.16	15.6	0.93	0.62	6.0
26	650	29.80	688.0	628.4	696.73	15.3	0.50	0.34	6.0
28	700	7.92	711.2	695.4	749.07	15.6	0.84	0.56	6.0
28	700	31.80	743.0	679.4	748.66	15.3	0.44	0.30	6.0
30	750	7.92	762.0	746.2	802.24	15.6	0.96	0.64	6.0
30	750	37.00	801.0	727.0	801.67	15.3	0.46	0.31	6.0
32	800	9.53	812.8	793.7	853.14	15.6	0.86	0.57	6.0
32	800	38.10	854.0	777.8	852.61	15.3	0.42	0.28	6.0
34	850	9.53	863.6	844.5	904.32	15.7	0.98	0.66	6.0
34	850	41.70	907.0	823.6	903.66	15.3	0.46	0.31	6.0
36	900	9.53	914.4	895.3	958.23	15.6	0.91	0.60	6.0
36	900	44.50	959.0	870.0	957.57	15.3	0.41	0.27	6.0
38	950	12.70	965.2	939.8	1009.26	15.6	0.92	0.61	6.0
38	950	44.40	1014.0	925.2	1008.60	15.3	0.44	0.29	6.0
40	1000	12.70	1016.0	990.6	1062.28	15.6	0.91	0.61	6.0
40	1000	49.70	1071.0	971.6	1061.53	15.3	0.40	0.26	6.0
42	1050	12.70	1066.8	1041.4	1113.40	15.7	0.97	0.65	6.0
42	1050	46.80	1116.0	1022.4	1112.65	15.3	0.49	0.32	6.0
44	1100	12.70	1117.6	1092.2	1164.50	15.7	1.04	0.69	8.0
44	1100	50.20	1168.0	1067.6	1163.63	15.3	0.48	0.32	8.0
46	1150	12.70	1168.4	1143.0	1217.51	15.7	1.02	0.68	8.0
46	1150	49.80	1218.0	1118.4	1216.67	15.3	0.51	0.34	8.0
48	1200	12.70	1219.2	1193.8	1268.45	15.7	0.98	0.65	8.0
48	1200	50.90	1271.0	1169.2	1267.61	15.3	0.48	0.32	8.0

Table A.11 – Dimensions for CL 600 integral flanges

CL 600									
NPS	DN	t _{min} /t _{max} mm	A _{min} A _{max} mm	B _{max} B _{min} mm	DA3 mm	αA2 °	αB1 °	αB2 °	Rv1 mm
½	15	2.77	21.3	15.8	30.85	15.1	0.15	0.10	3.0
½	15	7.65	27.0	11.7	30.85	15.1	0.15	0.10	3.0
¾	20	2.87	26.7	21.0	35.85	15.1	0.15	0.10	3.0
¾	20	8.70	33.0	15.6	35.85	15.1	0.15	0.10	3.0
1	25	2.77	33.4	27.9	42.85	15.1	0.14	0.10	3.0
1	25	10.15	41.0	20.7	42.84	15.1	0.15	0.10	3.0
1½	40	2.77	48.3	42.8	58.88	15.2	0.29	0.19	3.0
1½	40	12.00	58.0	34.0	58.86	15.1	0.19	0.13	3.0
2	50	2.77	60.3	54.8	71.89	15.2	0.33	0.22	3.0
2	50	15.10	73.0	42.8	71.84	15.1	0.17	0.11	3.0
2½	65	3.05	73.0	66.9	85.91	15.3	0.41	0.27	4.0
2½	65	14.00	87.0	59.0	85.86	15.2	0.26	0.17	4.0
3	80	3.05	88.9	82.8	101.93	15.4	0.53	0.35	4.0
3	80	12.15	98.0	73.7	101.87	15.2	0.34	0.22	4.0
4	100	3.05	114.3	108.2	129.96	15.4	0.57	0.38	4.0
4	100	15.90	129.0	97.2	129.87	15.2	0.33	0.22	4.0
5	125	3.40	141.3	134.5	157.87	15.3	0.46	0.31	4.0
5	125	16.90	156.0	122.2	157.79	15.2	0.27	0.18	4.0
6	150	7.11	168.3	154.1	187.84	15.3	0.44	0.29	4.0
6	150	18.80	184.0	146.4	187.76	15.2	0.25	0.16	4.0
8	200	6.35	219.1	206.4	239.91	15.4	0.58	0.39	4.0
8	200	21.65	237.0	193.7	239.77	15.2	0.29	0.20	4.0
10	250	6.35	273.1	260.4	299.94	15.4	0.59	0.40	6.0
10	250	25.05	293.0	242.9	299.77	15.2	0.31	0.21	6.0
12	300	8.38	323.9	307.1	349.01	15.5	0.67	0.45	6.0
12	300	28.55	346.0	288.9	348.78	15.2	0.35	0.23	6.0
14	350	7.92	355.6	339.8	382.06	15.5	0.73	0.49	6.0
14	350	29.75	377.0	317.5	381.79	15.3	0.37	0.25	6.0
16	400	9.53	406.4	387.3	436.09	15.5	0.72	0.48	6.0
16	400	33.75	431.0	363.5	435.79	15.3	0.37	0.25	6.0
18	450	9.53	457.2	438.1	488.19	15.5	0.81	0.54	6.0
18	450	38.75	487.0	409.5	487.79	15.3	0.39	0.26	6.0
20	500	12.70	508.0	482.6	541.20	15.5	0.81	0.54	6.0
20	500	41.20	538.0	455.6	540.79	15.3	0.39	0.26	6.0
22	550	12.70	558.8	533.4	593.17	15.5	0.75	0.50	8.0
22	550	45.20	592.0	501.6	592.74	15.2	0.35	0.23	8.0
24	600	12.70	609.6	584.2	644.23	15.5	0.79	0.53	8.0
24	600	49.65	647.0	547.7	643.72	15.2	0.35	0.23	8.0
26	650	14.20	660.4	632.0	697.24	15.6	0.83	0.55	8.0
26	650	46.30	697.0	604.4	696.73	15.3	0.41	0.27	8.0
28	700	15.88	711.2	679.4	749.39	15.6	0.92	0.61	8.0
28	700	44.90	745.0	655.2	748.85	15.3	0.51	0.34	8.0
30	750	15.88	762.0	730.2	802.45	15.6	0.95	0.63	8.0
30	750	48.50	799.0	702.0	801.83	15.3	0.50	0.33	8.0
32	800	17.48	812.8	777.8	853.41	15.6	0.89	0.59	8.0
32	800	48.60	850.0	752.8	852.85	15.3	0.50	0.34	8.0
34	850	17.48	863.6	828.6	904.56	15.6	0.96	0.64	9.0
34	850	51.70	903.0	799.6	903.90	15.4	0.53	0.36	9.0
36	900	19.05	914.4	876.3	958.35	15.5	0.78	0.52	9.0
36	900	57.30	957.0	842.4	957.75	15.3	0.43	0.28	9.0
38	950	20.00	965.2	925.2	1009.57	15.6	0.92	0.61	9.0
38	950	57.40	1008.0	893.2	1008.86	15.3	0.51	0.34	9.0
40	1000	20.00	1016.0	976.0	1062.68	15.7	0.97	0.65	9.0
40	1000	63.00	1062.0	936.0	1061.82	15.3	0.49	0.33	9.0
42	1050	22.20	1066.8	1022.4	1113.54	15.6	0.85	0.56	9.0
42	1050	59.60	1106.0	986.8	1112.87	15.3	0.50	0.33	9.0
44	1100	22.20	1117.6	1073.2	1164.68	15.6	0.92	0.61	10.0
44	1100	66.20	1160.0	1027.6	1163.85	15.3	0.50	0.33	10.0
46	1150	22.20	1168.4	1124.0	1217.92	15.7	1.03	0.69	10.0
46	1150	71.30	1221.0	1078.4	1216.88	15.4	0.52	0.35	10.0
48	1200	25.00	1219.2	1169.2	1268.61	15.6	0.83	0.55	10.0
48	1200	71.90	1273.0	1129.2	1267.80	15.3	0.46	0.31	10.0

Table A.12 – Dimensions for CL 900 integral flanges

CL 900									
NPS	DN	t _{min} /t _{max}	A _{min} A _{max}	B _{max} B _{min}	DA3	αA2	αB1	αB2	Rv1
		mm	mm	mm	mm	°	°	°	mm
½	15	2.77	21.3	15.8	30.85	15.1	0.15	0.10	3.0
½	15	7.65	27.0	11.7	30.85	15.1	0.15	0.10	3.0
¾	20	2.87	26.7	21.0	35.85	15.1	0.15	0.10	3.0
¾	20	8.70	33.0	15.6	35.85	15.1	0.15	0.10	3.0
1	25	3.38	33.4	26.6	42.85	15.1	0.15	0.10	3.0
1	25	10.15	41.0	20.7	42.84	15.1	0.15	0.10	3.0
1½	40	2.77	48.3	42.8	58.88	15.2	0.29	0.19	3.0
1½	40	12.00	58.0	34.0	58.86	15.1	0.19	0.13	3.0
2	50	2.77	60.3	54.8	71.89	15.2	0.33	0.22	3.0
2	50	15.10	73.0	42.8	71.84	15.1	0.17	0.11	3.0
2½	65	3.05	73.0	66.9	85.91	15.3	0.41	0.27	4.0
2½	65	16.55	87.0	53.9	85.85	15.2	0.22	0.15	4.0
3	80	3.05	88.9	82.8	101.93	15.4	0.53	0.35	4.0
3	80	15.70	98.0	66.6	101.85	15.2	0.26	0.17	4.0
4	100	3.05	114.3	108.2	129.96	15.4	0.57	0.38	4.0
4	100	18.50	129.0	92.0	129.86	15.2	0.29	0.19	4.0
5	125	6.55	141.3	128.2	157.86	15.3	0.43	0.28	4.0
5	125	20.05	156.0	115.9	157.78	15.2	0.23	0.15	4.0
6	150	7.11	168.3	154.1	187.87	15.3	0.45	0.30	4.0
6	150	24.60	189.0	139.8	187.76	15.1	0.21	0.14	4.0
8	200	6.35	219.1	206.4	239.97	15.4	0.59	0.39	6.0
8	200	29.20	241.0	182.6	239.78	15.2	0.27	0.18	6.0
10	250	7.80	273.1	257.5	299.99	15.4	0.59	0.39	6.0
10	250	31.40	293.0	230.2	299.78	15.2	0.30	0.20	6.0
12	300	8.38	323.9	307.1	349.03	15.4	0.62	0.41	7.0
12	300	36.45	346.0	273.1	348.77	15.2	0.29	0.20	7.0
14	350	9.53	355.6	336.5	382.06	15.4	0.65	0.43	7.0
14	350	41.00	382.0	300.0	381.76	15.2	0.29	0.19	7.0
16	400	12.70	406.4	381.0	436.11	15.4	0.66	0.44	7.0
16	400	48.25	441.0	344.5	435.74	15.2	0.28	0.19	7.0
18	450	11.13	457.2	434.9	488.20	15.5	0.73	0.49	7.0
18	450	48.25	495.0	398.5	487.78	15.2	0.33	0.22	7.0
20	500	12.70	508.0	482.6	541.28	15.5	0.77	0.51	8.0
20	500	51.05	545.0	442.9	540.81	15.2	0.37	0.24	8.0
22	550	22.23	558.8	514.3	593.26	15.5	0.73	0.48	8.0
22	550	54.55	598.0	488.9	592.83	15.3	0.39	0.26	8.0
24	600	14.27	609.6	581.1	644.44	15.6	0.84	0.56	10.0
24	600	60.60	653.0	531.8	643.83	15.3	0.38	0.25	10.0
26	650	14.20	660.4	632.0	697.46	15.6	0.86	0.57	10.0
26	650	58.80	706.0	588.4	696.85	15.3	0.43	0.29	10.0
28	700	22.20	711.2	666.8	749.16	15.4	0.59	0.39	10.0
28	700	63.90	759.0	631.2	748.73	15.2	0.33	0.22	10.0
30	750	17.50	762.0	727.0	802.29	15.4	0.66	0.44	11.0
30	750	68.00	808.0	672.0	801.75	15.2	0.35	0.23	11.0
32	800	25.00	812.8	762.8	853.31	15.4	0.66	0.44	11.0
32	800	70.60	864.0	722.8	852.78	15.2	0.37	0.24	11.0
34	850	25.00	863.6	813.6	904.73	15.6	0.90	0.60	12.0
34	850	75.70	915.0	763.6	903.92	15.3	0.46	0.31	12.0
36	900	22.20	914.4	870.0	958.48	15.5	0.71	0.47	12.0
36	900	77.30	969.0	814.4	957.83	15.3	0.39	0.26	12.0
38	950	30.00	965.2	905.2	1009.85	15.6	0.92	0.61	13.0
38	950	83.90	1023.0	855.2	1008.95	15.3	0.47	0.32	13.0
40	1000	30.00	1016.0	956.0	1062.61	15.5	0.75	0.50	14.0
40	1000	85.50	1077.0	906.0	1061.86	15.3	0.41	0.28	14.0
42	1050	25.00	1066.8	1016.8	1113.96	15.6	0.92	0.61	14.0
42	1050	91.10	1129.0	946.8	1112.92	15.3	0.45	0.30	14.0
44	1100	32.00	1117.6	1053.6	1164.59	15.5	0.70	0.47	15.0
44	1100	92.70	1183.0	997.6	1163.82	15.3	0.39	0.26	15.0
46	1150	36.00	1168.4	1096.4	1217.70	15.5	0.73	0.49	15.0
46	1150	93.30	1225.0	1038.4	1216.92	15.3	0.43	0.28	15.0
48	1200	36.00	1219.2	1147.2	1269.16	15.6	0.93	0.62	16.0
48	1200	102.40	1294.0	1089.2	1268.03	15.3	0.49	0.32	16.0

Table A.13 – Dimensions for CL 1500 integral flanges

CL 1500									
NPS	DN	t _{min} /t _{max}	A _{min} A _{max}	B _{max} B _{min}	DA3	αA2	αB1	αB2	Rv1
		mm	mm	mm	mm	°	°	°	mm
½	15	2.77	21.3	15.8	30.85	15.1	0.15	0.10	3.0
½	15	10.30	27.0	6.4	30.84	15.1	0.15	0.10	3.0
¾	20	2.87	26.7	21.0	35.85	15.1	0.15	0.10	3.0
¾	20	10.95	33.0	11.1	35.84	15.1	0.15	0.10	3.0
1	25	3.38	33.4	26.6	42.85	15.1	0.15	0.10	3.0
1	25	12.90	41.0	15.2	42.84	15.1	0.15	0.10	3.0
1½	40	3.68	48.3	40.9	58.88	15.2	0.28	0.19	3.0
1½	40	15.00	58.0	28.0	58.85	15.1	0.15	0.10	3.0
2	50	3.91	60.3	52.5	71.88	15.2	0.32	0.21	3.0
2	50	17.40	73.0	38.2	71.84	15.1	0.15	0.10	3.0
2½	65	5.16	73.0	62.7	85.90	15.3	0.39	0.26	4.0
2½	65	21.00	87.0	45.0	85.84	15.1	0.16	0.11	4.0
3	80	5.49	88.9	77.9	101.95	15.3	0.49	0.33	4.0
3	80	23.30	105.0	58.4	101.85	15.1	0.21	0.14	4.0
4	100	6.02	114.3	102.3	129.97	15.3	0.51	0.34	4.0
4	100	27.45	135.0	80.1	129.85	15.2	0.22	0.15	4.0
5	125	9.53	141.3	122.2	157.94	15.3	0.52	0.34	4.0
5	125	26.90	157.0	103.2	157.82	15.2	0.28	0.19	4.0
6	150	10.97	168.3	146.4	187.95	15.3	0.50	0.33	5.0
6	150	33.30	191.0	124.4	187.81	15.2	0.25	0.17	5.0
8	200	12.70	219.1	193.7	239.96	15.3	0.49	0.32	6.0
8	200	40.45	250.0	169.1	239.78	15.2	0.23	0.15	6.0
10	250	12.70	273.1	247.7	300.04	15.4	0.53	0.35	7.0
10	250	49.55	315.0	215.9	299.79	15.2	0.24	0.16	7.0
12	300	14.27	323.9	295.4	349.08	15.4	0.57	0.38	8.0
12	300	56.35	370.0	257.3	348.77	15.2	0.24	0.16	8.0
14	350	19.05	355.6	317.5	382.14	15.4	0.61	0.40	9.0
14	350	59.40	403.0	284.2	381.80	15.2	0.27	0.18	9.0
16	400	21.44	406.4	363.5	436.09	15.3	0.51	0.34	10.0
16	400	66.80	459.0	325.4	435.77	15.2	0.24	0.16	10.0
18	450	23.83	457.2	409.5	488.30	15.4	0.67	0.44	11.0
18	450	74.15	515.0	366.7	487.81	15.2	0.29	0.20	11.0
20	500	26.19	508.0	455.6	541.27	15.4	0.60	0.40	12.0
20	500	82.00	572.0	408.0	540.79	15.2	0.27	0.18	12.0
22	550	34.93	558.8	488.9	593.18	15.3	0.50	0.33	13.0
22	550	91.60	634.0	450.8	592.76	15.2	0.24	0.16	13.0
24	600	30.96	609.6	547.7	644.48	15.5	0.68	0.45	14.0
24	600	98.75	688.0	490.5	643.81	15.2	0.29	0.19	14.0
26	650	32.00	660.4	596.4	697.14	15.3	0.46	0.31	14.0
26	650	102.30	745.0	540.4	696.68	15.2	0.23	0.15	14.0
28	700	36.00	711.2	639.2	749.22	15.3	0.49	0.33	15.0
28	700	106.90	805.0	591.2	748.71	15.2	0.25	0.16	15.0
30	750	36.00	762.0	690.0	802.49	15.4	0.62	0.41	16.0
30	750	116.00	864.0	632.0	801.76	15.2	0.28	0.19	16.0
32	800	40.00	812.8	732.8	853.28	15.3	0.50	0.33	16.0
32	800	107.10	887.0	672.8	852.76	15.2	0.28	0.18	16.0
34	850	40.00	863.6	783.6	904.35	15.3	0.51	0.34	17.0
34	850	108.20	930.0	713.6	903.80	15.2	0.30	0.20	17.0
36	900	45.00	914.4	824.4	958.49	15.4	0.57	0.38	18.0
36	900	118.80	992.0	754.4	957.84	15.2	0.32	0.21	18.0
38	950	50.00	965.2	865.2	1009.67	15.4	0.64	0.43	19.0
38	950	122.40	1050.0	805.2	1008.93	15.2	0.36	0.24	19.0
40	1000	50.00	1016.0	916.0	1062.47	15.4	0.52	0.35	20.0
40	1000	129.50	1105.0	846.0	1061.82	15.2	0.30	0.20	20.0
42	1050	50.00	1066.8	966.8	1113.66	15.4	0.58	0.39	20.0
42	1050	128.60	1144.0	886.8	1112.94	15.2	0.34	0.23	20.0
44	1100	55.00	1117.6	1007.6	1164.46	15.3	0.50	0.33	22.0
44	1100	144.20	1216.0	927.6	1163.76	15.2	0.28	0.19	22.0
46	1150	60.00	1168.4	1048.4	1217.68	15.4	0.57	0.38	24.0
46	1150	156.30	1261.0	948.4	1216.82	15.2	0.30	0.20	24.0
48	1200	60.00	1219.2	1099.2	1268.47	15.3	0.48	0.32	26.0
48	1200	159.90	1309.0	989.2	1267.73	15.2	0.27	0.18	26.0

