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Petroleum and natural gas industries — Compact flanged connections with IX seal ring

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National foreword

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Petroleum and natural gas industries - Compact flanged connections with IX seal ring (ISO 27509:2012)

Industries du pétrole et du gaz naturel - Raccordements à brides compactes avec bague d'étanchéité IX (ISO 27509:2012)

Erdöl- und Erdgasindustrie - Kompakte Flanschverbindungen mit IX Dichtungsring (ISO 27509:2012)

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Foreword

This document (EN ISO 27509:2012) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" the secretariat of which is held by AFNOR.

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Endorsement notice

The text of ISO 27509:2012 has been approved by CEN as a EN ISO 27509:2012 without any modification.

Contents

Page

Introduction

This International Standard, which is based on NORSOK L-005[36], has been developed to provide a standard for compact flanged connections (CFCs) that constitutes an alternative to conventional flanges as specified in ASME standards, European Standards and other International Standards, with reduced mass and smaller overall dimensions, as well as increased reliability in leak tightness by means of its inherent design features and make up procedures. CFCs can also provide an alternative to other types of clamp and hub type mechanical connectors.

The use of load carrying sealing elements, traditionally referred to as "gaskets", does not comply with the fundamental requirements of this International Standard.

This International Standard has been developed for use in process piping systems, which are designed according to codes for pressure piping, e.g. ASME B31.3. See 4.7 for more details.

The flange designs have been selected to achieve a minimum safety factor of 2,0 when subjected to a design pressure equal to ASME B16.5 pressure temperature ratings within the temperature limits of this International Standard.

The main body of this International Standard contains all necessary information on how to manufacture and supply flange and seal ring materials, such as

— flange dimensions and material requirements;

— seal ring dimensions and material requirements;

— bolting dimensions and material requirements;

— requirements to tolerances and surface finish;

— requirements to designation and marking of finished products.

Normative annexes A and D cover the following topics:

— structural capacity equations for flange assemblies;

— bolt dimensions and masses.

Informative annexes B, C, E, F and G cover the following topics:

— how to apply the flanges to special geometries of valves and equipment nozzles;

— quality management;

— installation and assembly instructions, and guidelines on how to repair damage and irregularities on sealing surfaces;

— masses of all standard components;

— suitable dimensions of alternative metric bolting.

For the purposes of this International Standard, the following verbal forms apply:

— "shall" indicates a requirement strictly to be followed in order to conform to this International Standard and from which no deviation is permitted, unless accepted by all involved parties;

— "should" indicates 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;

— "may" indicates a course of action permissible within the limits of this International Standard;

— "can" is used for statements of possibility and capability, whether material, physical or casual.

Petroleum and natural gas industries — Compact flanged connections with IX seal ring

1 Scope

This International Standard specifies detailed manufacturing requirements for circular steel and nickel alloy compact flanged connections and associated seal rings, for designated pressures and temperatures 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 for CL 2500 (PN 420) for nominal sizes from DN 15 (NPS ½) to DN 600 (NPS 24).

NOTE NPS is in accordance with ASME B36.10M and ASME B36.19M.

This International Standard is applicable to welding neck flanges, blind flanges, paddle spacers and spacer blinds (paddle blanks), valve/equipment integral flanges, orifice spacers, reducing threaded flanges and rigid interfaces for use in process piping for the petroleum, petrochemical and natural gas industries.

This International Standard is applicable within a temperature range from −196 °C to +250 °C.

This International standard is not applicable for external pressure.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2768-1, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 4288, *Geometric Product Specifications (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 5167-2:2003, *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*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard*

ASME B16.34, *Valves — Flanged, Threaded and Welding End*

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASME B31.3, *Process Piping*

EN 1092-1, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 1779, *Non-destructive testing — Leak testing — Criteria for method and technique selection*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
class
CL
ASME pressure class in accordance with ASME B16.5 and ASME B16.34

3.1.2
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

3.1.3
gasket
barrier to prevent the passage of fluids, but which does transmit all loads between flanges

EXAMPLE As shown in EN 1591-1:2001, Figure 3.

3.1.4
purchaser
individual or organization that buys the pipe connection on behalf of the user and/or operator or for its own use

3.1.5
seal
component providing a barrier to prevent the passage of fluids, transmitting no significant loads between the flanges

3.1.6
supplier
individual or organization that takes the responsibility for the supply of the pipe connection and its conformance with this International Standard

3.2 Symbols

A outside diameter of neck

A_{max} maximum outer diameter to accommodate standard tools

A_{min} minimum neck outer diameter listed in Table 7 to Table 12

$Area_{015}$ cross-sectional area of the neck/pipe calculated from t_{015}

$Area_{eqv}$ cross-sectional area of a special flange neck geometry calculated from t_{eqv}

B bore diameter, where the bore should not exceed the maximum listed bore in this International Standard

B_{max} maximum listed bore diameter

B_{min}	minimum bore diameter for which the face angles are valid
B1	minimum bore diameter for flange to be blinded

NOTE B1 is also the start diameter for blind and reducing threaded flange face angles.

BCD	bolt circle diameter
d_B	bolt size
d_p	average diameter of neck end = (A+B)/2
DA1	internal diameter of groove
DA3	outer diameter of groove
DG4	seal ring seal diameter
DW1	inner recess diameter
DW2	outer recess diameter
DW3	outside diameter of flange
DW4	flange to neck fillet outer diameter
e	radial distance between BCD and d_p
e_B	(DW3 + DW2)/4 – BCD/2
e_p	(DW3 + DW2)/4 –(A+B)/4
E1	depth of groove
E2	depth of recess
E3	depth of recess for gasket
F_A	applied axial force
F_{cB}	bolt total plastic capacity (root area × number of bolts × 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
f_y	flange material yield strength at temperature
HP1	thickness of PB, PS and OS
HW3	flange thickness
HW5, HT5	overall length
L	bolt hole diameter
L1,L2,L3	bolt hole depths
M_A	applied bending moment
n	number of bolts
p	internal pressure in N/mm^2

RA	radius
RB	radius
RC	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_{015}	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
αA2	groove angle
αB1	flange face bevel angle
αB2	effective face angle/rear face bevel angle
ψ	flange utilization ratio

3.3 Abbreviated terms

BL	blind flange
CFC	compact flanged connection
CL	class
DN	nominal pipe diameter (expressed in millimetres)
ID	internal diameter
IF	integral flange (as part of some other equipment or component)
IX	special metallic seal ring applied in Clause 4
LB	line blinds (including PS and PB)
NPS	nominal pipe size (expressed in inches)
OD	outer diameter
OS	orifice spacer
PB	paddle blank
PN	nominal pressure (bar)
PS	paddle spacer
PTFE	polytetrafluoroethylene
RI	rigid interface

RT reducing threaded flange

WN weld neck

4 Design

4.1 General

In order to be compliant with this International Standard, CFCs fulfil the minimum design requirements outlined below.

— They have been designed for face-to-face make-up for transfer of the bolt loading through the flange faces.

— They have been designed so that a static mode is maintained in the bolted joint up to 1,5 times the specified pressure/temperature rating, see 7.2. Static mode is maintained as long as the difference between maximum and minimum nominal stress sustained by the bolts in the joint does not exceed 5 % of the minimum values specified in Table 3.

— They have been standardized to cover as a minimum the same pressure temperature class designations and sizes as can be found in ASME B16.5 with equal or better performance.

— They have been standardized to fit with commonly used standards by the valve industry (e.g. ASME B16.34, ISO 14313 and the EN 12516 series of parts), and other valve standards which make reference to these standards for pressure design.

— The weakest part of flanged connections according to this International Standard regarding fatigue failure is always located somewhere in the transition from flange to pipe or flange to nozzle neck of an equipment or valve. The bolted joint itself is never subjected to fatigue load if considerations to cycling temperatures are taken when selecting bolt material, see 6.3.

4.2 Design principles

Figure 1 shows the design principles of compact flanges and its seal system according to this International Standard.

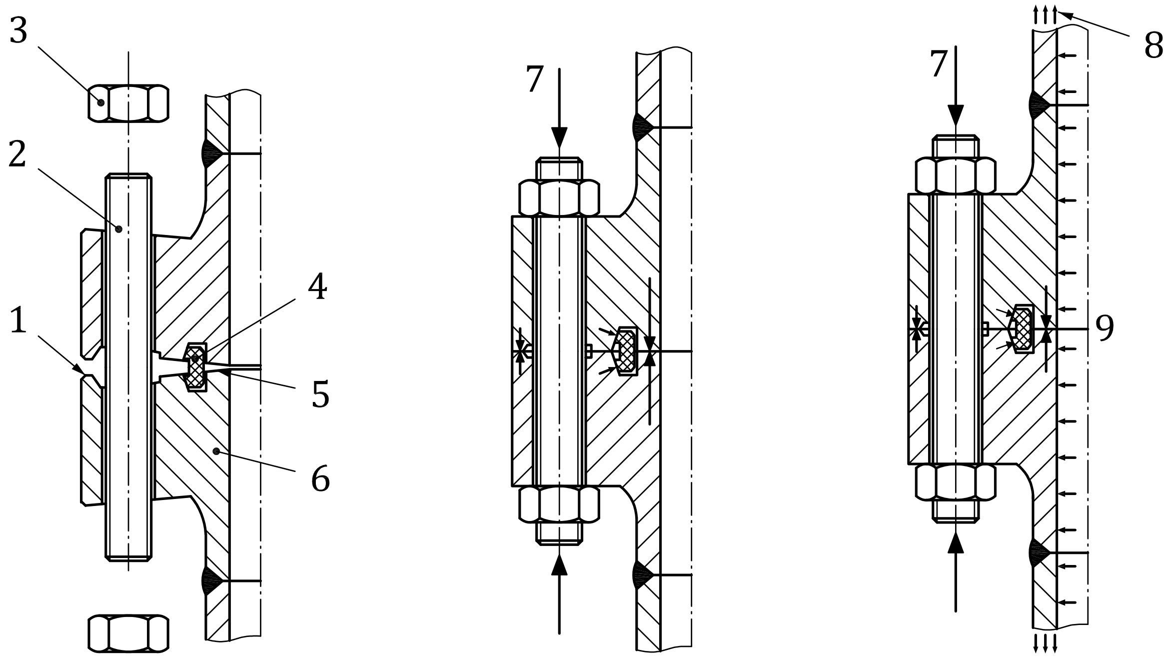
The flange face includes a slightly convex bevel with the highest point, called the heel, adjacent to the bore and a small outer wedge around the outer diameter of the flange. The assembly is made up by tightening/tensioning the flange bolting which pulls the two connector halves together. The bevel angles have been standardized for different and relevant adjoining pipe wall thicknesses for each welding neck flange of a given size and pressure class.

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, as illustrated in 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 1,5 times the flange pressure rating at room temperature for any combination of WN flange and a corresponding pipe within given limits of pipe wall thicknesses in tables of dimensions. This requirement is only applicable when the WN thickness fulfils the code requirement for minimum pipe wall thickness for the actual material. 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 in the way that adjoining flanges remain in contact along their outer circumference for all allowable load levels. 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.



a) Before assembly **b) Completed assembly** **c) Design loads**

Key

1 Wedge
2 Stud
3 Nut
4 IX seal ring
5 Heel
6 Weld neck flange
7 Bolt clamping force
8 Hydrostatic end force plus external loads
9 Fluid pressure

Figure 1 — Design principles of standard compact flange assemblies

4.3 Assembly requirements

In order to comply with the design principles as described in 4.2 it is mandatory to assemble the flanged connections to target bolt loads according to Table 1 below. For detailed advice on how to assemble compact flanges, see Annex E.

NOTE Compact flange IX seal rings require sufficient flexibility to enable seal ring size entrance and removal. The required spacing needs to be considered during piping design and layout to ensure necessary flexibility in the piping systems.

Table 1 — Target residual preload for bolt materials used to assemble compact flanges to this International Standard

Stud bolt size in	Target residual preload kN
½-UNC	44
⅝-UNC	71
¾-UNC	106
⅞-UNC	147
1-UNC	193
1 ⅛-8UN	255
1 ¼-8UN	325
1 ⅜-8UN	405
1 ½-8UN	492
1 ⅝-8UN	589
1 ¾-8UN	693
1 ⅞-8UN	807
2-8UN	929
2 ¼-8UN	1199
2 ½-8UN	1503
2 ¾-8UN	1667
3-8UN	2004
3 ¼-8UN	2373
3 ½-8UN	2773
3 ¾-8UN	3204
4-8UN	3666

4.4 Standard components

The types of flanges covered by this International Standard are given in Table 2.

Table 2 — Types of flanges and accepted raw material forms for manufacture

Type	Description	Raw material product forms
WN	Weld neck flange	Forged to shape
BL	Blind flange	Plate or forged to shape
IF	Integral flange as part of some other equipment or component	Forging, forged bar (maximum DN 50) or casting
RI	Rigid interface as part of some other equipment or component	Plate, forging or casting
PB	Paddle blank	Plate or forged to shape
PS	Paddle spacer	Plate or forged to shape
OS	Orifice spacer	Plate or forged to shape
RT	Reducing threaded flange	Plate or forged to shape

4.5 Units of measurements

In this International Standard, data are expressed in both SI units and USC units. For a specific order item, unless otherwise stated, only one system of units shall be used, without combining data expressed in the other system.

For data expressed in SI units, a comma is used as the decimal separator and a space is used as the thousands separator. For data expressed in USC units, a dot (on the line) is used as the decimal separator and a comma is used as the thousands separator.

4.6 Rounding

Except as otherwise required by this International Standard, to determine conformance with the specified requirements, observed or calculated values shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding method of ISO 80000-1:2009, Annex B, Rule A.

4.7 Compliance with piping design codes

Although not listed as a component standard in ASME B31.3, all components contained in this International Standard fulfil the requirements for unlisted piping components in paragraph 302.2.3 in ASME B31.3. This is based on full compliance with paragraph 304.7.2 (a), (b), (c) and (d):

a) The service experience requirement is fulfilled because this type of CFC has been widely used in the North Sea since 1990. The service experience covers the complete size range covered by this International Standard.

b) The experimental stress analysis requirements is fulfilled since a number of tests on strain gauged test specimens have been run over the years. Reference is made to References [40] to [43], [50], [51] and [52].

c) The proof test requirements are fulfilled since a number of pressure tests have been performed over the years. In addition to tests referenced under (b), reference is made to References [38], [44] and [45].

d) Compact flanged connections to this International Standard were originally developed and designed using the design by analysis method to pre 2007 issue of ASME VIII div.2, appendix 4 and appendix 6. Specific requirements may apply to components designed by analysis, depending on the applied piping design code. Such requirements normally include impact testing at a defined temperature relative to the minimum design temperature and a specified extent of non-destructive testing.

4.8 Compliance to this International Standard

The manufacturer shall be responsible for complying with all of the applicable requirements of this International Standard. It shall be permissible for the purchaser to make any investigation necessary in order to be assured of compliance by the manufacturer and to reject any material that does not comply.

5 Designation

5.1 Designation of flanges

The following shall designate the flanges in accordance with EN 1092-1:

— flange type abbreviation according to Table 2;

— number of this International Standard;

— nominal flange size (DN);

— pressure class designation;

— 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.

The designation elements shall be separated by a slash. The number of characters is not fixed.

Examples of designation are given below:

EXAMPLE 1 Designation of WN flange in CL 600, nominal size DN 250 with pipe schedule 40S, i.e. 9,3 mm wall thickness and material ASTM A182F51 (duplex):

WN/ISO 27509/DN250/CL600/9.3/A182F51

EXAMPLE 2 For designation of a BL flange in CL 2500, nominal size DN 200 and with material ASTM A516 Grade 70 (low temperature carbon steel):

BL/ISO 27509/DN200/CL2500/A516Grade70

EXAMPLE 3 Designation of an RT flange in CL900, nominal size DN 25, threaded outlet specified (0,5 inch NPT is default, see 8.9), and with material ASTM A182F316 (stainless steel):

RT/ISO 27509/DN25/CL900/0,5”NPT/A182F316

5.2 Designation of seal rings

The IX seal ring shall be designated as described below:

— number of this International Standard;

— type - and ring size - IX and the appropriate DN;

— material designation.

The designation elements shall be separated by “/” (slash). The number of characters is not fixed.

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

ISO 27509/IX250/A182F51

6 Materials

6.1 General

Criteria for the selection of materials suitable for a particular fluid service are not part of this International Standard.

6.2 Flange materials

Flanges covered by this International Standard shall be made from base material product forms as listed in Table 2. The standardized bevel angle as described in 4.2 is applicable for steel and nickel alloys, which are covered in this International Standard.

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 International Standard is 205 MPa at room temperature.

The elliptical transition between flange ring and flange neck of WN flanges, and the corresponding crotch transition of IF flanges shall be subject to 100 % surface examination irrespective of flange material. Examination method and acceptance criteria shall be according to standards referenced in the applied Piping Design Code.

Cast flanges shall be non-destructive tested to comply with casting factor used in calculations to determine performance. In general cast flanges used as IF should be examined by 100 % surface and volumetric control in order to obtain a casting factor of 1,0, and thus obtaining the minimum pressure and temperature ratings stated in Clause 7. Examination and acceptance criteria shall be agreed between purchaser and manufacturer, but sealing surfaces shall satisfy requirements in 8.12.

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 is accepted in the elliptical transition for the WN flange (see Figure 2) as well as in the crotch radius for the IF (see Figure 4) manufactured in line with this International Standard.

6.3 Bolting materials

The minimum bolt yield strength at temperature shall be in accordance with Table 3. Linear interpolation can be used to calculate minimum yield strength for intermediate temperatures.

Table 3 — Minimum bolt yield strength as function of maximum design temperature, T_{des}

Bolt nominal diameter, d_B	T_{des} **≤ 20 °C**	T_{des} **= 50 °C**	T_{des} **= 100 °C**	T_{des} **= 150 °C**	T_{des} **= 200 °C**	T_{des} **= 250°C**
d ≤ 2 ½”	725 MPa	713 MPa	672 MPa	648 MPa	632 MPa	613 MPa
2 ½” < d ≤ 4”	655 MPa	645 MPa	607 MPa	586 MPa	569 MPa	555 MPa

Bolt pre-load requirements described in Table 1 are based upon these requirements and so are the flange face angles and groove dimensional details.