Table A.14 – Dimensions for CL 2500 integral flanges

CL 2500									
NPS	DN	t _{min} /t _{max} mm	A _{min} A _{max} mm	B _{max} B _{min} mm	DA3 mm	αA2 °	αB1 °	αB2 °	Rv1 mm
½	15	2.77	21.3	15.8	30.85	15.1	0.15	0.10	3.0
½	15	10.30	27.0	6.4	30.84	15.1	0.15	0.10	3.0
¾	20	2.87	26.7	21.0	35.85	15.1	0.15	0.10	3.0
¾	20	10.95	33.0	11.1	35.84	15.1	0.15	0.10	3.0
1	25	3.38	33.4	26.6	42.85	15.1	0.15	0.10	3.0
1	25	12.90	41.0	15.2	42.84	15.1	0.15	0.10	3.0
1½	40	3.68	48.3	40.9	58.88	15.2	0.28	0.19	3.0
1½	40	17.35	58.0	23.3	58.84	15.1	0.15	0.10	3.0
2	50	3.91	60.3	52.5	71.90	15.2	0.34	0.23	3.0
2	50	20.55	73.0	31.9	71.85	15.1	0.16	0.10	3.0
2½	65	7.01	73.0	59.0	85.92	15.2	0.35	0.23	4.0
2½	65	24.50	90.0	41.0	85.85	15.1	0.17	0.11	4.0
3	80	5.49	88.9	77.9	101.96	15.3	0.44	0.29	4.0
3	80	25.05	104.0	53.9	101.87	15.1	0.22	0.14	4.0
4	100	8.56	114.3	97.2	129.94	15.2	0.37	0.24	5.0
4	100	31.55	133.0	69.9	129.85	15.1	0.18	0.12	5.0
5	125	15.88	141.3	109.5	157.91	15.3	0.39	0.26	6.0
5	125	35.85	163.0	91.3	157.81	15.2	0.22	0.15	6.0
6	150	10.97	168.3	146.4	187.96	15.3	0.45	0.30	7.0
6	150	43.85	196.0	108.3	187.79	15.1	0.20	0.13	7.0
8	200	15.09	219.1	188.9	240.01	15.3	0.47	0.31	8.0
8	200	52.95	253.0	147.1	239.80	15.1	0.21	0.14	8.0
10	250	15.09	273.1	242.9	300.11	15.4	0.52	0.35	11.0
10	250	67.95	319.0	183.1	299.80	15.1	0.22	0.14	11.0
12	300	17.48	323.9	288.9	349.23	15.4	0.60	0.40	13.0
12	300	81.05	376.0	213.9	348.80	15.2	0.22	0.15	13.0
14	350	19.05	355.6	317.5	382.26	15.4	0.59	0.40	15.0
14	350	83.20	412.0	245.6	381.81	15.2	0.24	0.16	15.0
16	400	21.44	406.4	363.5	436.44	15.4	0.66	0.44	18.0
16	400	98.30	473.0	276.4	435.85	15.2	0.26	0.17	18.0
18	450	23.88	457.2	409.4	488.32	15.4	0.56	0.37	20.0
18	450	108.90	535.0	317.2	487.77	15.1	0.21	0.14	20.0
20	500	26.19	508.0	455.6	541.43	15.4	0.61	0.41	22.0
20	500	117.00	582.0	348.0	540.79	15.2	0.23	0.15	22.0
22	550	53.98	558.8	450.8	593.41	15.4	0.56	0.37	24.0
22	550	122.10	633.0	388.8	592.88	15.2	0.28	0.18	24.0
24	600	52.37	609.6	504.9	644.53	15.4	0.59	0.40	26.0
24	600	136.20	692.0	419.6	643.86	15.2	0.27	0.18	26.0

A.5 Rigid interfaces

Rigid interfaces shall be made with seal grooves as specified in Annex B. The threaded bolt holes shall be made with minimum free hole depths and minimum thread engagement lengths as shown in Annex B. Flange bore shall not exceed the maximum bore listed for WN flanges. Diameters D_{i1} and D_{i2} shall be the same as diameters D_{W1} and D_{W2} respectively, and as given in Table A.1 to Table A.6 for WN flanges. The thickness of an RI flange shall be minimum $2,5 \times HW3$, see A.4, 4th paragraph. Rigid interfaces with zero angles $\alpha B1$ and $\alpha B2$ may also be used for wafer type valve designs.

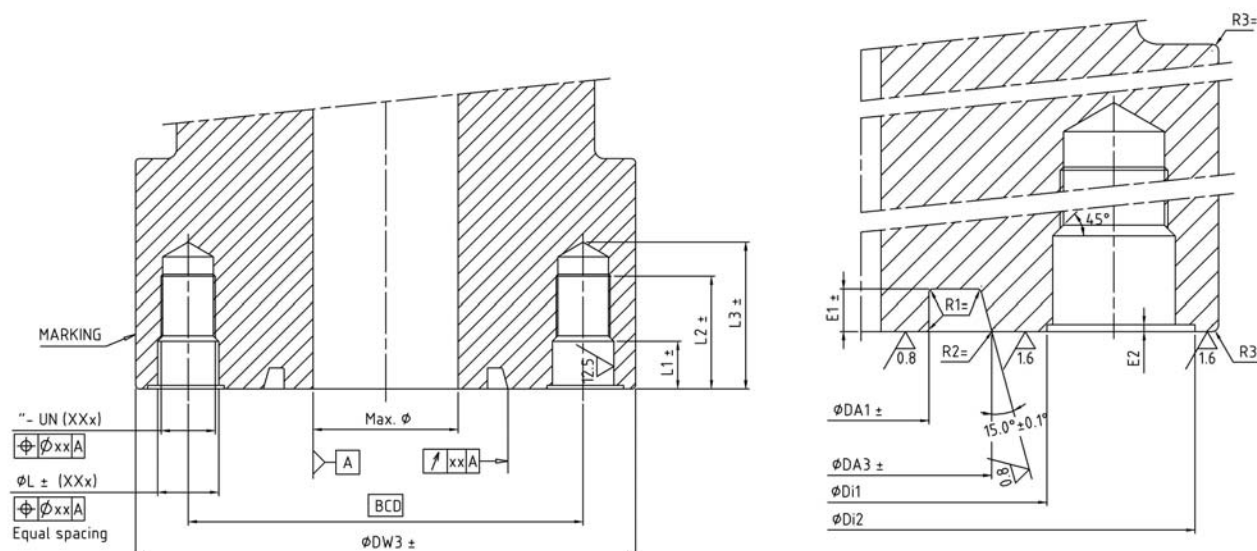


Figure A.4 – Nomenclatures for rigid interface flanges

Table A.15 – Bolt related flange data

Nominal bolt size	Free hole depth	Free hole plus thread engagement	Total depth	Bolt hole diameter	Recess
	$L1 \pm 1$	$L2 \pm 1$	$L3 \pm 1$	L	E2
in	mm	mm	mm	mm	mm
1/2	13	28	36	15.00	1.0
5/8	15	34	44	18.00	1.0
3/4	18	41	52	22.00	1.0
7/8	21	48	61	25.00	1.0
1	24	55	69	29.00	1.5
1 1/8	27	63	78	32.00	1.5
1 1/4	31	71	87	35.00	1.5
1 3/8	34	80	97	38.00	1.5
1 1/2	37	87	106 ± 2	42.00	1.5
1 5/8	41	95	116	45.00	1.5
1 3/4	44	105 ± 2	125	49.00	1.5
1 7/8	47	113	134	52.00	1.5
2	50	121	143	55.00	2.0
2 1/4	57	137	160	62.00	2.0
2 1/2	63	153	177	68.00	2.0
2 3/4	69	168	195	74.00	2.0
3	76	185	214	81.00	2.5
3 1/4	83	201	232	88.00	2.5
3 1/2	89	217	250	94.00	2.5
3 3/4	96	233	267	101.00	2.5
4	102	249	285	107.00	2.5

NOTE Thread engagement meets requirements in ASME VIII Div.2. AD-730.

A.6 Paddle spacer/paddle blank

PS flanges and PB flanges shall be made with seal grooves as specified in Annex B. Table A.16 lists the minimum thickness of PS flanges and PB flanges. All general flange dimensions shall be according to WN flanges and listed in Table A.1 to Table A.6. For PS flanges the bore shall not exceed the maximum bore listed for WN flanges. For PB flanges the diameter B1 of no sealing surface shall not exceed the minimum bore listed for WN flanges, see Table A.1 to Table A.6.

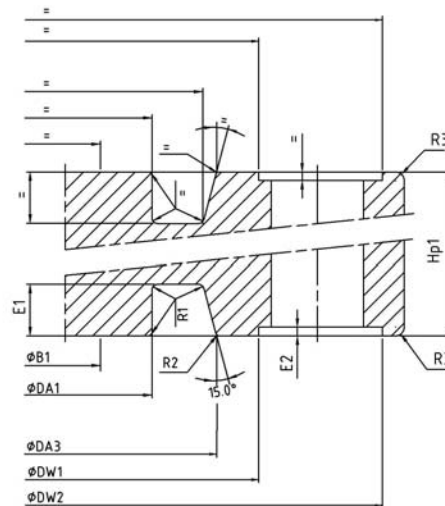
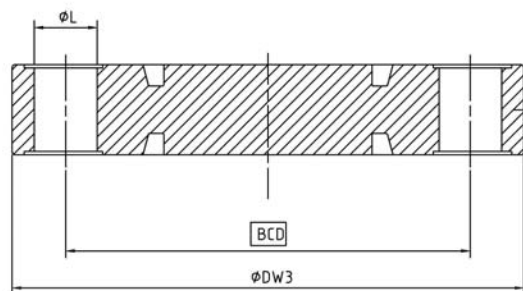


Figure A.5 – Nomenclatures for paddle blank (PB) flange

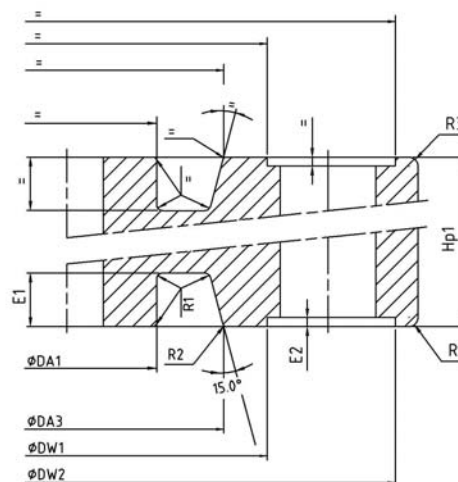
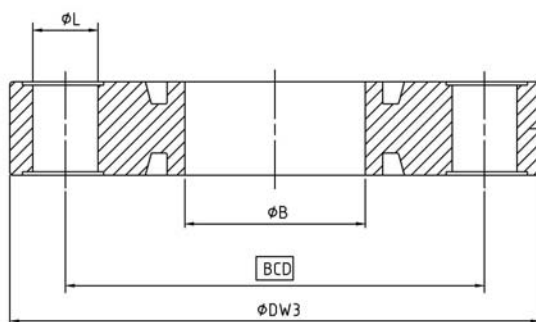


Figure A.6 – Nomenclatures for paddle spacer (PS) flange

Table A.16 – Flange thickness, HP1 (mm), for PS flanges and PB flanges

DN	NPS	CL 150	CL 300	CL 600	CL 900	CL 1500	CL 2500
15	½	17.0	17.0	17.0	17.0	17.0	17.0
20	¾	18.0	18.0	18.0	18.0	18.0	18.0
25	1	19.0	19.0	19.0	19.0	19.0	19.0
40	1½	22.0	22.0	22.0	22.0	22.0	22.0
50	2	23.0	23.0	23.0	23.0	23.0	25.0
65	2½	23.0	23.0	26.0	26.0	26.0	29.0
80	3	24.0	24.0	26.0	26.0	29.0	33.0
100	4	25.0	25.0	31.0	31.0	35.0	39.0
125	5	29.0	29.0	35.0	35.0	40.0	45.0
150	6	32.0	32.0	37.0	40.0	45.0	52.0
200	8	33.0	38.0	44.0	48.0	54.0	63.0
250	10	38.0	44.0	51.0	56.0	65.0	76.0
300	12	42.0	49.0	57.0	64.0	73.0	86.0
350	14	44.0	52.0	61.0	68.0	79.0	92.0
400	16	48.0	57.0	68.0	75.0	87.0	103.0
450	18	52.0	62.0	74.0	82.0	96.0	113.0
500	20	56.0	67.0	80.0	89.0	104.0	126.0
550	22	59.0	72.0	85.0	96.0	112.0	137.0
600	24	63.0	76.0	91.0	102.0	120.0	149.0
650	26	66.0	81.0	97.0	109.0	129.0	
700	28	70.0	85.0	102.0	116.0	137.0	
750	30	73.0	90.0	108.0	123.0	145.0	
800	32	76.0	94.0	113.0	129.0	153.0	
850	34	79.0	98.0	119.0	135.0	162.0	
900	36	82.0	102.0	125.0	142.0	172.0	
950	38	85.0	107.0	131.0	148.0	181.0	
1000	40	88.0	111.0	136.0	155.0	190.0	
1050	42	91.0	115.0	141.0	161.0	199.0	
1100	44	95.0	119.0	147.0	167.0	208.0	
1150	46	98.0	124.0	152.0	173.0	217.0	
1200	48	100.0	128.0	157.0	179.0	226.0	

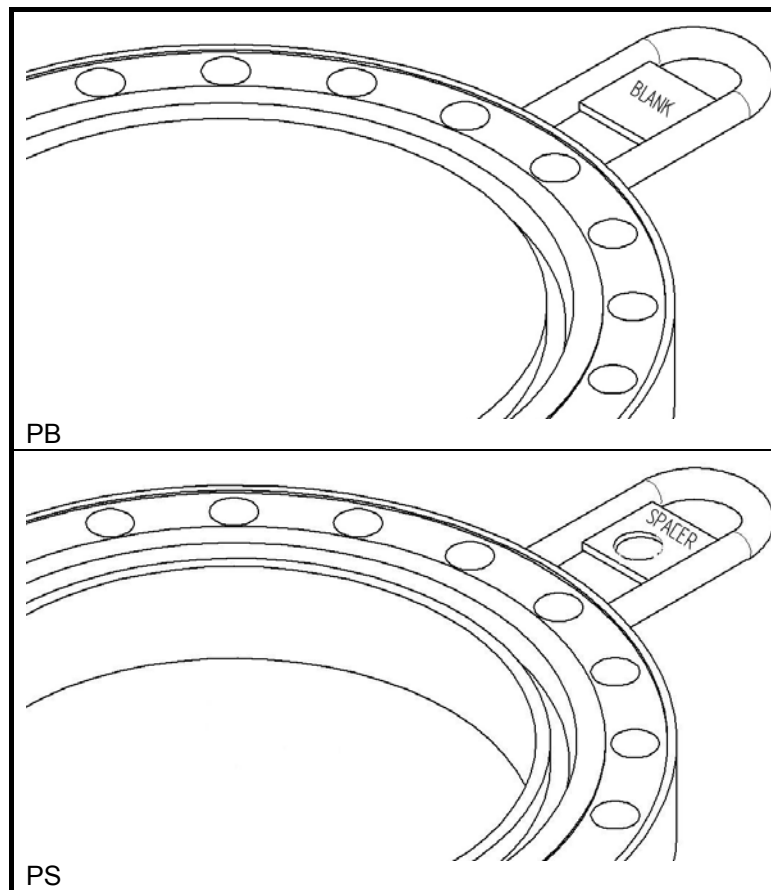


Figure A.7 – Handles and lifting lugs for paddle blanks (PBs) and paddle spacers (PSs)

Handle and lifting lugs

The handles for spades and spacers shall follow the design as shown in Figure A.7.

Handles shall be made of a rod with circular cross section and with a plate welded to the handle and die-stamped as appropriate with "BLANK" or "SPACER" on both sides with a minimum letter size of 10 mm. For small size flanges a suitable letter size shall be chosen.