Nuts shall have sufficient strength to carry 100 % of the bolt capacity defined by the specified minimum yield strength as listed above, and the thread stress area, see NOTE. Thread tolerances shall be considered in the nut strength evaluation.

NOTE Nuts to ISO 898-2 should not be used in order to reduce the risk of nut thread stripping.

Imperial or metric standard bolts threaded at both ends or full length may be used. Hex nuts with a minimum height equal to one nominal bolt diameter shall be used. The choice of bolt thread standard may affect assembly and bolt preloading procedures. Annex E is based on imperial bolting dimensions, while Annex G describes which metric bolts to choose for replacing the listed imperial bolts.

The effects of differential thermal expansion and bolt relaxation could affect the functionality of the joint up to loss of preload. Care shall be taken by selecting an appropriate bolt material for the above effects. Within the maximum temperature limits of this International Standard, it is acceptable to use low alloy steel bolting in combination with austenitic stainless steel flange materials. In such applications, washers shall be applied under the nuts in order to avoid indenting the nut into the flange which would cause loss of pre-load.

Washers shall be in same or equivalent grade of material as the nuts and should be through hardened.

Relaxation is not regarded to be of any importance for this flange standard since the maximum design temperature is 250 °C. A margin of 5 % points was used on bolt pre-load when documenting the flange standard to the functionality requirements in Clause 4, meaning the FEAs were performed with 70 % bolt yield as pre-load over the 75 % specified as target residual pre-load in Table 1. The 5 % point reduction was applied to account for uncertainties in pre-loading procedures and any long term relaxation.

6.4 Seal ring materials

Typical minimum yield stress and ultimate tensile 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.

The user is responsible for selecting a seal ring material which is suitable for the service medium and the design temperature conditions.

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

Seal rings shall be made of forged or worked material. For in service use, Table 4 gives a guideline for seal ring selection and temperature limitations.

Table 4 — Seal ring selection

Flange material	Service temperature	Seal ring material	
			Typical manufacturing standard
(Fine grained) carbon steel	-50 °C to +250 °C	Carbon steel or low alloy steels, e.g. CS360LT or AISI 4140	ASTM A788 or equivalent
Stainless steel	-50 °C to +250 °C	22Cr Duplex	ASTM A182 or equivalent
Stainless steel	-50 °C to +250 °C	17/4-PH	ASTM A705 or equivalent
Austenitic stainless steel and nickel alloys	-196 °C to +250 °C	Nickel alloys such as Alloy 625 or similar	ASTM B564 or equivalent

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 might 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.

NOTE 3 See Clause 12 for coating and colour coding.

7 Strength, pressure/temperature ratings and leak tightness

7.1 General

CFCs according to this standard have a level of structural safety that is comparable to that of the connecting pipe. CFCs in general 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.

Stresses resulting from bolt pre-loading shall be regarded as displacement stresses as defined in paragraph 319.2.3 of ASME B31.3, during testing and operation.

7.2 Pressure/temperature ratings

Flanges covered by this International Standard have been designated as one of the given classes in Table 5.

Table 5 — Pressure class designation and ASME rating ceiling values at room temperature to ASME B16.5, Table A-1 and Table A-2

Pressure class		Class abbreviation	Nominal pressure		ASME pressure rating ceiling values, see NOTE	
					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	1 500	103,4
Class	900	CL 900	PN	150	2 250	155,1
Class	1500	CL 1500	PN	260	3 750	258,6
Class	2500	CL 2500	PN	420	6 250	430,9
NOTE These values are applicable at room temperature, and are for information only.						

Flanged connections covered by a class in this International Standard will exceed the maximum rating of the corresponding ASME B16.5 class and material within the temperature range as defined by this International Standard. This corresponds to a utilization ratio of 0,5 according to Annex A, 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 (see 6.1).

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.

7.3 Pressure testing and leak tightness

Flanges are generally not required to be pressure tested until they are part of a piping system or pressure equipment, which shall be tested according to design codes and regulations for such pressure equipment and piping. However, orifice spacers contained in this standard, should undergo a hydrostatic pressure test before installation in order to verify appropriate quality of welded pressure tappings; see 8.8.

Flanged connections and flanged fittings may be subjected to system hydrostatic tests at a pressure of 1.5 times the 38 °C (100 °F) rating rounded off to the next higher 1 bar (25 psi) increment. Testing at any higher pressure is the responsibility of the user, taking into account the requirements of the applicable code or regulation.

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 (Pa x m^3/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.

8 Dimensions of flanges

8.1 General

A summary of the DNs applicable to each rating class is given in Table 6.

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 F.6).

Dimensions for all flange types according to this International Standard can be found in Table 7 to Table 27. Dimensional tolerances can be found in Table 28.

Table 6 — Overview of sizes and rating class (CL)

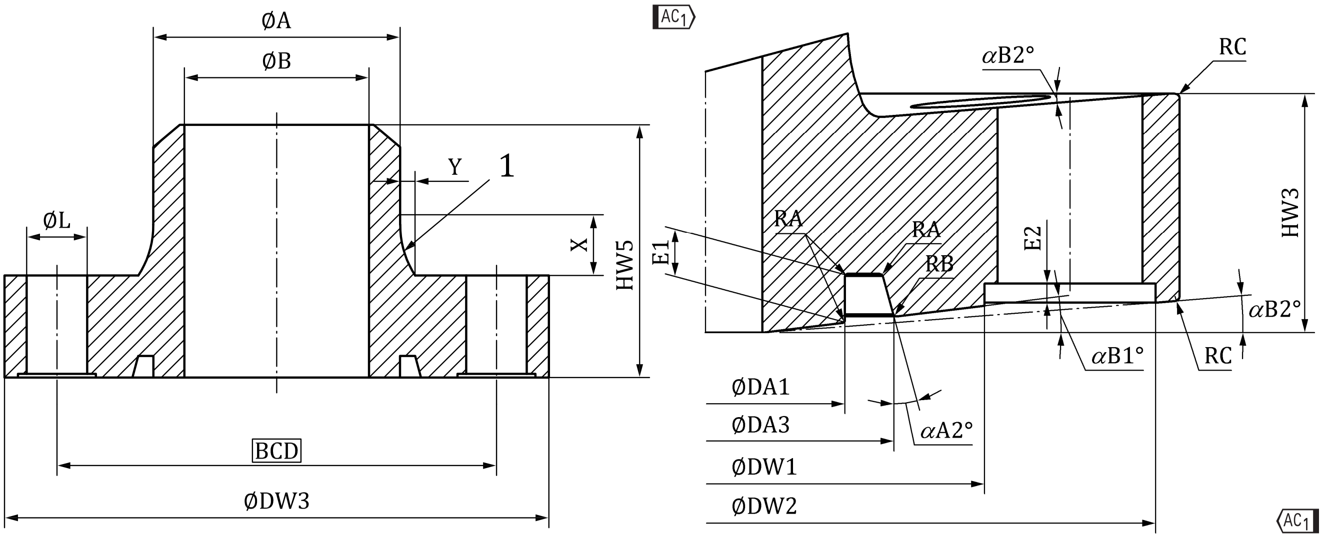
<table>
<tr><th>DN</th><th>NPS</th><th>CL 150</th><th>CL 300</th><th>CL 600</th><th>CL 900</th><th>CL 1500</th><th>CL 2500</th></tr>
<tr><td>15</td><td>½</td><td rowspan="10">Equal to CL 300[a]</td><td>–</td><td rowspan="4">Equal to CL 2500[a]</td><td rowspan="4">Equal to CL 2500[a]</td><td rowspan="4">Equal to CL 2500[a]</td><td>–</td></tr>
<tr><td>20</td><td>¾</td><td>–</td><td>–</td></tr>
<tr><td>25</td><td>1</td><td>–</td><td>–</td></tr>
<tr><td>40</td><td>1 ½</td><td>–</td><td>–</td></tr>
<tr><td>50</td><td>2</td><td>–</td><td rowspan="2">Equal to CL1500[a]</td><td rowspan="2">Equal to CL1500[a]</td><td>–</td><td>–</td></tr>
<tr><td>65</td><td>2 ½</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>80</td><td>3</td><td>–</td><td rowspan="3">Equal to CL 900[a]</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>100</td><td>4</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>125</td><td>5</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>150</td><td>6</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>200</td><td>8</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>250</td><td>10</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>300</td><td>12</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>350</td><td>14</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>400</td><td>16</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>450</td><td>18</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>500</td><td>20</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>550</td><td>22</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>600</td><td>24</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>650</td><td>26</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td></td></tr>
<tr><td>700</td><td>28</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>750</td><td>30</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>800</td><td>32</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>850</td><td>34</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>900</td><td>36</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>950</td><td>38</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>1000</td><td>40</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>1050</td><td>42</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>1100</td><td>44</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>1150</td><td>46</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>1200</td><td>48</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="8">A dash (–) indicates that there is an individual design for this size and class.</td></tr>
<tr><td colspan="8">[a] "Equal to CL xxxx” means that overall dimensions are equal for the referenced pressure classes. However, flange face bevel angles may be different.</td></tr>
</table>

8.2 Weld neck (WN) dimensions

The minimum outside diameter of the 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.

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.

Dimensions of WN flanges are defined in Figure 2. Given variations of wall thickness of connected pipe (t) in Table 7 to Table 12 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 wall thicknesses above the pipe wall thickness range given in the tables below. Dimensions of IF according to 8.4 should then be used, or WN flanges to a higher pressure class could be used. It is recommended to consider a lower pressure class WN flange if the selected pipe wall thickness is below the range specified for the original pressure class in Table 7 to Table12.



Key

1 Elliptical transition

Figure 2 — Nomenclatures for weld neck (WN) flanges

NOTE The back face of the flange is a tangential transition to the elliptical shape of the neck.

Table 7 — 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	RA	RB	RC	L	n	d_B
		mm	mm	mm	mm	mm	mm	mm	mm	mm	°	mm	mm	°	°	mm	mm	mm	mm	mm	mm	mm	mm		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	3,76-6,35	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	⅝
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	⅝
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	⅝
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	⅝
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	⅞
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	⅞
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	⅞
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	⅞
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	14,2	4,1	1,5	2,5	3,0	25,0	44	⅞
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	⅞
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	⅞

Table 8 — Dimensions of CL 300 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	RA mm	RB mm	RC mm	L mm	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	⅝
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	⅝
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	⅝
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	⅝
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	⅞
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	⅞
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	1⅛
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	1⅛
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	1¼
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	1¼
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	1¼
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	1¼
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	36	1⅜
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	1⅜
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	1268,63	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 9 — 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	RA	RB	RC	L	n	d_B
		mm	mm	mm	mm	mm	mm	mm	mm	mm	°	mm	mm	°	°	mm	mm	mm	mm	mm	mm	mm	mm		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	2,87-5,56	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	⅝
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	⅝
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	⅝
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	⅝
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	⅞
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	⅞
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	1⅛
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	1⅛
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	1¼
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	1¼
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	1¼
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	1⅜
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	1⅜
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	1⅝
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	1⅝
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	1⅞
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	1⅞
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 10 — Dimensions of CL 900 weld neck (WN) flanges

DN	NPS	t	A	B	DW1	DW2	DW3	BCD	DA1	DA3	αA2	E1	E2	αB1	αB2	HW3	HW5	X	Y	RA	RB	RC	L	n	d_B
		mm	mm	mm	mm	mm	mm	Mm	mm	mm	°	mm	mm	°	°	mm	mm	mm	mm	mm	mm	mm	mm		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	2,87-5,56	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	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	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	3,05-9,53	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	⅝
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	⅝
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	⅝
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	⅞
300	12	8,38-25,4	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	1⅛
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	1¼
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	1⅜
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	1⅝
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	1⅞
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 11 — Dimensions of CL 1500 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	RA mm	RB mm	RC 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	3,68-10,15	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	⅝
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	⅞
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	1⅜
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	1⅞
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	3½
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 12 — Dimensions of CL 2500 weld neck (WN) flanges

DN	NPS	t	A	B	DW1	DW2	DW3	BCD	DA1	DA3	αA2	E1	E2	αB1	αB2	HW3	HW5	X	Y	RA	RB	RC	L	n	d_B
		mm	mm	mm	mm	mm	mm	mm	mm	mm	°	mm	mm	°	°	mm	mm	mm	mm	mm	mm	mm	mm		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	⅝
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	⅞
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	1⅛
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	1⅜
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	1⅞
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

8.3 Blind flange (BL) dimensions

Dimensions specific to the blind flanges are given in this clause and are defined in Figure 3 and Table 13 and Table 14. The diameter B1 for blind flanges is the diameter of flat and no sealing surface without bevel face angle. All other dimensions are found in Table 7 to Table 12 for the WN flanges.

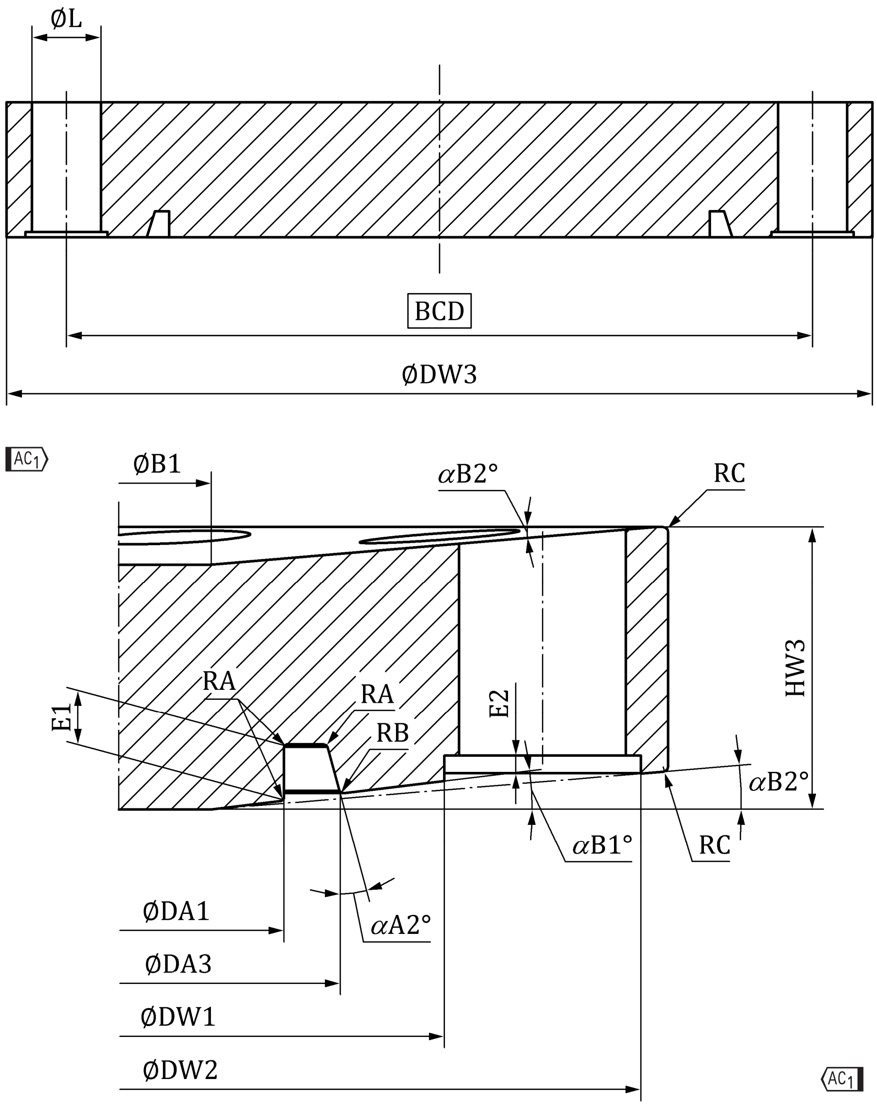


Figure 3 — Nomenclatures for blind flanges (BLs)

Table 13 — Dimensions for CL 150, CL 300 and CL 600 blind flanges (BLs)

		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 14 — Dimensions for CL 900, CL 1500 and CL 2500 blind flanges (BLs)

		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					

8.4 Integral flange (IF) dimensions

Dimensions specific to the integral flanges are given in this clause and are defined in Figure 4 and Table 15 to Table 20. All other dimensions are found in Table 7 to Table 12 for the WN flanges. Dimensions for valves 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 as outlined from requirements of ASME B16.34 and ISO 14313. 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 B. The minimum value for flange face angle αB1 is set to 0,15°. Any calculation resulting in smaller angles than 0,15° shall select angles and dimension corresponding to 0,15°.

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 15 to Table 20 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 (αB1 = 0°, αB2 = 0°). The thickness of the inlet nozzle and the supporting body flange shall then be minimum 2,5 x 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 diameter, DW3, in order to provide a maximum bending moment capacity, and to protect bolting from environmental corrosion etc.

Dimensions and angles in Table 15 to Table 20 and Annex B 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 International 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 International Standard. However, other functional requirements such as effect on flow patterns, and pigging requirements may require small and tapered step changes at the mating faces.