The handles for PSs shall be provided with a $\varnothing 12$ mm hole as shown in Figure A.7. This hole serves as a remote visual indicator.

CAUTION: PB handles shall not be supplied with any holes for any purpose to avoid misinterpretation.

The welds of the handles to the flange shall be capable of carrying the weight of the paddle flange. The handle shall also tolerate lifting the paddle flange from the floor in horizontal position to vertical position without being bent. Welding shall meet the visual inspection requirements of the appropriate piping design code.

A.7 Orifice spacers

Table A.17 – Thickness, HP1 (mm), for orifice spacers (OS)

DN	NPS	CL 150	CL 300	CL 600	CL 900	CL 1500	CL 2500
50	2	40	40	40	40	40	40
65	2½	40	40	40	40	40	40
80	3	40	40	40	40	40	40
100	4	40	40	40	40	40	40
150	6	50	50	50	50	50	50
200	8	50	50	50	50	50	50
250	10	50	50	50	50	50	50
300	12	60	60	60	60	60	60
350	14	60	60	60	60	60	60
400	16	60	60	60	60	60	60
450	18	70	70	70	70	70	70
500	20	70	70	70	70	70	70
550	22	70	70	70	70	70	70
600	24	70	70	70	70	70	70

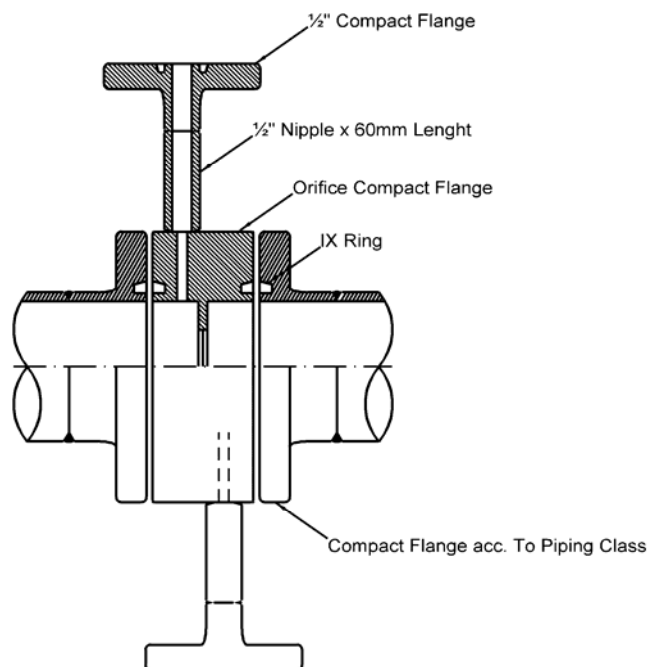


Figure A.8 – Orifice spacer design

Orifice spacers shall be according to requirements in ISO 5167-1 and ISO 5167-2.

Orifice spacers shall be made with seal grooves as specified in Annex B. Table A.17 lists the minimum thickness of orifice spacers. All general flange dimensions shall be according to WN flanges and listed in Tables A.1 to A.6. The bore diameter of an OS shall be the same as for WN flanges connected to it.

Thickness of orifice plate to be 6 mm for DN 500 to DN 600, 4 mm for DN 150 to DN 450, and 3 mm below DN 150.

Recommended hole diameter for tapping to be 6 mm for OS of DN 400 (NPS 16) and above, 4 mm for DN 150 (NPS 6) to DN 350 (NPS 14), and 3 mm below DN 150. The location of the tapping holes shall be in the middle between two bolt holes, and as close to the internal orifice plate as possible (one on each side of the plate).

A.8 Reducing threaded flanges

Dimensions specific to the reducing threaded flanges are given in this clause and are defined in Figure A.9. All other dimensions are found in Table A.1 to Table A.6 for the WN flanges. The threaded flanges shall have a taper pipe thread of size DN 15 (NPS ½), conforming to ASME B1.20.1, and have a bore, B, at the opposite end of 10 mm for DN 20 or 17,5 mm for all other nominal sizes, unless otherwise specified.

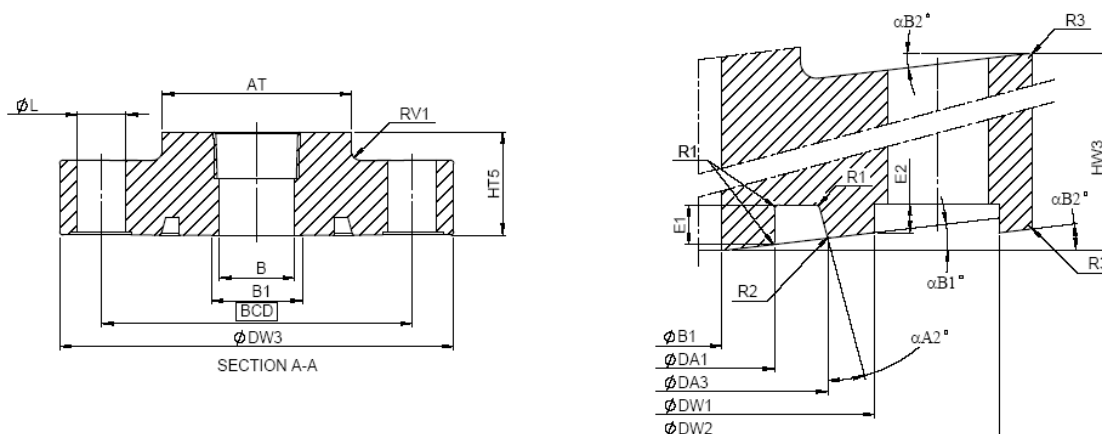


Figure A.9 – Nomenclatures for RTs

Note: B₁ is the diameter where the flange face angle αB1 starts.
The bore diameter B at the flange face shall be less than or equal to B₁.

Table A.18 – Dimensions for CL 150 and CL 300 reducing threaded flanges

DN	NPS	AT mm	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	HT5 mm	RV1 mm
20	¾	31.0	15.6	35.87	15.2	0.27	0.18	20.0	3.0
25	1	39.0	20.7	42.87	15.2	0.27	0.18	20.0	3.0
40	1½	52.0	38.1	58.85	15.2	0.28	0.18	22.0	3.0
50	2	67.0	49.2	71.84	15.2	0.27	0.18	22.0	3.0

Table A.19 – Dimensions for CL 600, CL 900 and CL 1500 reducing threaded flanges

DN	NPS	AT mm	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	HT5 mm	RV1 mm
20	¾	31.0	15.6	35.85	15.1	0.15	0.10	25.0	3.0
25	1	39.0	20.7	42.85	15.1	0.15	0.10	25.0	3.0
40	1½	52.0	34.0	58.86	15.1	0.20	0.13	30.0	3.0
50	2	67.0	42.8	71.85	15.1	0.22	0.14	30.0	3.0

Table A.20 – Dimensions for CL2500 reducing threaded flanges

DN	NPS	AT mm	B ₁ mm	DA3 mm	αA2 °	αB1 °	αB2 °	HT5 mm	RV1 mm
20	¾	31.0	11.1	35.85	15.1	0.15	0.10	25.0	3.0
25	1	39.0	15.2	42.85	15.1	0.15	0.10	25.0	3.0
40	1½	52.0	23.3	58.86	15.1	0.20	0.13	30.0	3.0
50	2	67.0	31.9	71.87	15.2	0.24	0.16	35.0	3.0

A.9 Flange tolerances

Table A.21 – Flange dimensional tolerances

Dimension	Flange type	Size range	Tolerance mm
Outside diameter at weld end (A)	WN	$\leq$ DN 100 $>$ DN 100 $\leq$ DN 350 $>$ DN 350 $\leq$ DN 600 $>$ DN 600	$-0+0.6$ $-0+1.0$ $-0+1.6$ $-0+2.4$
Bore diameter (B)	WN, IF, PS, OS, RT	$\leq$ DN 100 $>$ DN 100 $\leq$ DN 350 $>$ DN 350 $\leq$ DN 600 $>$ DN 600	$-0.6+0$ $-1.0+0$ $-1.6+0$ $-2.4+0$
Outside diameter of flange (DW3)	WN, BL, IF, PB, PS, OS	$\leq$ 150 mm OD $>$ 150 mm $\leq$ 620 mm OD $>$ 620 mm OD	± 0.5 ± 0.8 ± 1.2
Overall length of flange (HW5 and HT5)	WN, RT	$<$ 120 mm length $\geq$ 120 mm $\leq$ 400 mm length $>$ 400 mm length	± 0.8 ± 1.2 ± 2.0
Flange thickness HW3 (HP1)	WN, BL, IF, PS, PB, OS, RT	$\leq$ 30 mm thickness $>$ 30 mm $\leq$ 60 mm thickness $>$ 60 mm $\leq$ 120 mm thickness $>$ 120 mm thickness	± 0.5 ± 0.8 ± 1.2 ± 2.0
Groove OD run out	ALL	$\leq$ DN 125 $>$ DN 125 $\leq$ DN 600 $>$ DN 600	$-0+0.10$ $-0+0.15$ $-0+0.20$
ID of groove (DA1)	ALL	$\leq$ DN 125 $>$ DN 125 $\leq$ DN 600 $>$ DN 600	± 0.2 ± 0.3 ± 0.5
OD of groove (DA3)	ALL	$\leq$ DN 80 $>$ DN 80 $\leq$ DN 550 $>$ DN 550	± 0.05 ± 0.1 ± 0.15
Groove angle (α A2)	ALL	$\leq$ DN 500 $>$ DN 500	$\pm 0.1^\circ$ $\pm 0.15^\circ$
Face angle (α B1)	WN, IF, BL, RT	all sizes	$\pm 7.5\%$
Effective face angle (α B2)	WN, IF, BL, RT	all sizes	$\pm 7.5\%$
Rear face angle (α B2)	WN, IF, BL	all sizes	$\pm 15\%$
Flange face planarity	RI, OS	all sizes	$\pm 7.5\%$ of gap at DW3 for blind flange in same size and pressure class
IX seal groove depth (E1)	ALL	$\leq$ DN 250 $>$ DN 250 $\leq$ DN 450 $>$ DN 450 $\leq$ DN 650 $>$ DN 650 $\leq$ DN 850 $>$ DN 850 $\leq$ DN 1050 $>$ DN 1050	± 0.15 ± 0.20 ± 0.30 ± 0.40 ± 0.50 ± 0.60
Bolt hole diameter (L)	ALL	Bolt sizes to $\frac{3}{4}$ in Bolt sizes $\frac{7}{8}$ in to 2 $\frac{1}{2}$ in Bolt sizes 2 $\frac{3}{4}$ in to 4 in	± 0.3 ± 0.5 ± 0.8
Bolt hole position tolerance	ALL	Bolt size to $\frac{3}{4}$ in Bolt sizes $\frac{7}{8}$ in to 2 $\frac{1}{2}$ in Bolt sizes 2 $\frac{3}{4}$ in to 4 in	0.3 0.5 0.8
Bolt hole recess	ALL	The bolt hole recess as defined by DW1 and DW2 on drawings is allowed with a machining angle. However, the angle shall maintain the width of the outer rim, DW3 – DW2	

A.10 Flange weights

Table A.22 – Weights of CL 150 flanges

Nominal size		Neck wall thickness		Approximate weights (each)			
NPS	DN	Sch.	mm	Weld neck (WN) kg	Blind kg	Paddle blank (PB) kg	Paddle spacer (PS) kg
½	15	10S	2.11	0.7	0.7	0.8	0.8
½	15	160	4.78	0.7			0.8
¾	20	10S	2.11	0.7	0.8	0.9	0.9
¾	20	160	5.56	0.8			0.9
1	25	10S	2.77	0.9	0.9	1.1	1.1
1	25	160	6.35	1.0			1.1
1½	40	10S	2.77	1.1	1.2	1.8	1.5
1½	40	80	5.08	1.2			1.6
2	50	10S	2.77	1.3	1.4	2.2	1.8
2	50	80	5.54	1.4			1.9
2½	65	10S	3.05	1.6	1.9	2.7	2.1
2½	65	40	5.16	1.7			2.1
3	80	10S	3.05	1.9	2.5	3.4	2.3
3	80	40	5.49	2.1			2.5
4	100	10S	3.05	2.9	4.2	4.7	2.9
4	100	40	6.02	3.3			3.1
5	125	10S	3.40	3.8	6.2	7.1	3.9
5	125	40	6.55	4.4			4.1
6	150	10S	3.40	5.0	9.0	10	4.9
6	150	40	7.11	5.9			5.4
8	200	10S	3.76	6.1	13	16	6.7
8	200	20	6.35	6.8			7.1
10	250	10S	4.19	9.8	23	26	10
10	250	20	6.35	11			11
12	300	10S	4.57	12	33	38	13
12	300	20	6.35	13			13
14	350	10S	4.78	15	42	47	15
14	350	20	7.92	17			16
16	400	10S	4.78	23	62	69	23
16	400	20	7.92	25			24
18	450	10S	4.78	27	82	90	26
18	450	20	7.92	29			28
20	500	10S	5.54	34	107	118	32
20	500	20	9.53	38			35
22	550	10S	5.54	41	138	148	38
22	550	20	9.53	46			42
24	600	10	6.35	58	185	193	55
24	600	20	9.53	62			58
26	650	10	7.92	73	232	235	65
26	650	STD	9.53	76			67
28	700	10	7.92	85	283	286	76
28	700	STD	9.53	88			78
30	750	10	7.92	98	339	338	86
30	750	20	12.70	107			93
32	800	10	7.92	110	402	394	96
32	800	20	12.70	121			103
34	850	10	7.92	123	466	458	107
34	850	20	12.70	135			115
36	900	10	7.92	148	559	537	127
36	900	20	12.70	161			136
38	950	STD	9.53	172	649	616	146
38	950	XS	12.70	182			152
40	1000	STD	9.53	197	751	707	166
40	1000	XS	12.70	208			173
42	1050	STD	9.53	207	839	791	174
42	1050	ISO	16.00	230			181
44	1100	STD	9.53	227	953	900	192
44	1100	XS	12.70	240			200
46	1150	STD	9.53	245	1064	1007	207
46	1150	XS	12.70	259			216
48	1200	STD	9.53	268	1197	1112	222
48	1200	XS	12.70	282			232

Table A.23 – Weights of CL 300 flanges

Nominal size		Neck wall thickness		Approximate weights (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Sch.	mm	kg	kg	kg	kg
½	15	10S	2.11	0.7	0.7	0.8	0.8
½	15	160	4.78	0.7			0.8
¾	20	10S	2.11	0.7	0.8	0.9	0.9
¾	20	160	5.56	0.8			0.9
1	25	10S	2.77	0.9	0.9	1.1	1.1
1	25	160	6.35	1.0			1.1
1½	40	10S	2.77	1.1	1.2	1.8	1.5
1½	40	80	5.08	1.2			1.6
2	50	10S	2.77	1.3	1.4	2.2	1.8
2	50	80	5.54	1.4			1.9
2½	65	10S	3.05	1.6	1.9	2.7	2.1
2½	65	40	5.16	1.7			2.1
3	80	10S	3.05	1.9	2.5	3.4	2.3
3	80	40	5.49	2.1			2.5
4	100	10S	3.05	2.9	4.2	4.7	2.9
4	100	40	6.02	3.3			3.1
5	125	10S	3.40	3.8	6.2	7.1	3.9
5	125	40	6.55	4.4			4.1
6	150	10S	3.40	5.0	9.0	10	4.9
6	150	40	7.11	5.9			5.4
8	200	10S	3.76	9.7	19	20	9.3
8	200	40	8.18	11			10
10	250	10S	4.19	14	31	31	12
10	250	40	9.27	16			14
12	300	10S	4.57	19	47	47	17
12	300	40	10.31	23			20
14	350	10S	4.78	23	58	59	21
14	350	40	11.13	28			24
16	400	10S	4.78	36	90	86	31
16	400	40	12.70	43			35
18	450	10	6.35	43	117	112	37
18	450	40	14.27	53			42
20	500	10	6.35	59	159	152	50
20	500	40	15.09	71			57
22	550	20	9.53	75	202	193	63
22	550	60	22.23	95			75
24	600	20	9.53	96	264	244	80
24	600	40	17.48	111			88
26	650	10	7.92	109	322	299	91
26	650	ISO	16.00	126			101
28	700	10	7.92	128	392	360	106
28	700	30	15.88	147			117
30	750	10	7.92	163	492	446	136
30	750	ISO	17.50	189			151
32	800	STD	9.53	191	581	523	157
32	800	40	17.48	214			171
34	850	STD	9.53	228	697	618	186
34	850	ISO	20.00	262			207
36	900	STD	9.53	254	806	712	206
36	900	ISO	22.20	300			234
38	950	XS	12.70	296	928	824	240
38	950	ISO	20.00	324			258
40	1000	XS	12.70	339	1085	944	270
40	1000	ISO	22.20	380			296
42	1050	XS	12.70	388	1247	1081	311
42	1050	ISO	22.20	433			339
44	1100	XS	12.70	417	1391	1212	335
44	1100	ISO	25.00	480			374
46	1150	XS	12.70	480	1605	1385	385
46	1150	ISO	25.00	549			427
48	1200	XS	12.70	520	1781	1544	417
48	1200	ISO	25.00	594			463