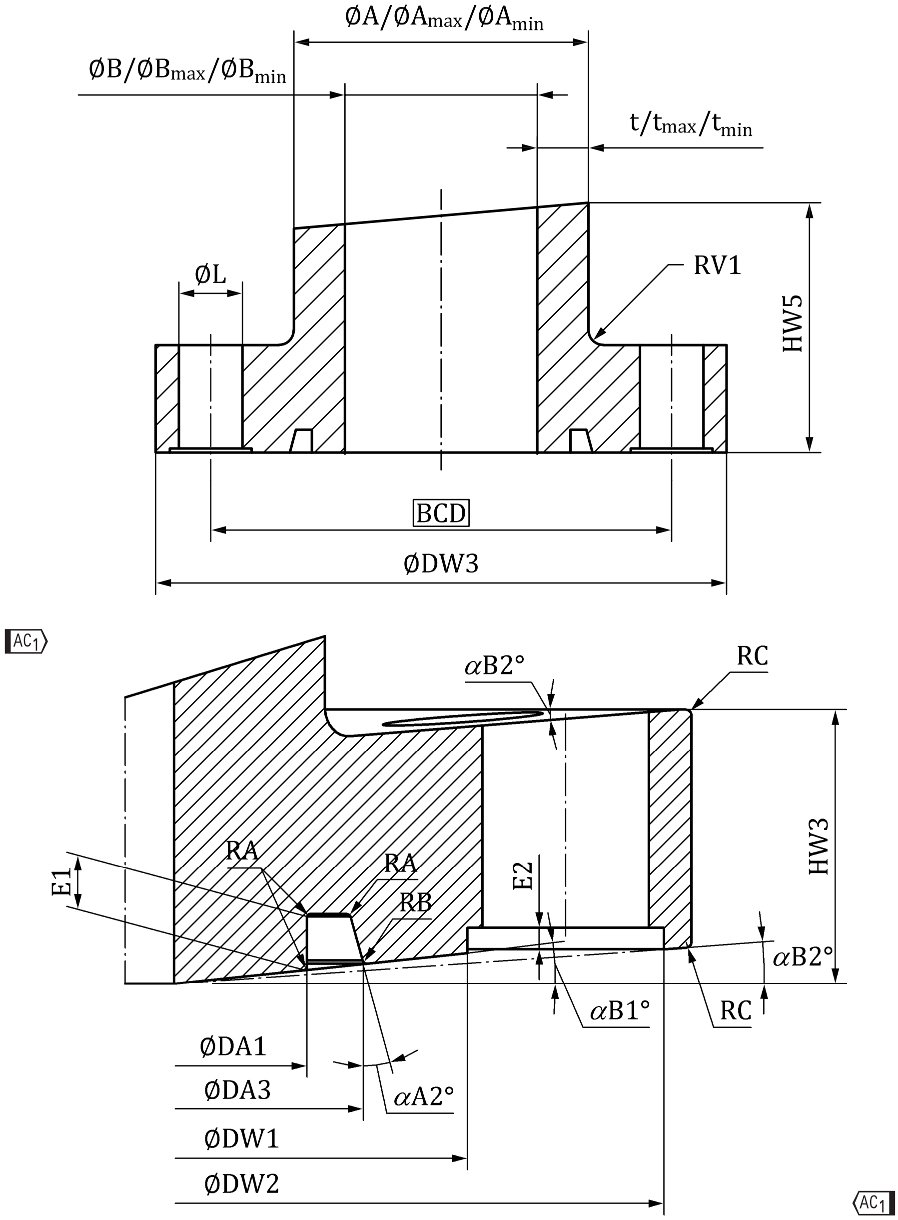


Figure 4 — Nomenclatures for integral flanges

Table 15 — Dimensions for CL 150 integral flanges (IFs)

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 16 — Dimensions for CL 300 integral flanges (IFs)

CL 300									
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	239,88	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 17 — Dimensions for CL 600 integral flanges (IFs)

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 18 — Dimensions for CL 900 integral flanges (IFs)

CL 900									
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	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 19 — Dimensions for CL 1500 integral flanges (IFs)

CL 1500									
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	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

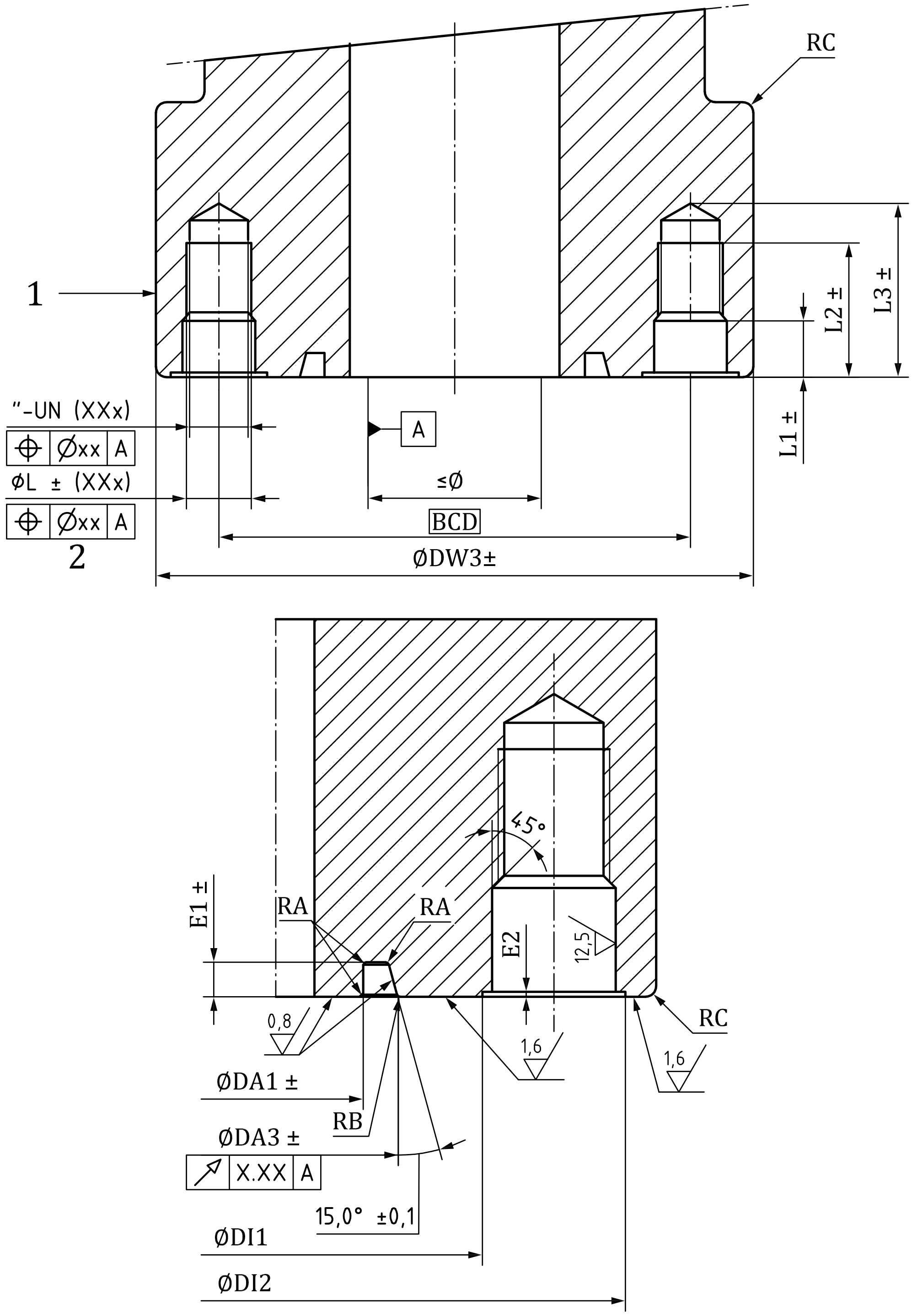
Table 20 — Dimensions for CL 2500 integral flanges (IFs)

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

8.5 Rigid interface (RI) dimensions

Dimensions specific to rigid interfaces are given in this clause and are defined in Figure 5 and Table 21. Rigid interfaces shall be made with seal grooves as specified in 8.5. The threaded bolt holes shall be made with minimum free hole depths and minimum thread engagement lengths as shown in Table 21.

Flange bore shall not exceed the maximum bore listed for WN flanges. Diameters DI1 and DI2 shall be the same as diameters DW1 and DW2 respectively, and as given in Table 7 to Table 12 for WN flanges. The thickness of an RI flange shall be minimum 2,5 x HW3 (see 8.4, fourth paragraph). Rigid interfaces with zero angles αB1 and αB2 may also be used for wafer type valve or equipment designs.



Key

1 Marking

2 Equal spacing

Figure 5 — Nomenclatures for rigid interfaces

Table 21 — Bolt related flange data for rigid interfaces (RIs)

Nominal bolt size	Free hole depth	Free hole plus thread engagement	Total depth	Bolt hole diameter	Recess
	L1 ± 1	L2 ± 1	L3 ± 1	L	E2
in	mm	mm	mm	mm	mm
½	13	34	42	15	1,0
⅝	15	42	52	18	1,0
¾	18	51	62	22	1,0
⅞	21	59	72	25	1,0
1	24	67	81	29	1,5
1 ⅛	27	75	90	32	1,5
1 ¼	31	82	98	35	1,5
1 ⅜	34	90	107 ± 2	38	1,5
1 ½	37	99	117	42	1,5
1 ⅝	41	107 ± 2	126	45	1,5
1 ¾	44	116	136	49	1,5
1 ⅞	47	123	144	52	1,5
2	50	131	153	55	2,0
2 ¼	57	148	171	62	2,0
2 ½	63	163	188	68	2,0
2 ¾	69	179	206	74	2,0
3	76	195	224	81	2,5
3 ¼	83	211	242	88	2,5
3 ½	89	227	260	94	2,5
3 ¾	96	243	277	101	2,5
4	102	259	295	107	2,5

NOTE 1 Thread engagement meets the maximum specified requirements in ASME VIII, Div.2:2007, chapter 4.5.3.

NOTE 2 Values of L1, L2 and L3 may not be applicable for wafer type valves or other pressure accessories with through-hole.

The outer diameter DA3 of the grooves and the groove angle of 15 ° as shown in Figure 6 and given in Table 22, are only valid for the flat face flanges, i.e. RI, PS, PB and OS flanges.

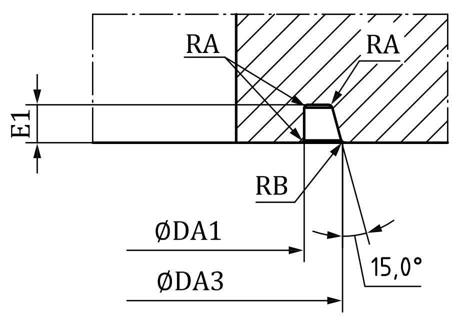


Figure 6 — Nomenclatures for IX seal grooves for flat face flanges

Table 22 — Dimensions of IX seal ring grooves for flat face flanges

DN	NPS	IX size	DA1 mm	DA3 mm	E1 mm	αA2 °
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

8.6 Dimensions of paddle blanks (PB) and paddle spacers (PS)

PB flanges and PS flanges are defined in Figure 7 and Figure 8 respectively, and shall be made with seal grooves as specified in 8.5. Table 23 lists the minimum thickness of PB flanges and PS flanges. All general flange dimensions shall be according to WN flanges as listed in Table 7 to Table 12. 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 be the same as for the BL flange; see 8.3 and Table 13.

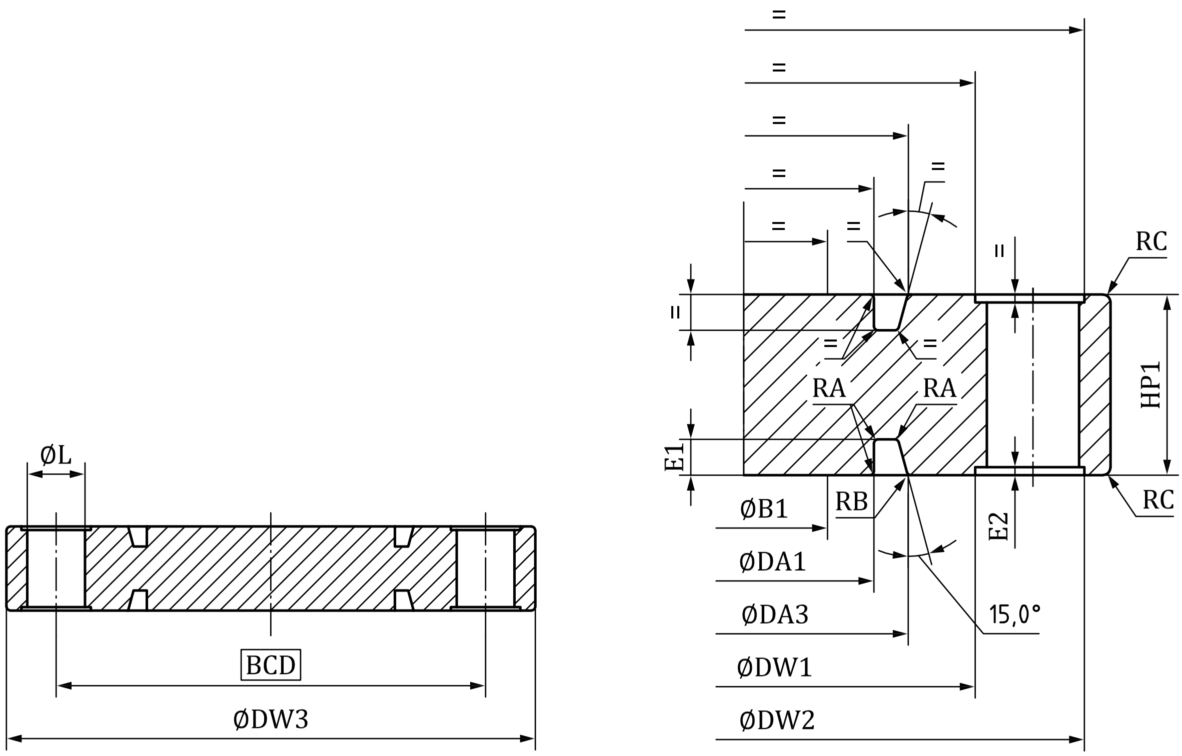


Figure 7 — Nomenclatures for paddle blank (PB) flanges

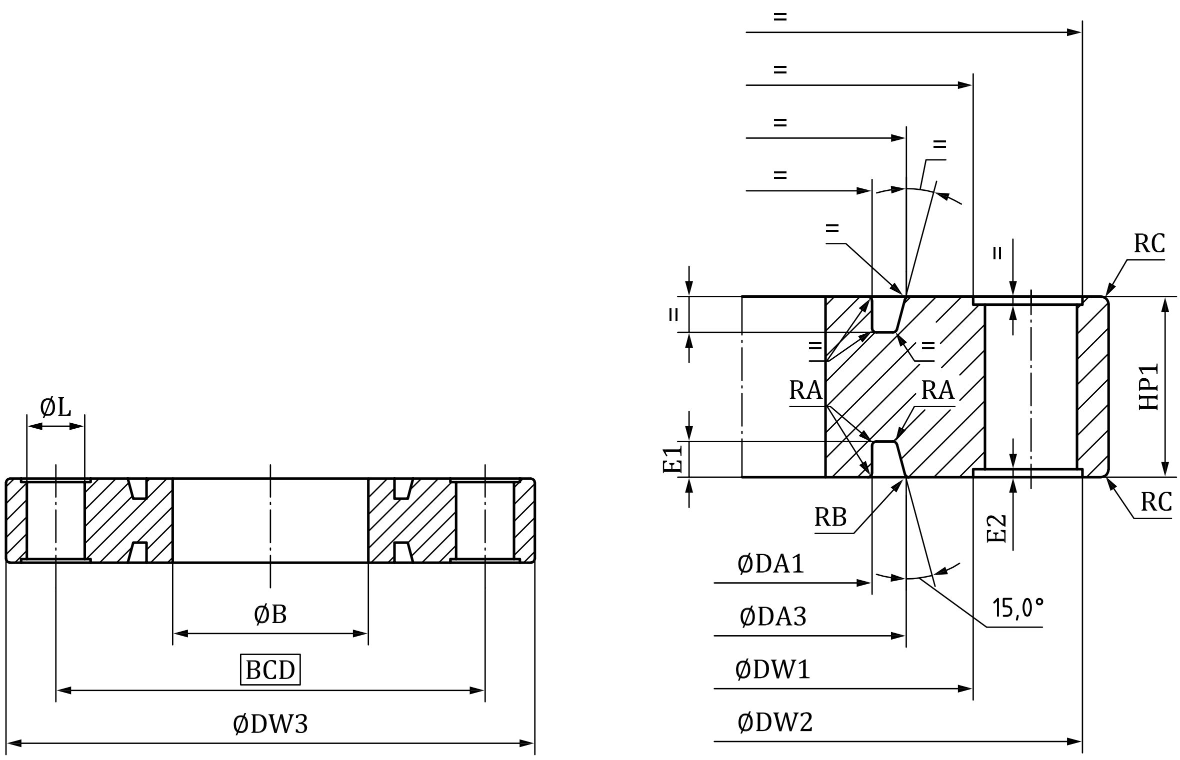


Figure 8 — Nomenclatures for paddle spacer (PS) flange

Table 23 — Flange thickness (HP1) for paddle spacer (PS) flanges and paddle blank (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	

8.7 Handle and lifting lugs

The handles for paddle blanks and spacers shall follow the design as shown in Figure 9.

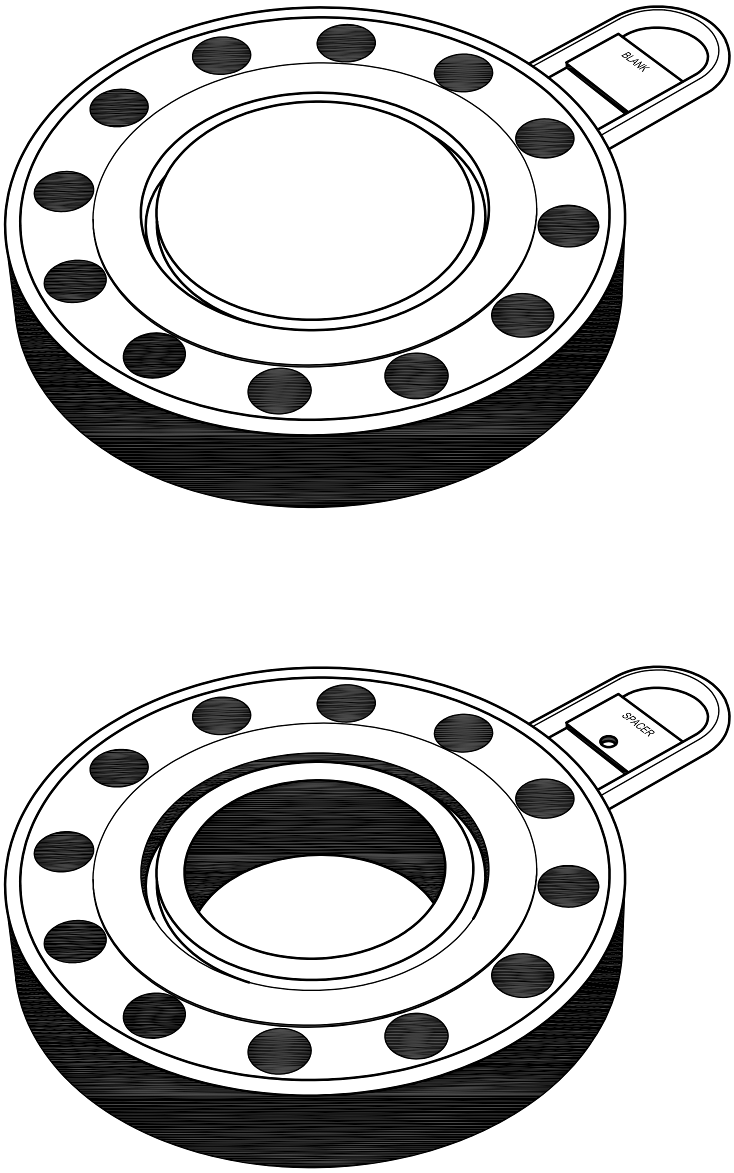


Figure 9 — Handles and lifting lugs for paddle blanks (PBs) and paddle spacers (PSs)

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.