Table A.24 – Weights of CL 600 flanges

Nominal size		Neck wall thickness		Approximate weights (each)			
NPS	DN	Sch.	mm	Weld neck (WN) kg	Blind kg	Paddle blank (PB) kg	Paddle spacer (PS) kg
½	15	40	2.77	0.9	0.9	0.8	0.8
½	15	160	4.78	1.0			0.8
¾	20	40	2.87	1.0	1.0	0.9	0.9
¾	20	160	5.56	1.1			0.9
1	25	10S	2.77	1.2	1.2	1.1	1.1
1	25	160	6.35	1.3			1.1
1 ½	40	10S	2.77	1.6	1.7	1.7	1.4
1 ½	40	160	7.14	1.9			1.5
2	50	10S	2.77	2.0	2.3	2.3	1.8
2	50	160	8.74	2.4			2.0
2 ½	65	10S	3.05	2.5	3.0	3.0	2.3
2 ½	65	80	7.01	2.9			2.4
3	80	10S	3.05	2.6	3.4	3.5	2.4
3	80	80	7.62	3.1			2.6
4	100	10S	3.05	4.9	6.9	6.8	4.5
4	100	80	8.56	5.9			5.0
5	125	10S	3.40	6.8	10	10	6.1
5	125	80	9.53	8.3			6.8
6	150	40	7.11	9.2	13	14	8.1
6	150	80	10.97	10			8.6
8	200	10S	3.76	12	23	23	11
8	200	80	12.70	16			13
10	250	20	6.35	23	43	41	19
10	250	100	18.26	31			23
12	300	30	8.38	37	69	64	31
12	300	80	17.48	44			35
14	350	20	7.92	41	84	79	35
14	350	80	19.05	52			41
16	400	30	9.53	60	123	113	50
16	400	80	21.44	73			57
18	450	STD	9.53	81	170	156	68
18	450	80	23.83	100			79
20	500	30	12.70	99	214	197	82
20	500	80	26.19	121			94
22	550	30	12.70	131	287	256	107
22	550	80	28.58	161			124
24	600	XS	12.70	153	353	317	125
24	600	80	30.96	194			149
26	650	ISO	14.20	174	419	383	143
26	650	ISO	28.00	210			164
28	700	30	15.88	218	520	468	177
28	700	ISO	28.00	253			197
30	750	30	15.88	248	617	559	202
30	750	ISO	30.00	295			229
32	800	40	17.48	301	748	664	241
32	800	ISO	30.00	348			268
34	850	40	17.48	356	894	792	287
34	850	ISO	32.00	417			322
36	900	40	19.05	422	1078	921	327
36	900	ISO	36.00	499			372
38	950	ISO	20.00	472	1112	1071	378
38	950	ISO	36.00	552			425
40	1000	ISO	20.00	519	1379	1215	414
40	1000	ISO	40.00	629			479
42	1050	ISO	22.20	626	1645	1394	483
42	1050	ISO	40.00	733			545
44	1100	ISO	22.20	672	1832	1571	524
44	1100	ISO	45.00	820			611
46	1150	ISO	22.20	778	2079	1803	617
46	1150	ISO	45.00	942			711
48	1200	ISO	25.00	904	2436	2008	682
48	1200	ISO	45.00	1058			771

Table A.25 – Weights of CL 900 flanges

Nominal size		Neck wall thickness		Approximate weights (each)			
				Weld neck (WN) kg	Blind kg	Paddle blank (PB) kg	Paddle spacer (PS) kg
NPS	DN	Sch.	mm				
½	15	40	2.77	0.92	0.91	0.8	0.8
½	15	160	4.78	0.96			0.8
¾	20	40	2.87	1.0	1.0	0.9	0.9
¾	20	160	5.56	1.1			0.9
1	25	40	3.38	1.2	1.2	1.1	1.1
1	25	160	6.35	1.3			1.1
1 ½	40	10S	2.77	1.6	1.7	1.7	1.4
1 ½	40	160	7.14	1.9			1.5
2	50	10S	2.77	2.0	2.3	2.3	1.8
2	50	160	8.74	2.4			2.0
2 ½	65	10S	3.05	2.5	3.0	3.0	2.3
2 ½	65	160	9.53	3.1			2.5
3	80	10S	3.05	2.6	3.4	3.5	2.4
3	80	160	11.13	3.5			2.8
4	100	10S	3.05	4.9	6.9	6.8	4.5
4	100	120	11.13	6.4			5.2
5	125	40	6.55	7.7	10.2	10	6.5
5	125	120	12.70	9.1			7.1
6	150	40	7.11	10.8	15.3	15	9.1
6	150	120	14.27	13.1			10
8	200	20	6.35	18.3	29.8	28	15
8	200	120	18.26	24.0			18
10	250	30	7.80	30.5	52.3	48	25
10	250	120	21.44	39.6			30
12	300	30	8.38	44.5	80.5	75	38
12	300	120	25.40	59.1			45
14	350	30	9.53	53.6	99.9	92	44
14	350	120	27.79	71.9			54
16	400	40	12.70	81.5	147	133	66
16	400	120	30.96	105			78
18	450	30	11.13	106	202	182	86
18	450	100	29.36	135			102
20	500	30	12.70	142	274	244	115
20	500	100	32.54	180			135
22	550	60	22.23	199	352	313	156
22	550	100	34.93	228			171
24	600	30	14.27	225	448	394	181
24	600	100	38.89	290			215
26	650	ISO	20.00	292	560	488	228
26	650	ISO	36.00	342			254
28	700	ISO	22.20	346	671	589	270
28	700	ISO	40.00	407			303
30	750	ISO	17.50	394	816	716	314
30	750	ISO	45.00	503			373
32	800	ISO	25.00	502	982	856	392
32	800	ISO	45.00	591			439
34	850	ISO	25.00	614	1208	1026	473
34	850	ISO	50.00	739			539
36	900	ISO	25.00	688	1391	1189	533
36	900	ISO	50.00	827			607
38	950	ISO	30.00	847	1653	1397	647
38	950	ISO	55.00	1001			728
40	1000	ISO	30.00	937	1874	1595	720
40	1000	ISO	55.00	1106			809
42	1050	ISO	32.00	1010	2067	1779	778
42	1050	ISO	60.00	1215			887
44	1100	ISO	32.00	1110	2318	2005	859
44	1100	ISO	60.00	1332			977
46	1150	ISO	36.00	1320	2690	2291	1006
46	1150	ISO	65.00	1571			1138
48	1200	ISO	36.00	1595	3215	2651	1196
48	1200	ISO	65.00	1873			1339

Table A.26 – Weights of CL 1500 flanges

Nominal size		Neck wall thickness		Approximate weights (each)			
				Weld neck (WN) kg	Blind kg	Paddle blank (PB) kg	Paddle spacer (PS) kg
NPS	DN	Sch.	mm				
½	15	40	2.77	0.92	0.91	0.8	0.8
½	15	XXS	7.47	0.99			0.8
¾	20	40	2.87	1.0	1.0	0.9	0.9
¾	20	XXS	7.82	1.1			0.9
1	25	40	3.38	1.2	1.2	1.1	1.1
1	25	XXS	9.09	1.4			1.1
1½	40	40	3.68	1.7	1.7	1.7	1.4
1½	40	XXS	10.15	2.0			1.6
2	50	40	3.91	2.1	2.3	2.3	1.9
2	50	XXS	11.07	2.6			2.1
2 ½	65	40	5.16	2.7	3.0	3.0	2.3
2 ½	65	XXS	14.02	3.5			2.7
3	80	40	5.49	4.4	5.1	4.9	3.8
3	80	XXS	15.24	5.6			4.3
4	100	40	6.02	8.2	9.8	9.2	7.0
4	100	XXS	17.12	10			7.8
5	125	80	9.53	13	15.6	14	11
5	125	XXS	19.05	16			12
6	150	80	10.97	21	25.2	23	17
6	150	XXS	21.95	25			18
8	200	80	12.70	33	43.3	39	26
8	200	ISO	25.00	39			29
10	250	60	12.70	61	84.1	72	47
10	250	160	28.58	73			53
12	300	60	14.27	81	117	102	63
12	300	160	33.32	100			73
14	350	80	19.05	109	152	134	85
14	350	160	35.71	129			95
16	400	80	21.44	158	228	187	116
16	400	160	40.49	187			130
18	450	80	23.83	210	302	260	160
18	450	160	45.24	251			180
20	500	80	26.19	291	423	347	214
20	500	160	50.01	347			240
22	550	100	34.93	407	573	449	284
22	550	160	53.98	459			309
24	600	80	30.96	485	706	578	356
24	600	160	59.54	578			400
26	650	ISO	32.00	623	949	708	424
26	650	ISO	60.00	729			475
28	700	ISO	36.00	732	1126	843	496
28	700	ISO	60.00	837			546
30	750	ISO	36.00	862	1330	1032	605
30	750	ISO	65.00	1007			674
32	800	ISO	40.00	930	1510	1138	630
32	800	ISO	70.00	1092			709
34	850	ISO	40.00	1103	1815	1367	752
34	850	ISO	75.00	1316			857
36	900	ISO	45.00	1422	2223	1717	994
36	900	ISO	80.00	1664			1111
38	950	ISO	50.00	1647	2526	2018	1180
38	950	ISO	80.00	1877			1292
40	1000	ISO	50.00	1812	2941	2227	1242
40	1000	ISO	85.00	2104			1386
42	1050	ISO	50.00	2159	3453	2666	1517
42	1050	ISO	90.00	2529			1699
44	1100	ISO	55.00	2350	3863	2912	1607
44	1100	ISO	95.00	2746			1805
46	1150	ISO	60.00	2708	4355	3353	1879
46	1150	ISO	110.00	3244			2147
48	1200	ISO	60.00	2997	5000	3717	2030
48	1200	ISO	115.00	3630			2350

Table A.27 – Weights of CL 2500 flanges

Nominal size		Neck wall thickness		Approximate weights (each)			
				Weld neck (WN) kg	Blind kg	Paddle blank (PB) kg	Paddle spacer (PS) kg
NPS	DN	Sch.	mm				
½	15	40	2.77	0.9	0.9	0.8	0.8
½	15	XXS	7.47	1.0			0.8
¾	20	40	2.87	1.0	1.0	0.9	0.9
¾	20	XXS	7.82	1.1			0.9
1	25	40	3.38	1.2	1.2	1.1	1.1
1	25	XXS	9.09	1.4			1.1
1½	40	40	3.68	1.7	1.7	1.7	1.4
1½	40	ISO	12.50	2.1			1.6
2	50	40	3.91	2.9	3.0	2.8	2.4
2	50	ISO	14.20	3.6			2.7
2 ½	65	80	7.01	5.3	5.4	4.9	4.3
2 ½	65	ISO	16.00	6.2			4.6
3	80	40	5.59	7.6	8.4	7.7	6.4
3	80	ISO	17.50	9.2			7.1
4	100	80	8.56	13	14	13	11
4	100	ISO	22.20	16			12
5	125	160	15.88	19	20	18	15
5	125	ISO	25.00	22			16
6	150	80	10.97	27	32	29	22
6	150	ISO	30.00	34			25
8	200	100	15.09	55	65	57	43
8	200	ISO	36.00	68			48
10	250	80	15.09	87	110	95	67
10	250	ISO	45.00	115			79
12	300	80	17.48	131	168	146	101
12	300	ISO	55.00	177			121
14	350	80	19.05	173	223	189	132
14	350	ISO	55.00	226			155
16	400	80	21.44	268	346	284	200
16	400	ISO	65.00	351			235
18	450	80	23.88	348	453	376	259
18	450	ISO	70.00	457			305
20	500	80	26.19	439	580	496	334
20	500	ISO	80.00	591			402
22	550	160	53.98	708	808	679	506
22	550	ISO	85.00	809			551
24	600	140	52.37	870	1027	869	634
24	600	ISO	95.00	1035			707

Annex B (Normative) Seals dimensions and weights

B.1 IX seal ring grooves

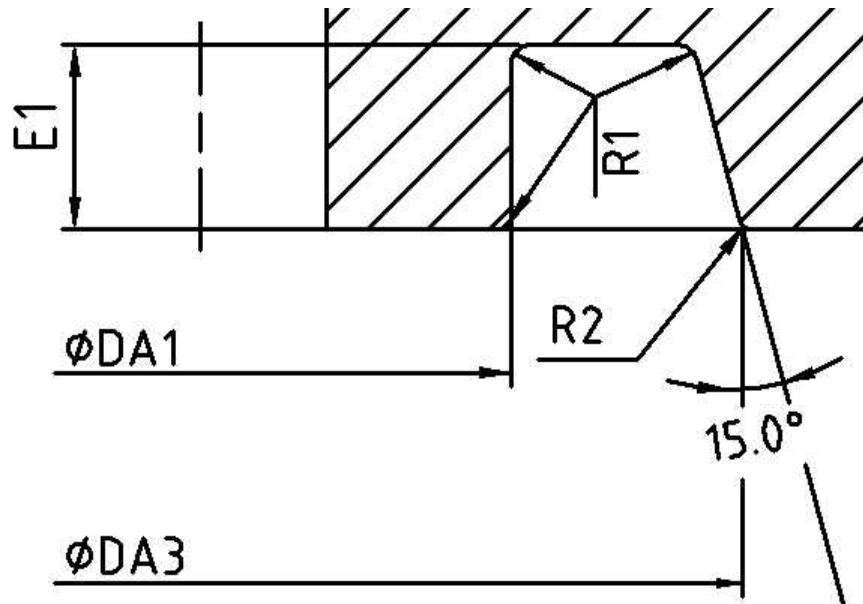


Figure B.1 – Nomenclature for IX seal grooves

The IX seal grooves are identical for all pressure classes and dimensions are hence given per DN in Annex A.

The outer diameter DA3 of the grooves and the groove angle $\alpha A2$ are only valid for the flat face flanges, i.e. RI, PS, PB and OS flanges. For flanges with face bevel angle (WN, BL, IF and RT), these dimensions vary with the face angle.

Table B.1 – Dimensions of IX seal ring grooves

DN	NPS	IX size	DA1 mm	DA3 mm	E1 mm	$\alpha A2$ °
15	½	IX15	20.8	30.83	5.30	15.0
20	¾	IX20	25.8	35.82	5.30	15.0
25	1	IX25	32.8	42.82	5.30	15.0
40	1½	IX40	47.8	58.81	5.58	15.0
50	2	IX50	59.8	71.80	6.19	15.0
65	2½	IX65	72.8	85.79	6.79	15.0
80	3	IX80	87.8	101.77	7.42	15.0
100	4	IX100	113.8	129.75	8.40	15.0
125	5	IX125	139.8	157.68	9.27	15.0
150	6	IX150	167.7	187.66	10.12	15.0
200	8	IX200	217.7	239.62	11.48	15.0
250	10	IX250	271.7	299.58	12.90	15.0
300	12	IX300	321.7	348.54	13.97	15.0
350	14	IX350	353.7	381.51	14.63	15.0
400	16	IX400	405.7	435.47	15.63	15.0
450	18	IX450	455.7	487.43	16.54	15.0
500	20	IX500	507.7	540.39	17.63	15.0
550	22	IX550	557.7	592.35	18.45	15.0
600	24	IX600	607.7	643.32	19.23	15.0
650	26	IX650	659.5	696.23	20.00	15.0
700	28	IX700	709.5	748.19	20.92	15.0
750	30	IX750	761.5	801.15	21.65	15.0
800	32	IX800	811.5	852.11	22.32	15.0
850	34	IX850	861.5	903.07	22.97	15.0
900	36	IX900	913.5	957.03	23.82	15.0
950	38	IX950	963.5	1007.99	24.44	15.0
1000	40	IX1000	1015.5	1060.95	25.06	15.0
1050	42	IX1050	1065.5	1111.91	25.65	15.0
1100	44	IX1100	1115.5	1162.87	26.42	15.0
1150	46	IX1150	1167.5	1215.83	27.00	15.0
1200	48	IX1200	1217.5	1266.79	27.54	15.0

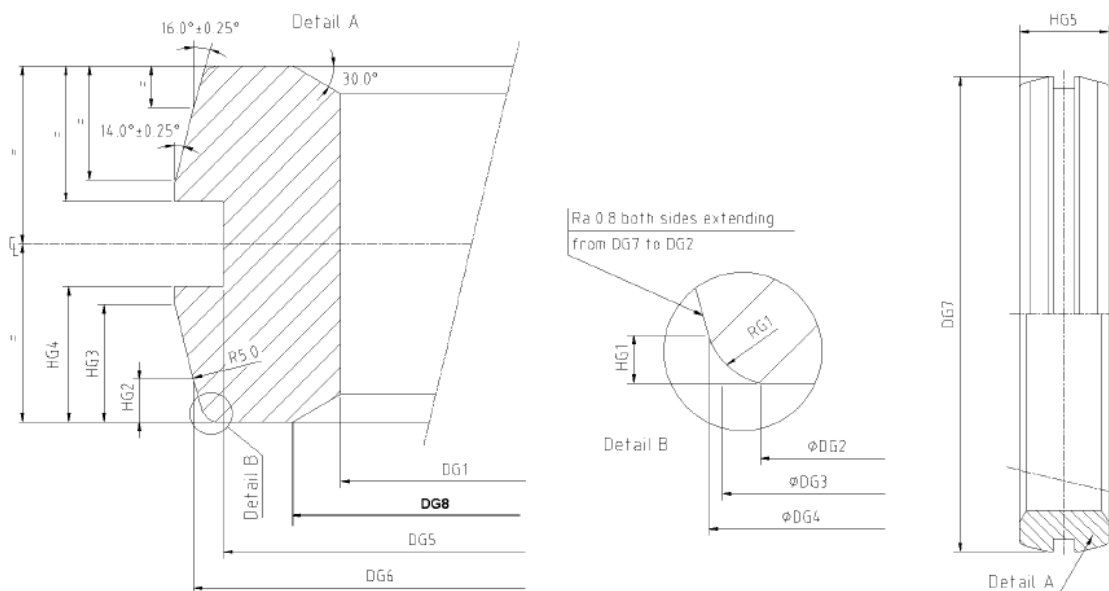
B.2 IX seal ring dimension**Figure B.2 – IX seal ring nomenclatures**