The handles for PSs shall be provided with a Ø12 mm hole as shown in Figure 9. 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 mass 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.

8.8 Dimensions of orifice spacers (OS)

Orifice spacers for measurement of flow shall have the internal plate and test ports designed and manufactured (as part of the spacer) in accordance with ISO 5167-1 and ISO 5167-2:2003, 5.2.3. A design suitable for compact flanges is shown in Figure 10.

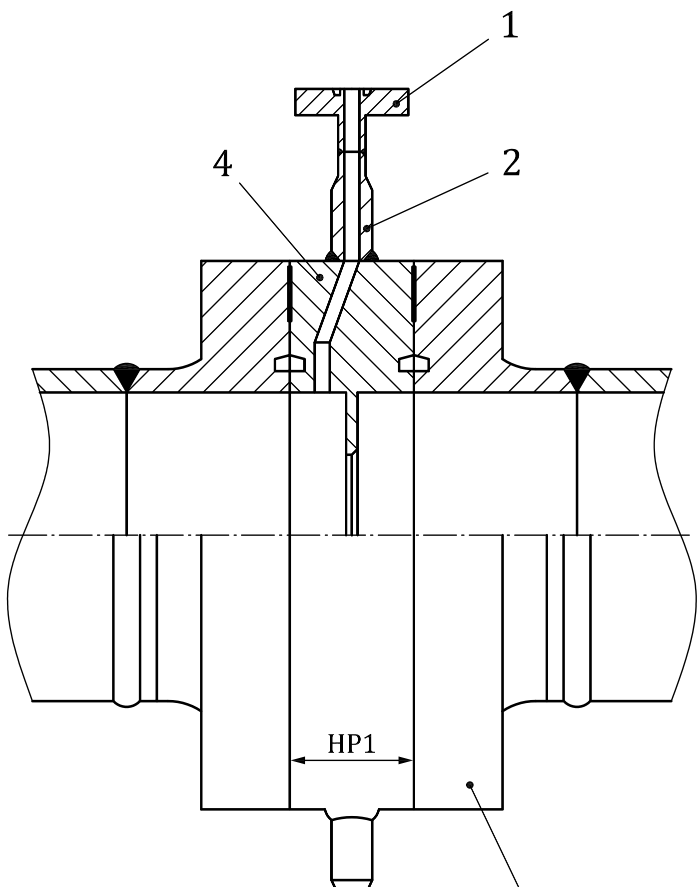
When orifice spacers for measurement of flow are designed in accordance with Figure 10 and ISO 5167-2:2003, 5.2.2.3, Table 24 lists the minimum thickness of orifice spacers for measurement of flow. Adequate spacing between tappings shall be maintained in order to minimize localized heat input. Welding procedures shall be qualified such to avoid distortion of the spacer dimensions and shape.

OS may alternatively be designed in accordance with ISO 5167-2:2003, 5.2.3, i.e. with corner tappings in order to minimize thickness. In this case, however, minimum thickness shall never be less than the greater of 30 mm or the thickness of a PS according to Table 23. Flange tappings shall still be adequately spaced, and located at the centre plane of the spacer.

The location of the tapping holes shall be in the middle between two bolt holes.

Orifice spacers without pressure tappings, typically used for throttling of flow only, may use the flange thickness of PSs in Table 23.

Orifice spacers shall be made with seal grooves as specified in 8.5. All general flange dimensions shall be according to WN flanges as listed in Table 7 to Table 12. The bore diameter of an OS shall be the exact same as for WN flanges connected to it.



Key

1 1/2" Flange sch 160

2 1/2" Nipple × 90 mm length

3 Compact flange according to piping class

4 Orifice spacer with thickness minimum HP1

Figure 10 — Nomenclatures for rigid interfaces

Table 24 — Thickness, HP1 (mm), for orifice spacers (OS)

DN	NPS	CL 150	CL 300	CL 600	CL 900	CL 1500	CL 2500
50	2	80	80	80	80	80	80
65	2½	80	80	80	80	80	80
80	3	85	85	85	85	85	85
100	4	90	90	90	90	90	90
150	6	94	94	94	94	94	94
200	8	97	97	97	97	97	97
250	10	101	101	101	101	101	101
300	12	104	104	104	104	104	104
350	14	106	106	106	106	106	106
400	16	109	109	109	109	109	109
450	18	112	112	112	112	112	112
500	20	115	115	115	115	115	115
550	22	118	118	118	118	118	118
600	24	121	121	121	121	121	121

8.9 Dimensions of reducing threaded flanges (RTs)

Dimensions specific to the reducing threaded flanges can be found in Table 25, Table 26 and Table 27, and the nomenclatures are defined in Figure 11. All other dimensions are found in Table 7 to Table 12 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.

The application of threads according to ISO 7-1 is also acceptable. Marking shall be adapted accordingly.

AC1

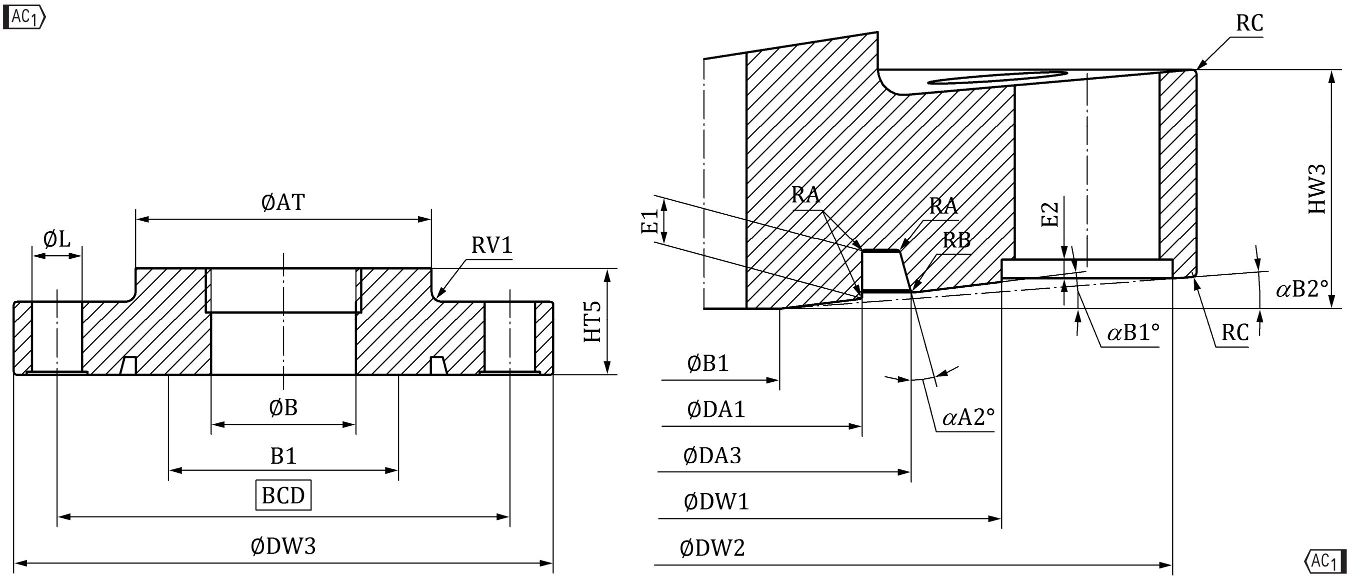


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Figure 11 — Nomenclatures for RTs

Table 25 — Dimensions for CL 150 and CL 300 reducing threaded flanges (RTs)

DN	NPS	AT mm	B1 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 26 — Dimensions for CL 600, CL 900 and CL 1500 reducing threaded flanges (RTs)

DN	NPS	AT mm	B1 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 27 — Dimensions for CL 2500 reducing threaded flanges (RTs)

DN	NPS	AT mm	B1 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

8.10 Auxiliary connections

Auxiliary connections or openings for flanged fittings (such as test ports) are not required unless specified by the purchaser.