Table B.2 – Dimensions of IX seal rings and their weights

DN	NPS	IX size	DG1 mm	DG2 mm	DG3 mm	DG4 mm	DG5 mm	DG6 mm	DG7 mm	DG8 mm	HG1 mm	HG2 mm	HG3 mm	HG4 mm	HG5 mm	RG1 mm	Weight kg
15	½	IX15	22.2	27.91	28.46	28.66	27.47	29.14	30.19	24.7	0.35	1.20	3.30	3.8	10.00	0.5	0.02
20	¾	IX20	27.2	32.93	33.47	33.67	32.48	34.16	35.20	29.7	0.35	1.20	3.30	3.8	10.00	0.5	0.03
25	1	IX25	34.2	39.95	40.49	40.69	39.50	41.18	42.22	36.7	0.35	1.20	3.30	3.8	10.00	0.5	0.03
40	1½	IX40	49.3	55.84	56.38	56.58	55.34	57.11	58.21	51.9	0.35	1.27	3.48	4.0	10.56	0.5	0.05
50	2	IX50	61.3	68.43	69.08	69.32	67.92	69.89	71.13	64.4	0.42	1.41	3.89	4.5	11.78	0.6	0.08
65	2½	IX65	74.4	82.14	82.79	83.03	81.52	83.69	85.05	77.8	0.42	1.56	4.28	4.9	12.98	0.6	0.12
80	3	IX80	89.5	97.74	98.49	98.77	97.09	99.47	100.96	93.3	0.49	1.71	4.70	5.4	14.24	0.7	0.17
100	4	IX100	115.7	125.17	126.04	126.36	124.44	127.15	128.85	120.1	0.56	1.94	5.34	6.2	16.19	0.8	0.28
125	5	IX125	142.0	152.66	153.64	154.00	151.87	154.87	156.75	146.7	0.63	2.15	5.92	6.8	17.94	0.9	0.42
150	6	IX150	170.2	182.17	183.25	183.66	181.32	184.61	186.66	175.4	0.70	2.36	6.48	7.5	19.64	1.0	0.62
200	8	IX200	220.5	233.46	234.66	235.10	232.45	236.19	238.54	226.5	0.77	2.68	7.38	8.5	22.36	1.1	0.99
250	10	IX250	274.9	292.64	294.05	294.57	291.57	295.78	298.42	281.7	0.91	3.02	8.31	9.6	25.20	1.3	1.85
300	12	IX300	325.0	341.13	342.65	343.21	339.97	344.52	347.36	332.5	0.98	3.26	8.96	10.4	27.15	1.4	2.18
350	14	IX350	357.1	373.87	375.38	375.94	372.58	377.34	380.32	365.0	0.98	3.42	9.39	11.0	28.46	1.4	2.60
400	16	IX400	409.3	427.36	428.98	429.58	425.98	431.08	434.27	417.9	1.05	3.66	10.05	11.9	30.47	1.5	3.43
450	18	IX450	459.4	478.90	480.63	481.27	477.45	482.85	486.23	468.6	1.12	3.87	10.65	12.7	32.28	1.6	4.38
500	20	IX500	511.6	531.45	533.29	533.97	529.93	535.63	539.20	521.4	1.19	4.09	11.24	13.5	34.06	1.7	5.27
550	22	IX550	561.7	583.04	584.99	585.71	581.62	587.44	591.18	572.1	1.26	4.28	11.78	14.3	35.69	1.8	6.48
600	24	IX600	611.9	633.64	635.70	636.46	632.40	638.26	642.16	622.8	1.33	4.47	12.29	15.0	37.25	1.9	7.55
650	26	IX650	664.0	686.37	688.42	689.18	685.19	691.09	695.16	675.5	1.33	4.66	12.81	15.7	38.81	1.9	8.74
700	28	IX700	714.1	738.01	740.17	740.97	737.01	742.94	747.16	726.1	1.40	4.83	13.28	16.3	40.25	2.0	10.4
750	30	IX750	766.3	790.65	792.92	793.77	789.83	795.79	800.16	778.8	1.47	5.00	13.76	17.0	41.69	2.1	11.8
800	32	IX800	816.4	841.32	843.70	844.58	840.67	846.66	851.16	829.4	1.54	5.16	14.20	17.6	43.03	2.2	13.3
850	34	IX850	866.6	892.10	894.48	895.36	891.52	897.53	902.18	879.9	1.54	5.32	14.63	18.2	44.34	2.2	14.8
900	36	IX900	918.7	945.78	948.27	949.19	945.38	951.41	956.19	932.6	1.61	5.48	15.06	18.8	45.65	2.3	17.1
950	38	IX950	968.8	996.59	999.08	1000.00	996.26	1002.30	1 007.21	983.1	1.61	5.63	15.47	19.3	46.88	2.3	18.9
1000	40	IX1000	1021.0	1049.28	1051.88	1052.85	1049.13	1055.19	1 060.23	1035.7	1.68	5.77	15.88	19.9	48.12	2.4	20.9
1050	42	IX1050	1071.1	1100.00	1102.70	1103.71	1100.02	1106.10	1 111.26	1086.2	1.75	5.92	16.27	20.4	49.29	2.5	23.0
1100	44	IX1100	1121.3	1150.83	1153.53	1154.54	1150.92	1157.00	1 162.28	1136.8	1.75	6.05	16.64	21.0	50.43	2.5	25.1
1150	46	IX1150	1173.4	1203.55	1206.36	1207.40	1203.82	1209.91	1 215.31	1189.3	1.82	6.19	17.03	21.5	51.59	2.6	27.5
1200	48	IX1200	1223.6	1254.39	1257.20	1258.25	1254.73	1260.83	1 266.35	1239.8	1.82	6.32	17.39	22.0	52.68	2.6	29.9

Table B.3 – IX seal ring dimensional tolerances

Dimension	Size range	Tolerance mm
ID (DG1)	$\leq IX80$	± 0.2
	$> IX80 \leq IX350$	± 0.3
	$> IX350$	± 0.4
Diameter bottom recess (DG5)	$\leq IX80$	± 0.1
	$> IX80 \leq IX350$	± 0.2
	$> IX350$	± 0.4
Diameter, DG6	$\leq IX150$	$-0/+0.1$
	$> IX150$	$-0/+0.2$
OD of ring (DG7)	$\leq IX150$	$-0/+0.1$
	$> IX150$	$-0/+0.2$
Height, HG2	$\leq IX40$	± 0.05
	$> IX40 \leq IX200$	± 0.1
	$> IX200 \leq IX400$	± 0.2
	$> IX400 \leq IX600$	± 0.3
	$> IX600 \leq IX800$	± 0.4
	$> IX800 \leq IX1000$	± 0.5
	$> IX1000$	± 0.6
Height to end angle (HG3)	$\leq IX40$	± 0.05
	$> IX40 \leq IX200$	± 0.1
	$> IX200 \leq IX400$	± 0.2
	$> IX400 \leq IX600$	± 0.3
	$> IX600 \leq IX800$	± 0.4
	$> IX800 \leq IX1000$	± 0.5
	$> IX1000$	± 0.6
Height of ring (HG5)	$\leq IX150$	$-0.1/+0$
	$> IX150 \leq IX350$	$-0.2/+0$
	$> IX350 \leq IX550$	$-0.3/+0$
	$> IX550 \leq IX700$	$-0.4/+0$
	$> IX700 \leq IX900$	$-0.5/+0$
	$> IX900 \leq IX1100$	$-0.6/+0$
	$> IX1100$	$-0.7/+0$

B.3 IX seal ring shear force capacity

During installation, the IX seal shall not be subjected to shear loads greater than the capacity values listed below.

Table B.4 – Shear force capacity IX seal rings

DN	NPS	IX size	Installation shear capacity kN
15	½	IX15	9.9
20	¾	IX20	9.9
25	1	IX25	9.9
40	1½	IX40	11.8
50	2	IX50	14.4
65	2½	IX65	17.2
80	3	IX80	20.2
100	4	IX100	26.3
125	5	IX125	32.9
150	6	IX150	40.3
200	8	IX200	49.8
250	10	IX250	74.9
300	12	IX300	75.1
350	14	IX350	81.7
400	16	IX400	94.3
450	18	IX450	107.3
500	20	IX500	116.2
550	22	IX550	130.2
600	24	IX600	139.5
650	26	IX650	149.0
700	28	IX700	164.3
750	30	IX750	174.3
800	32	IX800	184.3
850	34	IX850	194.4
900	36	IX900	211.4
950	38	IX950	222.1
1000	40	IX1000	233.0
1050	42	IX1050	244.0
1100	44	IX1100	255.1
1150	46	IX1150	266.5
1200	48	IX1200	277.9

Annex C

(Normative)

Bolt dimensions and weights

Table C.1 – Length of stud bolts for CL 150

Bolting				Torque tool		Tension tool				Weight of stud bolts and nuts						
DN	Nom. size NPS	Number	Nominal diameter in	Length of stud bolts		LB mm	Length of stud bolts		LB mm	"Washer" (thickness)		"Washer" OD/ID mm	Torque tool		Tension tool	
				Standard mm	mm		Standard mm	mm		WN/BL mm	LB/WN mm		Standard bolt set kg	LB bolt set kg	Standard bolt set kg	LB bolt set kg
15	½	4	½	70	85	110	110	110	110	28	10	26 / 14	0.5	0.5	0.6	0.6
20	¾	4	½	70	85	110	110	110	110	28	9	26 / 14	0.5	0.5	0.6	0.6
25	1	4	½	70	90	110	110	110	110	28	8	26 / 14	0.5	0.6	0.6	0.6
40	1½	4	½	70	90	110	110	110	110	28	5	26 / 14	0.5	0.6	0.6	0.6
50	2	4	½	70	90	110	110	110	110	28	4	26 / 14	0.5	0.6	0.6	0.6
65	2½	4	½	70	95	110	110	110	110	26	4	26 / 14	0.5	0.6	0.6	0.6
80	3	8	½	75	100	110	110	110	110	22		26 / 14	1.0	1.2	1.3	1.3
100	4	8	½	85	110	110	110	120	120	14		26 / 14	1.1	1.3	1.3	1.3
125	5	12	½	90	120	110	110	130	130	7		26 / 14	1.7	2.0	1.9	2.1
150	6	12	½	95	125	105	105	140	140				1.7	2.1	1.8	2.2
200	8	12	½	90	125	110	110	135	135	5		26 / 14	1.7	2.1	1.9	2.2
250	10	16	½	105	140	115	115	155	155				2.5	3.0	2.6	3.2
300	12	20	½	110	150	120	120	165	165				3.2	3.9	3.3	4.2
350	14	20	½	115	160	125	125	170	170				3.3	4.1	3.4	4.2
400	16	20	¾	130	180	145	145	195	195				5.8	7.2	6.2	7.6
450	18	20	¾	140	190	155	155	205	205				6.1	7.5	6.5	7.9
500	20	24	¾	145	205	165	165	220	220				7.5	9.5	8.1	10.0
550	22	28	¾	155	215	170	170	230	230				9.1	11.4	9.7	12.0
600	24	24	¾	170	235	190	190	255	255				12.4	15.6	13.4	16.5
650	26	24	¾	180	250	200	200	265	265				12.9	16.3	13.9	17.0
700	28	28	¾	190	260	210	210	280	280				15.6	19.6	16.8	20.7
750	30	32	¾	200	270	215	215	290	290				18.5	23.0	19.5	24.3
800	32	36	¾	205	280	225	225	300	300				21.2	26.6	22.6	28.1
850	34	40	¾	210	290	230	230	310	310				24.0	30.4	25.6	32.0
900	36	32	¾	230	310	250	250	335	335				28.8	35.8	30.6	38.0
950	38	36	¾	240	325	260	260	345	345				33.4	41.8	35.4	43.8
1000	40	40	¾	245	335	270	270	355	355				37.7	47.5	40.4	49.7
1050	42	44	¾	250	345	275	275	365	365				42.0	53.5	45.0	55.9
1100	44	44	¾	260	355	280	280	375	375				43.2	54.7	45.6	57.1
1150	46	48	¾	265	365	290	290	385	385				47.8	61.0	51.1	63.6
1200	48	52	¾	275	375	295	295	395	395				53.2	67.5	56.1	70.3

Table C.2 – Length of stud bolts for CL 300

Bolting			Torque tool		Tension tool			Weight of stud bolts and nuts	
			Length of stud bolts		Length of stud bolts			Torque tool	
DN	Nom. size NPS	Number	Nominal diameter in	Standard mm	LB mm	Standard mm	LB mm	Standard bolt set kg	LB bolt set kg
15	1/2	4	1/2	70	85	110	110	0.5	0.5
20	3/4	4	1/2	70	85	110	110	0.5	0.5
25	1	4	1/2	70	90	110	110	0.5	0.6
40	1 1/2	4	1/2	70	90	110	110	0.5	0.6
50	2	4	1/2	70	90	110	110	0.5	0.6
65	2 1/2	4	1/2	70	95	110	110	0.5	0.6
80	3	8	1/2	75	100	110	110	1.0	1.2
100	4	8	1/2	85	110	110	120	1.1	1.3
125	5	12	1/2	90	120	110	130	1.7	2.0
150	6	12	1/2	95	125	105	140	1.7	2.1
200	8	12	5/8	115	155	135	170	3.2	3.6
250	10	20	5/8	130	175	145	190	5.8	7.1
300	12	20	5/8	140	190	155	205	6.1	7.5
350	14	24	5/8	145	200	165	215	7.5	9.3
400	16	24	3/4	170	225	190	245	12.4	15.1
450	18	28	3/4	180	240	200	260	15.1	18.5
500	20	24	7/8	200	265	220	290	19.6	23.9
550	22	28	7/8	210	280	230	305	23.7	29.0
600	24	28	1	230	310	260	335	33.9	41.9
650	26	32	1	240	325	270	350	39.8	49.6
700	28	32	1	250	335	280	365	41.0	50.7
750	30	32	1 1/8	275	365	300	390	57.1	70.1
800	32	32	1 1/8	285	375	310	405	58.5	71.6
850	34	32	1 1/4	300	400	335	430	76.5	94.4
900	36	32	1 1/4	310	415	345	445	78.3	97.1
950	38	36	1 1/4	320	430	355	460	90.1	112.3
1000	40	40	1 1/4	335	445	365	480	103.5	128.1
1050	42	36	1 5/8	350	465	385	500	118.6	146.6
1100	44	40	1 3/8	360	480	395	515	134.5	167.0
1150	46	36	1 1/2	380	505	420	540	153.0	189.3
1200	48	36	1 1/2	390	515	425	555	155.9	192.2

Table C.3 – Length of stud bolts for CL 600

Bolting				Torque tool		Tension tool				Weight of stud bolts and nuts					
DN	Nom. size NPS	Number	Nominal diameter in	Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"		Torque tool		Tension tool	
				Standard mm	LB mm	Standard mm	LB mm	WN/BL mm	LB/WN mm	OD/ID mm	Standard bolt set kg	LB bolt set kg	Standard bolt set kg	LB bolt set kg	
15	½	4	½	80	95	110	110	18	4	26 / 14	0.5	0.6	0.6	0.6	
20	¾	4	½	80	95	110	110	18	4	26 / 14	0.5	0.6	0.6	0.6	
25	1	4	½	80	100	110	110	18		26 / 14	0.5	0.6	0.6	0.6	
40	1½	8	½	85	105	110	120	12		26 / 14	1.1	1.2	1.3	1.3	
50	2	8	½	85	110	110	120	12		26 / 14	1.1	1.3	1.3	1.3	
65	2½	12	½	90	115	110	130	5		26 / 14	1.7	2.0	1.9	2.1	
80	3	12	½	90	115	110	125	7		26 / 14	1.7	2.0	1.9	2.1	
100	4	12	¾	110	140	135	155	10		31 / 17	3.1	3.6	3.6	3.9	
125	5	12	¾	115	150	135	170				3.2	3.8	3.6	4.1	
150	6	12	¾	120	155	135	170				3.3	3.9	3.6	4.1	
200	8	20	¾	135	175	150	195				5.9	7.1	6.4	7.6	
250	10	20	¾	160	210	180	230				10.0	12.0	10.8	12.8	
300	12	20	¾	180	240	205	260				15.3	18.6	16.6	19.7	
350	14	24	¾	190	250	210	275				19.0	22.9	20.3	24.6	
400	16	24	1	215	285	240	310				27.7	33.8	29.9	35.9	
450	18	24	1 ⅛	235	310	265	340				38.5	46.6	41.7	49.9	
500	20	28	1 ⅛	250	330	275	355				46.8	56.9	50.0	60.1	
550	22	24	1¼	270	355	305	390				53.4	64.8	58.1	69.5	
600	24	28	1¼	285	375	315	405				64.6	78.7	69.3	83.4	
650	26	32	1¼	295	390	325	420				75.7	92.7	81.0	98.0	
700	28	32	1½	315	415	350	450				97.9	119.5	105.4	127.1	
750	30	36	1½	325	435	360	470				112.5	139.3	121.1	147.9	
800	32	32	1½	350	460	385	500				128.3	156.6	137.3	167.0	
850	34	32	1½	370	485	410	530				159.0	193.8	171.1	207.4	
900	36	32	1¾	390	515	435	560				165.1	202.9	178.7	216.5	
950	38	32	1¾	400	535	445	580				207.5	257.4	224.1	272.3	
1000	40	36	1¾	415	550	460	595				239.6	295.9	258.4	314.6	
1050	42	32	1¾	445	585	490	63				259.3	318.8	278.4	344.3	
1100	44	36	1¾	455	600	500	650				296.4	365.8	318.0	389.7	
1150	46	36	2	470	620	520	670				353.5	435.1	380.7	462.4	
1200	48	36	2	500	655	550	705				369.8	454.2	397.1	481.9	

Table C.4 – Length of stud bolts for CL 900

Bolting			Torque tool		Tension tool			Weight of stud bolts and nuts	
			Length of stud bolts		Length of stud bolts			Torque tool	
DN	Nom. size NPS	Number	Nominal diameter in	Standard mm	LB mm	Standard mm	LB mm	Standard bolt set kg	LB bolt set kg
15	1/2	4	1/2	80	95	110	110	0.5	0.6
20	3/4	4	1/2	80	95	110	110	0.5	0.6
25	1	4	1/2	80	100	110	110	0.5	0.6
40	1 1/2	8	1/2	85	105	110	120	1.1	1.3
50	2	8	1/2	85	110	110	120	1.1	1.3
65	2 1/2	12	1/2	90	115	110	130	1.7	2.0
80	3	12	1/2	90	115	110	125	1.7	2.0
100	4	12	5/8	110	140	135	155	3.1	3.6
125	5	12	5/8	115	150	135	170	3.2	3.6
150	6	16	5/8	125	165	145	185	4.5	5.0
200	8	20	3/4	155	200	175	220	9.8	11.6
250	10	20	7/8	180	240	205	260	15.3	18.6
300	12	20	1	205	270	230	295	22.4	27.1
350	14	24	1	215	285	240	310	27.7	33.8
400	16	24	1 1/8	240	315	270	345	39.0	47.2
450	18	24	1 1/4	265	345	295	375	52.7	63.5
500	20	24	1 3/8	285	375	320	410	68.5	83.1
550	22	24	1 1/2	310	405	350	445	88.5	106.9
600	24	24	1 5/8	330	435	375	475	110.2	134.0
650	26	24	1 3/4	355	465	400	510	143.1	173.6
700	28	24	1 7/8	390	505	435	550	152.8	184.8
750	30	24	1 7/8	410	535	460	585	183.3	223.1
800	32	24	2	435	565	485	615	223.0	270.1
850	34	24	2 1/4	450	585	505	640	297.9	359.9
900	36	24	2 1/4	485	625	540	685	314.0	378.3
950	38	24	2 1/2	495	640	555	705	403.5	485.6
1000	40	24	2 1/2	525	680	590	745	420.5	508.3
1050	42	28	2 1/2	530	690	595	755	493.8	599.6
1100	44	28	2 1/2	570	735	630	800	520.3	629.4
1150	46	28	2 3/4	595	770	665	840	663.7	803.7
1200	48	28	3	605	785	685	860	818.0	989.4

Table C.5 – Length of stud bolts for CL 1500

Bolting			Torque tool		Tension tool			Weight of stud bolts and nuts	
			Length of stud bolts		Length of stud bolts			Torque tool	
DN	Nom. size NPS	Number	Nominal diameter in	Standard mm	LB mm	Standard mm	LB mm	Standard bolt set kg	LB bolt set kg
15	1/2	4	1/2	80	95	110	110	0.5	0.6
20	3/4	4	1/2	80	95	110	110	0.5	0.6
25	1	4	1/2	80	100	110	110	0.5	0.6
40	1 1/2	8	1/2	85	105	110	120	1.1	1.3
50	2	8	1/2	85	110	110	120	1.1	1.3
65	2 1/2	12	1/2	90	115	110	130	1.7	2.0
80	3	12	3/8	105	135	135	150	3.1	3.6
100	4	12	3/4	130	165	160	180	5.3	6.0
125	5	12	7/8	150	190	185	210	8.2	9.3
150	6	12	1	170	215	210	240	11.9	13.7
200	8	16	1	190	245	215	270	17.1	20.2
250	10	16	1 1/4	235	300	265	330	32.5	38.3
300	12	20	1 1/4	250	320	280	355	42.2	50.1
350	14	20	1 3/8	265	345	300	380	54.4	65.2
400	16	20	1 1/2	305	390	345	430	72.9	86.6
450	18	20	1 3/4	330	425	375	470	113.5	135.4
500	20	20	1 7/8	365	470	415	520	140.8	168.7
550	22	20	2	405	515	455	565	176.8	210.0
600	24	20	2 1/4	425	545	480	600	238.7	284.6
650	26	20	2 1/4	475	605	535	665	257.9	307.6
700	28	24	2 1/4	495	635	555	690	318.6	382.9
750	30	24	2 1/2	520	665	580	725	417.6	499.8
800	32	24	2 1/2	550	705	615	765	434.6	522.5
850	34	24	2 3/4	585	750	655	820	562.0	675.2
900	36	20	3 1/4	630	800	710	885	720.1	855.8
950	38	20	3 1/2	650	830	740	920	882.5	1050.1
1000	40	24	3 1/4	685	875	765	955	916.8	1098.8
1050	42	20	3 3/4	725	920	820	1020	1108.2	1317.6
1100	44	24	3 1/2	745	955	835	1045	1169.5	1405.3
1150	46	24	3 3/4	770	990	865	1085	1387.9	1671.4
1200	48	24	3 3/4	815	1040	910	1135	1445.9	1735.8

Table C.6 – Length of stud bolts for CL 2500

Bolting			Torque tool		Tension tool			Weight of stud bolts and nuts	
			Length of stud bolts		Length of stud bolts			Torque tool	
					"Washer"				
					(thickness)				
DN	Nom. size NPS	Number	Nominal diameter in	Standard mm	LB mm	Standard mm	LB mm	Standard bolt set kg	LB bolt set kg
15	1/2	4	1/2	80	95	110	110	0.5	0.6
20	3/4	4	1/2	80	95	110	110	0.5	0.6
25	1	4	1/2	80	100	110	110	0.5	0.6
40	1 1/2	8	1/2	85	105	110	120	1.1	1.3
50	2	8	5/8	100	125	135	140	2.0	2.4
65	2 1/2	8	3/4	120	145	160	165	3.3	4.0
80	3	8	7/8	135	165	185	190	5.1	6.2
100	4	8	1	160	195	210	225	7.7	9.1
125	5	12	1	170	215	210	240	11.9	13.7
150	6	12	1 1/8	195	245	235	275	17.1	19.2
200	8	12	1 3/8	235	295	280	330	30.2	35.1
250	10	16	1 1/2	270	350	310	385	53.8	64.1
300	12	16	1 3/4	305	390	355	435	86.1	101.9
350	14	16	1 7/8	330	425	380	470	105.2	125.4
400	16	16	2 1/4	385	485	450	545	178.7	209.3
450	18	16	2 1/4	405	520	465	575	184.9	220.1
500	20	16	2 1/2	440	565	505	630	248.2	295.4
550	22	16	3	500	635	590	710	410.3	483.8
600	24	16	3 1/4	535	685	640	770	515.4	611.2

The tables above give all dimensional data for the bolts to be used with NCF5. In the columns for washers when using tension tools, the minimum washer thicknesses to achieve sufficient length/diameter ratio are listed. This minimum washer thickness is included in the bolt lengths listed for tension tools. If greater washer thickness is used, the bolt lengths shall be increased accordingly

Annex D (Normative) Pressure temperature ratings

D.1 Flange structural capacity equations

The flange capacity can be calculated using the equations below. The strength terms in the warping moment limit load capacity is as follows: the first term is the flange ring capacity, second term is the support effect of the shear force from the pipe to the flange ring and the last term is the neck wall thickness warping resistance.

The reduction factors c_M and c_S take into account the reduction of the bending-carrying capacity and the shear force capacity of the neck cross section as a result of existing neck wall membrane stresses based on von Mises criterion by the factor δ_Q . The capacity equation is as given in a former revision of EN 1591-1, with a slight modification. The correction factor $d\delta_R$ accounting for axial tension force has been neglected and c_M has been simplified. Bolt interaction effects have been added. Comparison with elastic plastic finite element analysis has shown a good fit with the proposed simplified equations

The capacity method complies with the requirements of ASME VIII Div.2, Appendix 4 and Appendix 6.

Capacity

The axial load capacity of the flange can be calculated to be according to equation (D.1) for the flange only and equation (D.2) for flange and bolt interaction (bolt prying).

$$F_f = \frac{W_F}{e} \quad (D.1)$$

$$F_{fP} = \frac{W_F}{e_p} + F_{cB} \times \frac{e_B}{e_p} \quad (D.2)$$

The warping moment capacity of the flange including support from the neck is given by:

$$W_F = \frac{\pi}{4} \times f_y \times \left[2 \times b \times Hw3^2 + 2.2 \times c_S \times Hw3 \times t \times \sqrt{d_p \times t} + c_M \times d_p \times t^2 \right] \quad (D.3)$$

where

$$\delta_Q = \frac{p \times d_p}{2 \times f_y \times t} \quad (D.4)$$

$$c_M = \sqrt{1 - 0.75 \times \delta_Q^2} \quad (D.5)$$

$$c_S = \sqrt{c_M \times (0.5 - 0.4 \times \delta_Q)} \quad (D.6)$$

$$b = \frac{(Dw3 - B)}{2} - L \quad (D.7)$$

$$e_B = \left[\frac{(Dw3 + Dw2)}{2} - BCD \right] \times 0.5 \quad (D.8)$$

$$e_p = \left[\frac{(D_{w3} + D_{w2})}{2} - d_p \right] \times 0.5 \quad (D.9)$$

Loads

$$F_{End} = \frac{\pi \times DG4^2}{4} \times p \quad (D.10)$$

$$F_R = F_A + \frac{4}{BCD} \times M_A \quad (D.11)$$

Flange utilisation ratio

$$\psi = \frac{F_{End} + F_R}{\min(F_{cB}, F_{fp})} \quad (D.12)$$

where

A	=	pipe/neck outer diameter, see Annex A
B	=	bore diameter, see Annex A
BCD	=	bolt circle diameter, see Annex A
F_A	=	applied axial force
F_{cB}	=	bolt total plastic capacity (root area x number of bolts x yield strength)
F_f	=	flange axial load capacity without effect of bolt prying
F_{fp}	=	flange axial load capacity including the effect of bolt prying
F_{End}	=	end cap force calculated to seal ring seal diameter
F_R	=	resulting force from external tension force F_A and external bending moment M_A
H_{w3}	=	flange ring thickness, see Annex A
$DG4$	=	seal ring seal diameter, see Annex B
D_{w2}	=	flange outer recess diameter, see Annex A
D_{w3}	=	flange outer diameter, see Annex A
L	=	bolt hole diameter, see Annex A
M_A	=	applied bending moment
d_p	=	average diameter of pipe/neck = $(A+B)/2$
e	=	radial distance between BCD and d_p
e_B	=	radial distance from flange outer rim to bolt circle diameter
e_p	=	radial distance from flange outer rim to pipe mean diameter
f_v	=	flange material yield strength at temperature
t	=	pipe/neck wall thickness
p	=	internal pressure in N/mm^2
ψ	=	flange utilisation ratio

Allowable utilisation ratios

ψ	< 2/3	Design condition for sustained loads
ψ	< 0.9	Design condition for sustained loads + displacement load amplitude
ψ	< 0.8	Design condition for sustained loads + occasional loads such as wind load, wave and current loads with annual probability of $\leq 10^{-2}$
ψ	< 0.9	Hydrostatic pressure test
ψ	< 1.0	Accidental loads, annual probability of $\leq 10^{-4}$

Annex E (Informative) Materials

Some typical materials are listed in Table E.1 to Table E2.

Table E.1 – List of typical flange material specifications

Material group	Material group in NORSOK M-630	EN steel no.	Material specification (ASTM)		
			Forgings	Castings	Plates
CS 235	Carbon steel Type 235		A105	A216 Grade WCB	A516 Grade 60, 70
CS 235LT	Carbon steel Type 235LT impact tested		A350 Grade LF2	A352 Grade LCC	A516 Grade 70
CS 360LT	Carbon steel Type 360LT impact tested	1.0570 1.0571	A694 Grade F52	A352 Grade LCC	A516 Grade 70
SS 316	Stainless steel Type 316	1.4404	A182 Grade F316	A351 Grade CF8M or CF3M	A240 Grade 316
SS 22Cr	Stainless steel Type 22Cr Duplex	1.4462	A182 Grade F51 (UNS S31803) or F60 (UNS S32205)	A995 UNS Grade 4 (J92205)	A240 UNS S31803 UNS S32205
SS 25Cr	Stainless steel Type 25Cr Duplex	1.4507 1.4410 1.4501	A182 F61 (UNS S32550) F53 (UNS S32750) F55 (UNS S32760)	A995 A5 (UNS J93404) A6 (UNS J93380)	A240 UNS S32550 UNS S32750 UNS S32760
SS 6Mo	Stainless steel Type 6Mo	1.4547	A182 Grade F44 UNS N08367 UNS N08926	A351 CK-3MCuN CN-3MN	A240 UNS S31254 UNS N08367 UNS N08926
SS Super-Austenite	Superaustenitic stainless steel. Not covered by NORSOK M-630	1.4565	A182 Grade F49	UNS S34565 UNS J95370	A240 UNS S34565
Alloy 625	Nickel base alloys	2.4856	B564 N06625	A494 Grade CW-6MC	B443 UNS N06625

The material groups contain materials of similar chemical/mechanical properties and corrosion resistance in order to facilitate an equivalent application of materials in a group depending on pressure, temperature and fluid.

Table E.2 – List of typical IX seal ring material specifications

Material group	Material group in NORSOK M-630	EN steel no.	Material specification		
			Forgings	Seamless pipe	Welded pipe
CS 360LT	Carbon steel Type 360LT impact tested	1.0570 1.0571	ASTM A694 Grade F52	API 5L X52	EN 10025 S355J2G3
SS 22Cr	Stainless steel Type 22Cr Duplex	1.4462	ASTM A182 Grade F51 Grade F60	ASTM A790 UNS S31803 UNS S32205	A928 UNS S31803 UNS S32205
17-4 PH	Martensitic stainless steel		ASTM A705 Grade 630 1150HM		
A-286	Nickel base alloys	1.4980	ASTM A638 Grade 660		
Alloy 625	Nickel base alloys	2.4856	ASTM B564 N06625		

Annex F (Informative) Metric bolting

If metric bolts shall be used, their size shall be selected based on Table F.1. Metric bolts will then fit in the standard bolt holes. Washers shall always be used with metric bolts in order to achieve the standard bearing area between nut and bearing surface.

The target bolt pre-load is the same for imperial and metric bolts. In Table F.2 the bolt torque values for a friction coefficient of 0,12 are listed. The resulting loads as a fraction of bolt yield are also given for information.

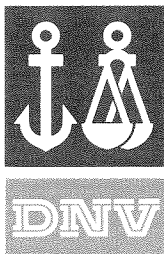
Table F.1 – Metric bolt sizes for replacing the listed imperial bolts

ISO (DIN) METRIC			ANSI-INCH (UNC-8UN, ASME B18.2.2)		
Nominal size	Diameter mm	Root area mm ²	Nominal size	Diameter mm	Root area mm ²
M12x1.75	12	76.25	½-UNC	12.7	81.07
M16x2	16	144.12	⅝-UNC	15.875	130.16
M20x2.5	20	225.19	¾-UNC	19.05	194.78
M22x2.5	22	281.53	7/8-UNC	22.225	270.44
M24x3	24	324.27	1-UNC	25.4	355.41
M30x3.5	30	518.99	1 ⅝-8UN	28.575	469.42
M33x3.5	33	647.19	1 ¾-8UN	31.75	599.26
M36x4	36	759.28	1 ⅞-8UN	34.925	744.94
M39x4	39	912.87	1 ½-8UN	38.1	906.45
M42x4.5	42	1045.15	1 ⅝-8UN	41.275	1083.80
M45x4.5	45	1224.12	1 ¾-8UN	44.45	1276.99
M48x5	48	1376.59	1 ⅞-8UN	47.625	1486.00
M52x5	52	1652.21	2-8UN	50.8	1710.85
M60x5.5	60	2227.23	2 ¼-8UN	57.15	2208.06
M64x6	64	2519.52	2 ½-8UN	63.5	2768.61
M72x6	72	3281.53	2 ¾-8UN	69.85	3392.49
M76x6	76	3700.23	3-8UN	76.2	4079.72
M85x6	85	4734.21	3 ¼-8UN	82.55	4830.28
M90x6	90	5363.62	3 ½-8UN	88.9	5644.18
M95x6	95	6032.29	3 ¾-8UN	95.25	6521.42
M100x6	100	6740.24	4-8UN	101.6	7462.00

Table F.2 – Bolt torque values for metric bolts

Bolt torque values for NCF5 with metric bolts			
Stud size	Target residual preload kN	Applied torque M = 0,12 Nm	Fraction of bolt yield applied
M12x1.75	44.0	92.6	0.80
M16x2	71.0	188.6	0.68
M20x2.5	106.0	350.4	0.65
M22x2.5	147.0	528.4	0.72
M24x3	193.0	780.7	0.82
M30x3.5	255.0	1255.0	0.68
M33x3.5	325.0	1736.0	0.69
M36x4	405.0	2374.0	0.74
M39x4	492.0	3119.0	0.69
M42x4.5	589.0	4040.0	0.78
M45x4.5	693.0	5084.0	0.78
M48x5	807.0	6340.0	0.81
M52x5	929.0	7779.0	0.78
M60x5.5	1199.0	11400.0	0.74
M64x6	1503.0	15310.0	0.82
M72x6	1667.0	18710.0	0.78
M76x6	2004.0	23770.0	0.83
M85x6	2373.0	30830.0	0.77
M90x6	2773.0	38320.0	0.79
M95x6	3204.0	46540.0	0.81
M100x6	3666.0	56280.0	0.83

Annex G
(Informative)
Statement of compliance



DET NORSKE VERITAS

STATEMENT OF CONFORMITY

*Application of the Council Directive 97/23/EC of 29 May 1997 on Pressure Equipment,
as amended.*

STATEMENT NO.: 341.1-J-2586

This Statement consists of 1 page and plus 1 appendix

This is to certify that the design of
NORSOK COMPACT FLANGES

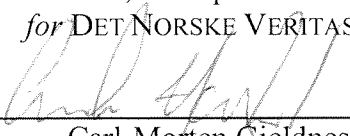
with type designation
NCF5

*as specified in appendix to this document, is found to comply with
the requirements applicable to it.*

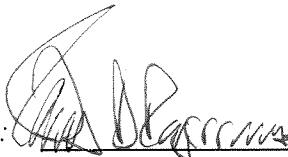
The design of the components has been assessed with respect to conformity with the relevant requirements of the Pressure Equipment Directive.

*Further details of the product and conditions for the Statement of Conformity
are given overleaf.*

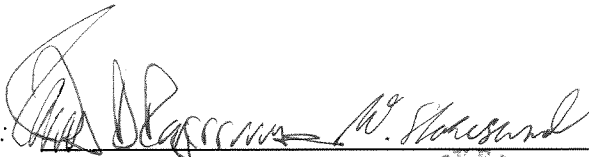
Place and date
Høvik, 15 September 2003
for DET NORSKE VERITAS AS


Carl-Morten Gjeldnes

Head of section, TNCNO750
Technical Services

Notified Body no.: 
0575

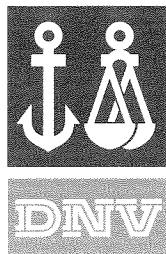
DNV local office:
Oslo


Hans Dyrda
Rasmussen/Walther
Storesund
Surveyor



Notice: The certificate is subject to terms and condition, if any, overleaf. Any significant changes in design or construction of the product, the quality system or amendments to the Directive or Standards referenced above may render this certificate invalid. The product liability rests with the manufacturer or his representative in accordance with the Council Directive, as amended.

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.



APPENDIX, REV. 0

Covered products

Product	Designation
NORSOK Compact Flange L-005	NCF 5

Type of Flanges as given in NORSOK Standard L-005 Chapter 5.4.

Approach

The design evaluation is limited to the essential requirements given in the Pressure Equipment Directive, Annex I, Ch. 2. Design.

The design has been assessed for conformity with the relevant requirements, following the procedure laid down by the Pressure Equipment Directive Annex III Module B1.

The following main design aspects have been considered:

- Review of technical documentation as listed in Annex III Module B1 Ch. 3
- Review of FEM analyses to support the design calculations
- Performance of a test on a full scale specimen to support the validity of the design and the FEM analyses.

Design

The design approach was found to be relevant for NCF5 flanges to be installed on equipment covered by the Pressure Equipment Directive.

Tests

The test carried out showed that the component did not exhibit significant leaks or deformation exceeding the determined threshold.

Materials

The standard covers several material grades and temperature ranges. It is the responsibility of the manufacturer of the pressure equipment into which the components are integrated to ensure proper selection of materials for the applicable temperature ranges.

Particular material appraisal as required by PED annex 1 sec. 4.2 is the formal responsibility of the manufacturer of the pressure equipment into which the components are integrated and, when regarding pressure equipment in category III, the Notified Body responsible for conformity assessment of the equipment.





CE-mark of conformity

The components are not entitled to bear the CE-mark of conformity.

Comments

It is the responsibility of the manufacturer of the pressure equipment into which the components are integrated to analyse the hazards in line with the requirements of the third preliminary observation of Annex I

The following official guidelines have been considered: 4/9, 5/3, 8/4.

Place and date
Høvik, 15 September 2003


Walther Storesund
Surveyor



Annex H (Normative) Integral flange angle selection

H.1 General

The flange face angle in the first edition of this NORSOK standard was standardised per size and pressure class. The assumption behind the standardisation was that the flange neck was sufficiently long so that the equipment did not affect the flange warping stiffness.

In this new annex to the second edition of this NORSOK standard, two approaches are presented for selecting flange face angle on equipment integral NCF5 flanges. The most suitable method may vary for each case, depending on type of equipment, type of fabrication method, size limitations etc.

H.2 Method 1: Use flange length HW5 and interpolated face angle within thickness range given in tables in A.4

In cases where the total length of the nozzle or equipment is limited for various reasons, the total flange/nozzle length can be selected as HW5. There will then be sufficient space for inserting the bolts, but the equipment geometry may affect the flange warping stiffness. The flange face angles shall then be selected from the tables in this annex. DA3, $\alpha A2$, $\alpha B1$ and $\alpha B2$ shall be linearly interpolated based on the actual flange neck thickness which in turn is based on the values listed for t_{min} and t_{max} .

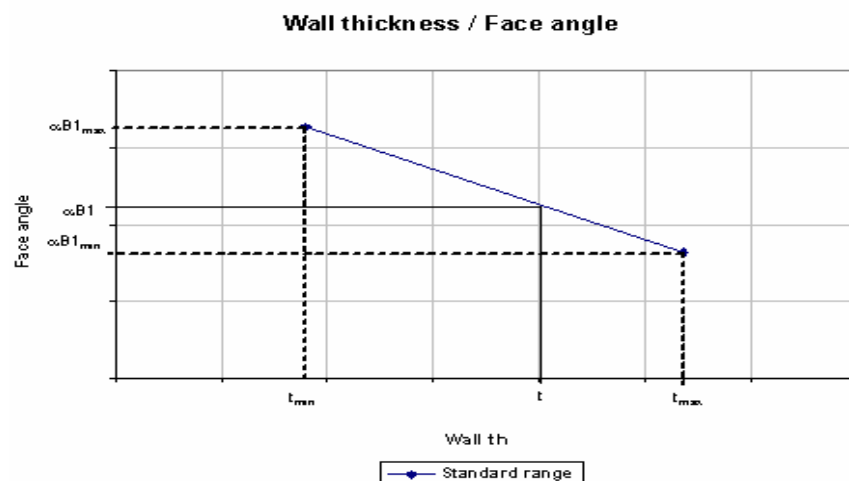


Figure H.1 – Linear behaviour between wall thickness and flange face angle

H.3 Method 2: Special flange neck geometries

An equipment supplier may require a design beyond the method described above. This may be due to length requirements for interface with the piping system or equipment space requirements in any other respect.

The approach for finding the correct face angle for such applications is finding an equivalent thickness for the equipment flange neck within a distance equal the standard flange overall length (HW5). A cross section area approach gives background for calculating the equivalent wall thickness, from which a relevant face angle can be found.

Examples are given in H.4.

H.4 Examples

H.4.1 Standard flange length with interpolated face angles

Specifications:

Pressure class	CL 1500
Pipe size	DN 300

Flange neck outer diameter, A 340,0 mm
 Flange neck inner diameter, B 288,9 mm
 Flange neck wall thickness, t 25,55 mm

Optimised seal groove outer diameter:

$$\begin{aligned}
 DA3 &= \frac{(DA3_{\max} - DA3_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t) + DA3_{\min} \\
 &= \frac{349.08 - 348.77}{56.35 - 14.27} \times (56.35 - 25.55) + 348.77 = 349 \text{ mm}
 \end{aligned}
 \tag{H.1}$$

Optimised seal groove angle:

$$\begin{aligned}
 \alpha A2 &= \frac{(\alpha A2_{\max} - \alpha A2_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t) + \alpha A2_{\min} \\
 &= \frac{15.4 - 15.2}{56.35 - 14.27} \times (56.35 - 25.55) + 15.2 = 15.3^\circ
 \end{aligned}
 \tag{H.2}$$

Optimised face angle:

$$\begin{aligned}
 \alpha B1 &= \frac{(\alpha B1_{\max} - \alpha B1_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t) + \alpha B1_{\min} \\
 &= \frac{0.57 - 0.24}{56.35 - 14.27} \times (56.35 - 25.55) + 0.24 = 0.48^\circ
 \end{aligned}
 \tag{H.3}$$

Optimised rear face bevel angle:

$$\begin{aligned}
 \alpha B2 &= \frac{(\alpha B2_{\max} - \alpha B2_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t) + \alpha B2_{\min} \\
 &= \frac{0.38 - 0.16}{56.35 - 14.27} \times (56.35 - 25.55) + 0.16 = 0.32^\circ
 \end{aligned}
 \tag{H.4}$$

All other dimensions shall be according to specified values.

H.4.2 Special flange neck geometries with interpolated face angle from cross section area estimation (non-standard flange neck geometry)

Specifications:

Pressure class	CL1500
Pipe size	DN750

Valve dimensions (see Figure H.2):

Flange neck outer diameter, A 864,0 mm
 Flange neck inner diameter, B 682,0 mm
 Flange neck wall thickness, t 91,0 mm

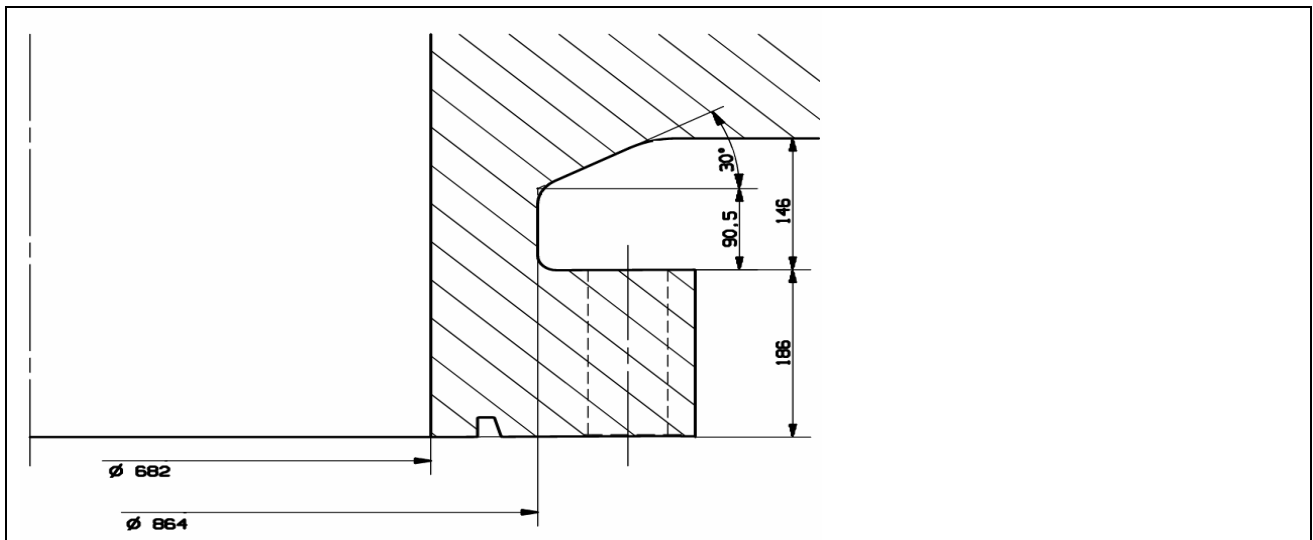


Figure H.2 –Valve design example H.4.2

Other essential dimensions:

Flange overall length, HW5 304,0 mm

Flange thickness, HW3 186,0 mm

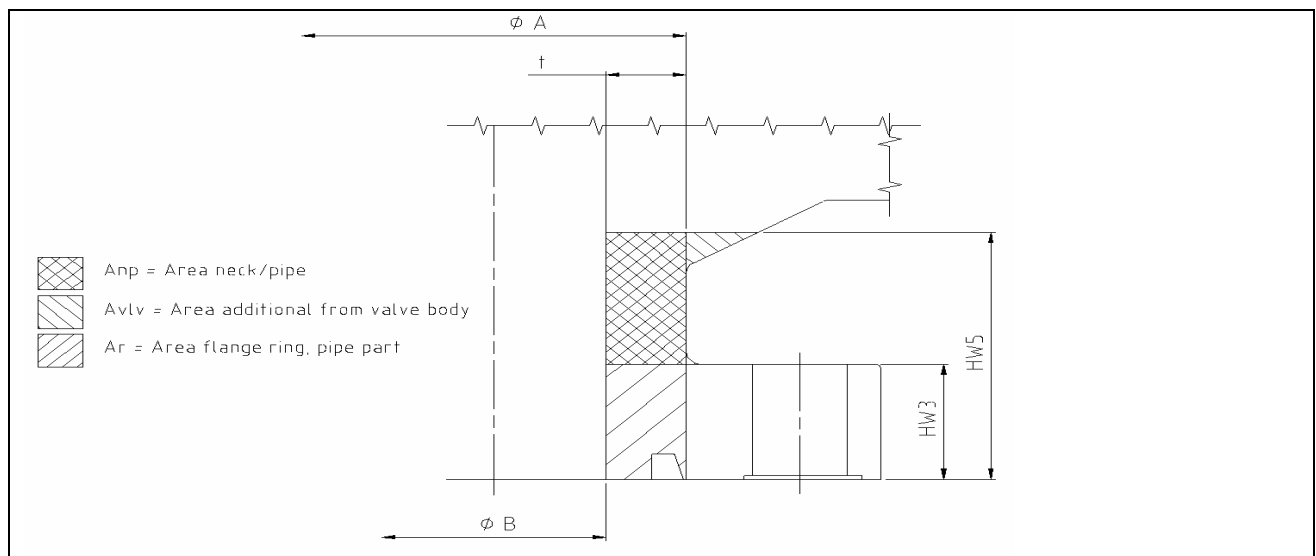


Figure H.3 – Cross section areas example H.4.2

True cross section area for actual wall thickness (see Figure H.3.):

$$\begin{aligned}
 Area_{eqv} &= A_r + A_{n/p} + A_{vlv} = \\
 &= HW3 \times t + [(HW5 - HW3) \times t] + \left[\frac{(HW5 - HW3 - 90.5) \times \frac{HW5 - HW3 - 90.5}{\tan(30^\circ)}}{2} \right] = \quad (H.5) \\
 &= 186.0 \times 91.00 + [(304.0 - 186.0) \times 91.00] + \left[\frac{(304.0 - 186.0 - 90.5) \times \frac{304.0 - 186.0 - 90.5}{\tan(30^\circ)}}{2} \right] = 28319 \text{ mm}^2
 \end{aligned}$$

Equivalent wall thickness:

$$t_{eqv} = \frac{Area_{eqv}}{Hw5} = \frac{28319}{304} = 93.15 \text{ mm} \quad (\text{H.6})$$

This equivalent wall thickness is within standard range. Hence optimised dimensions can be calculated from interpolation as shown below.

Optimised seal groove outer diameter:

$$\begin{aligned} DA3 &= \frac{(DA3_{\max} - DA3_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + DA3_{\min} \\ &= \frac{802.49 - 801.76}{116.00 - 36.00} \times (116.00 - 93.15) + 801.76 = 801.97 \text{ mm} \end{aligned} \quad (\text{H.7})$$

Optimised seal groove angle:

$$\begin{aligned} \alpha A2 &= \frac{(\alpha A2_{\max} - \alpha A2_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + \alpha A2_{\min} \\ &= \frac{15.4 - 15.2}{116.00 - 36.00} \times (116.00 - 93.15) + 15.2 = 15.3^\circ \end{aligned} \quad (\text{H.8})$$

Optimised face angle:

$$\begin{aligned} \alpha B1 &= \frac{(\alpha B1_{\max} - \alpha B1_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + \alpha B1_{\min} \\ &= \frac{0.62 - 0.28}{116.00 - 36.00} \times (116.00 - 93.15) + 0.28 = 0.38^\circ \end{aligned} \quad (\text{H.9})$$

Optimised rear face bevel angle:

$$\begin{aligned} \alpha B2 &= \frac{(\alpha B2_{\max} - \alpha B2_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + \alpha B2_{\min} \\ &= \frac{0.41 - 0.19}{116.00 - 36.00} \times (116.00 - 93.15) + 0.19 = 0.25^\circ \end{aligned} \quad (\text{H.10})$$

All other dimensions shall be according to specified values.

If the equivalent wall thickness for an application is outside standard range, extrapolation can be done based on the assumed linearity both within and outside the wall thickness range, see example H.4.3 for procedure.

H.4.3 Special flange neck geometries with interpolated face angle from effective inner diameter and cross section area estimation

Pipe requirements:

Pressure class	CL 1500
Pipe size	DN 700

Valve dimensions (see Figure H.4):

Flange neck outer diameter, A	769,0 mm
Flange face inner diameter, Bf	639,0 mm
Flange neck inner diameter, Bn	591,0 mm
Height of inner diameter transition, h _t	90,0 mm

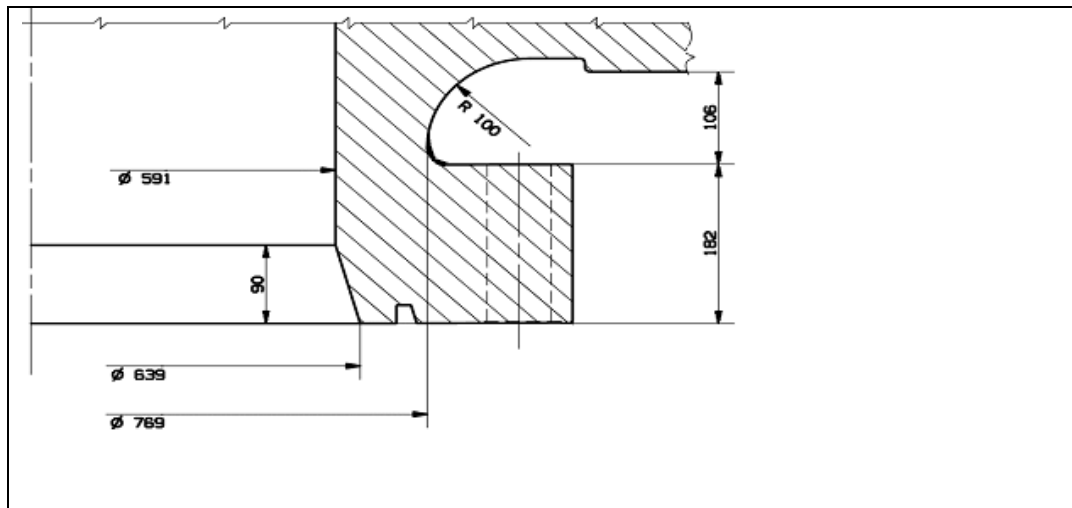


Figure H.4 - Valve design, example H.4.3

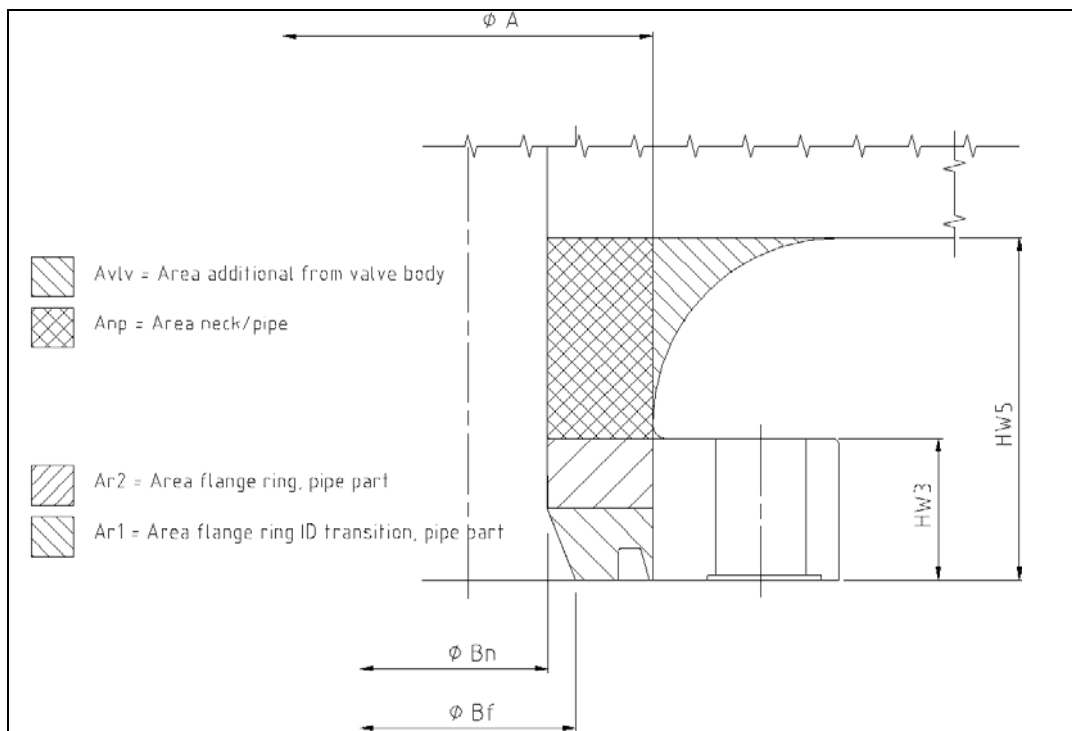


Figure H.5 - Cross section areas, example H.4.3

True cross section area for actual wall thickness (see Figure H.5):

$$Area_{eqv} = A_{r1} + A_{r2} + A_{n/p} + A_{vlv} = 26431 \text{ mm}^2 \quad (\text{H.11})$$

where

$$A_{r1} = h_t \times \frac{\frac{A - B_n}{2} + \frac{A - B_f}{2}}{2} = 90 \times \frac{\frac{769.0 - 591.0}{2} + \frac{769.0 - 639.0}{2}}{2} = 6930 \text{ mm}^2 \quad (\text{H.12})$$

and

$$A_{r2} = (HW3 - h_t) \times \frac{A - B_n}{2} = (182.0 - 90) \times \frac{769.0 - 591.0}{2} = 8188 \text{ mm}^2 \quad (\text{H.13})$$

and

$$A_{n/p} = (HW5 - HW3) \times \frac{A - B_n}{2} = (285.0 - 182.0) \times \frac{769.0 - 591.0}{2} = 9167 \text{ mm}^2 \quad (\text{H.14})$$

and

$$A_{v/v} = r \times r - \pi \times r^2 \times \frac{90}{360} = 100 \times 100 - \pi \times 100^2 = 2146 \text{ mm}^2 \quad (\text{H.15})$$

Here the area $A_{v/v}$ is assumed to be inscribed of the quarter circle formed by the simplification of the outer neck transition into the larger valve body. "r" equals the transition radius.

Equivalent wall thickness:

$$t_{eqv} = \frac{Area_{eqv}}{Hw5} = \frac{26431}{285.0} = 92.74 \text{ mm} \quad (\text{H.16})$$

This equivalent wall thickness is within standard range. Hence optimised dimensions can be calculated by interpolation as shown below.

Optimised seal groove outer diameter:

$$\begin{aligned} DA3 &= \frac{(DA3_{\max} - DA3_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + DA3_{\min} \\ &= \frac{749.22 - 748.71}{106.90 - 36.00} \times (106.90 - 92.74) + 748.71 = 748.81 \text{ mm} \end{aligned} \quad (\text{H.17})$$

Optimised seal groove angle:

$$\begin{aligned} \alpha A2 &= \frac{(\alpha A2_{\max} - \alpha A2_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + \alpha A2_{\min} \\ &= \frac{15.3 - 15.2}{106.90 - 36.00} \times (106.90 - 92.74) + 15.2 = 15.2^\circ \end{aligned} \quad (\text{H.18})$$

Optimised face angle:

$$\begin{aligned} \alpha B1 &= \frac{(\alpha B1_{\max} - \alpha B1_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + \alpha B1_{\min} \\ &= \frac{0.49 - 0.25}{106.90 - 36.00} \times (106.90 - 92.74) + 0.25 = 0.30^\circ \end{aligned} \quad (\text{H.19})$$

Optimised rear face bevel angle:

$$\begin{aligned} \alpha B2 &= \frac{(\alpha B2_{\max} - \alpha B2_{\min})}{(t_{\max} - t_{\min})} \times (t_{\max} - t_{eqv}) + \alpha B2_{\min} \\ &= \frac{0.33 - 0.16}{106.90 - 36.00} \times (106.90 - 92.74) + 0.16 = 0.19^\circ \end{aligned} \quad (\text{H.20})$$

All other dimensions shall be according to specified values.

If the equivalent wall thickness for an application is outside standard range, extrapolation can be done based on the assumed linearity both within and outside the wall thickness range, see example H.4.5.

H.4.4 Special flange neck geometries with interpolated face angle from effective inner diameter in “extended range” and cross section area estimation

Pipe requirements:

Pressure class CL 1500
Pipe size DN 700

Valve dimensions (see Figure H.6):

Flange neck outer diameter, A 769,0 mm
Flange face inner diameter, B_f 581,0 mm
Flange neck inner diameter, B_n 555,0 mm
Height of inner diameter transition, h_t 73,7 mm

The cross section area estimation follows the previous example.

True cross section area for actual wall thickness (see Figure H.4.6):

$$Area_{eqv} = A_{r1} + A_{r2} + A_{n/p} + A_{vlv} = 32162 \text{ mm}^2 \quad (\text{H.21})$$

where

$$A_{r1} = h_t \times \frac{\frac{A - B_n}{2} + \frac{A - B_f}{2}}{2} = 73.7 \times \frac{\frac{769.0 - 555.0}{2} + \frac{769.0 - 581.0}{2}}{2} = 7407 \text{ mm}^2 \quad (\text{H.22})$$

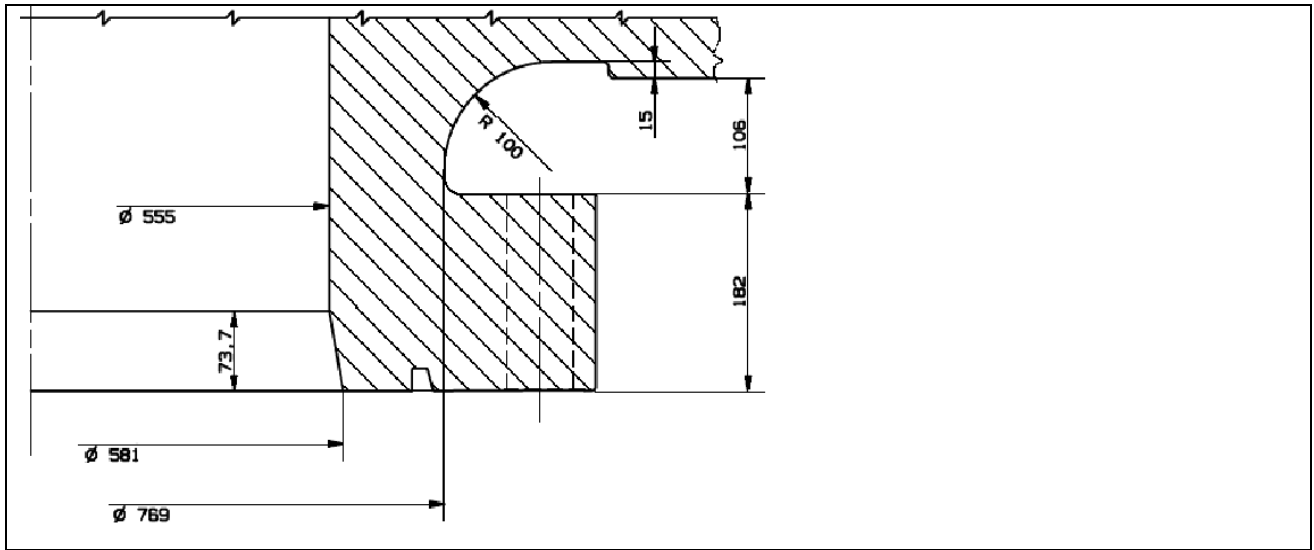


Figure H.6 - Valve design example H.4.4

and

$$A_{r2} = (HW3 - h_t) \times \frac{A - B_n}{2} = (182.0 - 73.7) \times \frac{769.0 - 555.0}{2} = 11588 \text{ mm}^2 \quad (\text{H.23})$$

and

$$A_{n/p} = (HW5 - HW3) \times \frac{A - B_n}{2} = (285.0 - 182.0) \times \frac{769.0 - 555.0}{2} = 11021 \text{ mm}^2 \quad (\text{H.24})$$

and

$$A_{vlv} = r \times r - \pi \times r^2 \times \frac{90}{360} = 100 \times 100 - \pi \times 100^2 = 2146 \text{ mm}^2 \quad (\text{H.25})$$

Here the area A_{vv} is assumed to be inscribed of the quarter circle formed by the simplification of the outer neck transition into the larger valve body. “r” equals the transition radius.

Equivalent wall thickness:

$$t_{eqv} = \frac{Area_{eqv}}{Hw5} = \frac{32162}{285} = 112.85 \text{ mm} \quad (\text{H.26})$$

This equivalent wall thickness is outside standard range. Optimised dimensions shall be calculated by extrapolation in the “extended” wall thickness range as shown below.

First we check for what wall thickness will cause the face bevel angle to reach $0,15^\circ$:

$$t_{015} = \frac{0.15^\circ - \alpha B1_{\min}}{\alpha B1_{\min} - \alpha B1_{\max}} + t_{\max} = \frac{0.15^\circ - 0.25}{0.25 - 0.49} + 106.90 = 136.44 \text{ mm} \quad (\text{H.27})$$

Extrapolation in “extended range” for optimised face angle:

$$\alpha B1 = \alpha B1_{\max} - \frac{\alpha B1_{\max} - \alpha B1_{\min}}{t_{\max} - t_{\min}} = 0.49 - \frac{0.49 - 0.25}{106.90 - 36.00} = 0.23^\circ \quad (\text{H.28})$$

Extrapolation in “extended range” for optimised seal groove outer diameter:

$$DA3 = DA3_{\max} - \frac{DA3_{\max} - DA3_{\min}}{t_{\max} - t_{\min}} = 749.22 - \frac{749.22 - 748.71}{106.90 - 36.00} = 748.67 \text{ mm} \quad (\text{H.29})$$

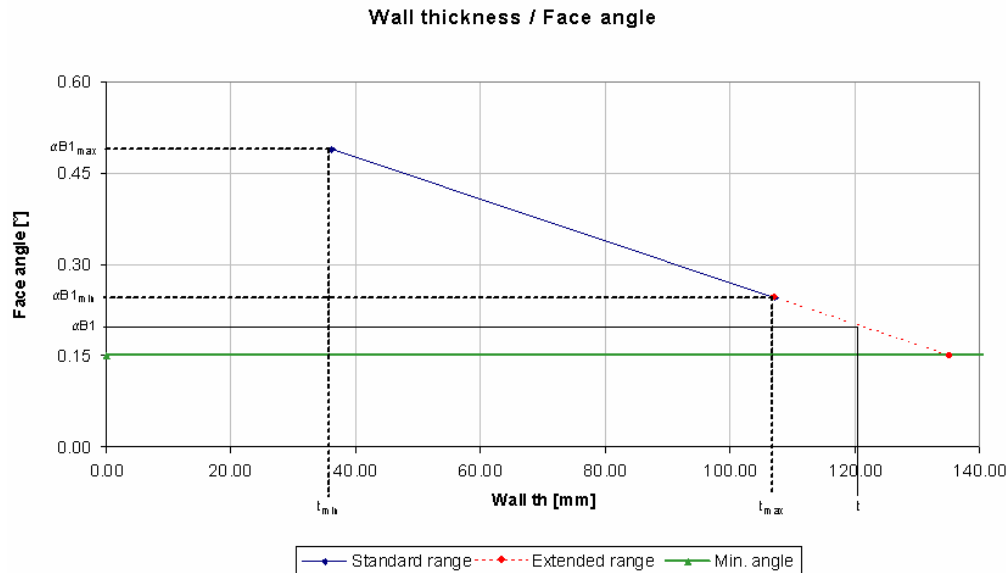


Figure H.7 – Linear behaviour between wall thickness and flange face angle for “extended” range

Extrapolation in “extended range” for optimised seal groove angle:

$$\alpha A2 = \alpha A2_{\max} - \frac{\alpha A2_{\max} - \alpha A2_{\min}}{t_{\max} - t_{\min}} = 15.3 - \frac{15.3 - 15.2}{106.90 - 36.00} = 15.2^\circ \quad (\text{H.30})$$

Extrapolation in “extended range” for optimised rear face bevel angle:

$$\alpha B2 = \alpha B2_{\max} - \frac{\alpha B2_{\max} - \alpha B2_{\min}}{\frac{t_{\max} - t_{\min}}{t_{eqv} - t_{\min}}} = 0.33 - \frac{0.33 - 0.16}{\frac{106.90 - 36.00}{112.85 - 36.00}} = 0.15^{\circ} \quad (\text{H.31})$$

All other dimensions shall be according to specified values.

Bibliography

The qualification of NCF5 is based on work performed on the SPO compact flange. The SPO compact flange has been qualified by a large number of laboratory tests. The test reports are listed below. The design has also been supported by very extensive non-linear and linear finite element analysis. The design and analyses reports are listed below.

Independent testing performed on SPO compact flanges

[1] DNV report nos 90-3241 and 91-3156

Test plan and test report for prototype testing of a 9 5/8" production riser compact flange connector for the "Snorre" TLP. This includes repeated make up break out and interchangeability testing, full length make up testing, fatigue testing, experimental stress analysis, static proof load testing under combined internal pressure bending and axial load, ultimate strength testing and elevated temperature testing.

[2] DNV report nos 91-3193 and 91-2010

Test plan and test report for prototype testing of a 24" oil export riser compact flange connector for the "Snorre" TLP. This includes repeated make up break out and interchangeability testing, full length make up testing, fatigue testing, experimental stress analysis, static proof load testing under combined internal pressure bending and axial load, ultimate strength testing and elevated temperature testing.

[3] British Gas report R 4844

This describes tests on a 30" class 600 SPO Compact Flange carried out at British Gas' test facility.

[4] DNV report no 91-3458

This describes seven burst tests performed on SPO Compact Flanges by DNV.

[5] DNV report no 94-3567

This describes a gas test on a 4" class 1500 SPO Compact Flange.

[6] DNV report no 96-3426

This describes a fire test on a 10" class 1500 SPO Compact Flange.

[7] DNV report no 96-3263

Tests on SPO Compact Flanges with damaged seal surfaces and with repaired damages.

[8] IKM report no 961010-02

Report on an underwater repair pressure test for damage to seal surfaces.

[9] Report from CALtec

Report on measurement of water locking effect in an SPO Compact Flange for sub sea use.

[10] DNV report no 96-3160

Tests on bolt pre-tensioning equipment and methods for SPO Compact Flanges.

[11] DNV report no. 97-3547.

Reliability evaluation of SPO Compact Flange System. The report documents that the structural capacity and the reliability with regards to leak tightness is of the same order of magnitude as that of a girth weld.

[12] Prototype test by DNV for revised type approval, DNV report no 98-3430

To comply with new EU requirements SPO's type approval was revised to provide a basis for PED approval. For this revised type approval an ultimate load test was performed on a 6" Class 1500 SPO CFS Compact Flange to verify the precision of non-linear FEM analysis.

[13] DNV report no. 00-1008.

Hydrostatic seal test, 16" SPO Compact Flange, Three-point Bending.

Hydrostatic pressure test + ULS and PLS load test of the 16" SPO CFS for Heidrun Gas Export Riser.

[14] DNV report 2003-1139

Testing of NORSOK NCF5 flange DN150/CL1500/IX.

Design documentation**[15] Vector International AS, SPO report no. B20/96, February 1997.**

CFS standard - type approval FEM analyses.

[16] Vector International AS, SPO report no. 70, November 1997.

Evaluation of non-linear finite element analyse of ultimate strength.

[17] Vector International AS, SPO report no. 82, January 1998.

Shake Down Analysis of 14" CL1500 Compact Flange.

[18] Vector International AS report no. A10185, June 2003.

Simplification of CFS face angles for NORSOK standardisation.

[19] Vector International AS report no. A10742, August 2003.

Design calculations for DNV approval of NORSOK flanges.