Tapping holes shall be tapped radially on the outer edge of a flange, centralized between two bolt holes, and may either be threaded or attached by butt welding directly to the outer edge of the flange.

Welding to attach auxiliary connections to flanges shall be made by a qualified welder using a qualified weld procedure in accordance with the relevant design Code. No welding is accepted in the elliptical transition for the WN flange (see Figure 2) as well as in the crotch radius for the IF (see Figure 4) manufactured in line with this International Standard. Socket welding is not acceptable.

Unless otherwise specified, integrally reinforced branch connections shall be used for welded connections.

Auxiliary connections shall not be made on flange rims smaller than DN 400, or where HW3 is smaller than 40 mm. The connection shall be DN 15 (NPS ½), unless otherwise specified by the purchaser.

8.11 Flange tolerances

Tolerances applicable to all types of flanges according to this International Standard can be found in Table 28. Medium tolerances specified in ISO 2768-1 shall be used for non specified tolerances.

Table 28 — Flange dimensional tolerances

Dimension	Flange type	Size range	Tolerance mm
Outside diameter at weld end (A)	WN	≤ DN 100 > DN 100 ≤ DN 350 > DN 350 ≤ DN 600 > DN 600	–0+0,6 -0+1,0 -0+1,6 -0+2,4
Bore diameter (B)	WN, IF, PS, OS, RT	≤ DN 100 > DN 100 ≤ DN 350 > DN 350 ≤ 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	≤ 150 mm OD > 150 mm ≤ 620 mm OD > 620 mm OD	± 0,5 ± 0,8 ± 1,2
Overall length of flange (HW5 and HT5)	WN, RT	< 120 mm length ≥ 120 mm ≤ 400 mm length > 400 mm length	± 0,8 ± 1,2 ± 2,0
Flange thickness HW3 (HP1)	WN, BL, IF, PS, PB, OS, RT	≤ 30 mm thickness > 30 mm ≤ 60 mm thickness > 60 mm ≤ 120 mm thickness > 120 mm thickness	± 0,5 ± 0,8 ± 1,2 ± 2,0
Groove OD run out [a]	ALL	≤ DN 125 > DN 125 ≤ DN 600 > DN 600	-0+0,10 -0+0,15 -0+0,20
ID of groove (DA1)	ALL	≤ DN 125 > DN 125 ≤ DN 600 > DN 600	± 0,2 ± 0,3 ± 0,5
OD of groove (DA3)	ALL	≤ DN 80 > DN 80 ≤ DN 550 > DN 550	± 0,05 ± 0,1 ± 0,15
Groove angle (α A2)	ALL	≤ DN 500 > DN 500	± 0,1° ± 0,15°
Face angle (α B1)	WN, IF. BL, RT	all sizes	± 7,5 %
Effective face angle (α B2)	WN, IF. BL, RT	all sizes	± 7,5 %
Rear face angle (αB2)	WN, IF. BL	all sizes	± 15 %
Flange face flatness	RI, OS	all sizes	± 7,5 % of gap at DW3 for blind flange in same size and pressure class
IX seal groove depth (E1)	ALL	≤ DN 250 > DN 250 ≤ DN 450 > DN 450 ≤ DN 650 > DN 650 ≤ DN 850 > DN 850 ≤ DN 1050 > DN 1050	± 0,15 ± 0,20 ± 0,30 ± 0,40 ± 0,50 ± 0,60
Bolt hole diameter (L)	ALL	Bolt sizes to ¾ in Bolt sizes to $^{7}/_{8}$ in to 2 ½ in Bolt sizes to 2 $^{3}/_{4}$ in to 4 in	± 0,3 ± 0,5 ± 0,8
Bolt hole position tolerance	ALL	Bolt sizes to ¾ in Bolt sizes to $^{7}/_{8}$ in to 2 ½ in Bolt sizes to 2 $^{3}/_{4}$ 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] Concentricity of the outside diameter of the groove to the centreline of the flange.			

8.12 Surface finish

The flange surfaces shall be machined to comply with the requirements of Table 29 (see Figure 12), i.e. with the most stringent requirements to the sealing surfaces of the heel and the IX seal groove, see ISO 4287. A sample of at least 10 % of the batch shall be checked by methods defined in ISO 4288. For integral flanges the limit of machining is defined by dimension HW5.

It is not acceptable to supply flanges with any imperfections on flange sealing faces (i.e. OD surface of IX groove, Flange heel face and wedge) as shown in Figure 1.

Table 29 — 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

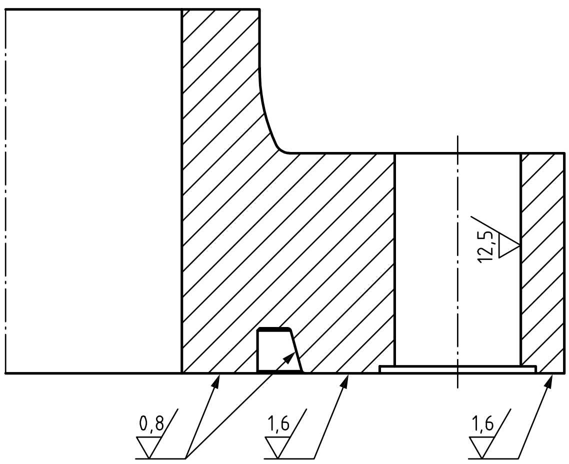


Figure 12 — Surface finish

9 Marking of flanges

9.1 Flanges other than integral flanges

Flanges other than IFs and RIs shall be marked with the following information:

a) the manufacturer's name or trade-mark (see 9.2) ABCO

b) the type of flange (see Table 2) WN, BL, PB, PS, OS, RT

c) the ISO standard identification ISO NNNN

d) the nominal size (DN) (see 9.3) DN 00

e) the pressure class (CL) designation (see 9.4) CL 000

f) the pipe dimensions (see 9.5) 12.5

g) the material designation (see 9.6) A182-F316

h) the thread identification where appropriate (see 9.7) ¾-14NPT

i) the heat number, or melt number or suitable quality control number traceable to the heat number (see 9.8) 000000

NOTE Where a flange is subsequently used to form an integral part of a component and the component has a lower pressure rating than that of the flange, the lower rating should be clearly marked on the component,

9.2 Manufacturer's name or trademark

Manufacturer's name or trademark shall be applied. Phrasing shall be such that confusion with subsequent marking of the component is avoided.

9.3 Nominal size

Only nominal diameter (DN) shall be applied. Table 6 governs reference to nominal pipe size (NPS).

9.4 Pressure class designation

Only pressure class (CL) in accordance with ASME B16.5 shall be applied. Table 5 governs reference to nominal pressure (PN). When flanges of type BL, OS, PB and PS are identical for several pressure classes, the flange shall be marked with the specified pressure class designation, and can be marked with all pressure class designations when specified by the purchaser.

9.5 Pipe dimensions

For standard pipes, the wall thickness shall be given in mm to the accuracy of one decimal. For non-standard pipes, the nominal pipe bore and wall thickness shall be given.

9.6 Material designation

The material designation shall be the minimum information required to identify the material in the finished condition, e.g. the grade identification, preceded by the specification (standard) number where necessary.

EXAMPLE

a) A182-F316

b) EN 10222-5 Gr 1.4462

9.7 Identification of internally threaded flanges

Internally threaded flanges shall be marked to indicate the type of thread used.

Threads to ASME B1.20.1 shall be designated by the nominal size, number of threads per inch and the letters NPT, e.g. 3/4-14NPT.

Threads to IS0 7-1 shall be designated by the letter symbols Rc or Rp, as appropriate, in accordance with IS0 7-1 followed by the nominal size, e.g. Rc 3/4.

9.8 Material traceability

The number (either heat-, melt- or quality control number) used to identify the component for material traceability shall in an unambiguous way link the certification provided with the quality of the material of the component proper in the finished condition.

9.9 Marking examples

EXAMPLE 1: A 10” class 600 welding neck, WN, from a supplier by the name of XXX supplying in stainless steel from a heat no. F1245:

XXX/WN/ISO 27509/DN250/CL600/9.3/A182-F316/F1245

EXAMPLE 2: A 6” class 900 blind flange, BL, from a supplier by name YYY supplying in 22Cr. Duplex steel from heat no. F1277:

YYY/BL/ISO 27509/DN150/CL 900/A182-F51/F1277

EXAMPLE 3: A 1” class 900 reducing threaded flange, RT, from a supplier by name ZZZ supplying in stainless steel from heat no. F1299:

ZZZ/RT/ISO 27509/DN25/CL900/0,5”NPT/A182-F316/F1299

Optional marking, see 9.4:

ZZZ/RT/ISO 27509/DN25/CL600-CL1500/0.5”NPT/A182-F316/F1299

Alternative marking in case of threads to ISO 7-1, R_c ½:

ZZZ/RT/ISO 27509/DN25/CL600-CL1500/ISO7-Rc 0.5/A182-F316/F1299

All flanges, other than IFs shall be marked with the suppliers trade mark followed by the flange designation and material charge (cast) identification as follows:

— supplier's name or trade mark;

— designation according to 5.1;

— cast number of melt identification or suitable quality control number traceable to the cast number.

All elements shall be separated by a slash. The number of characters is not fixed.

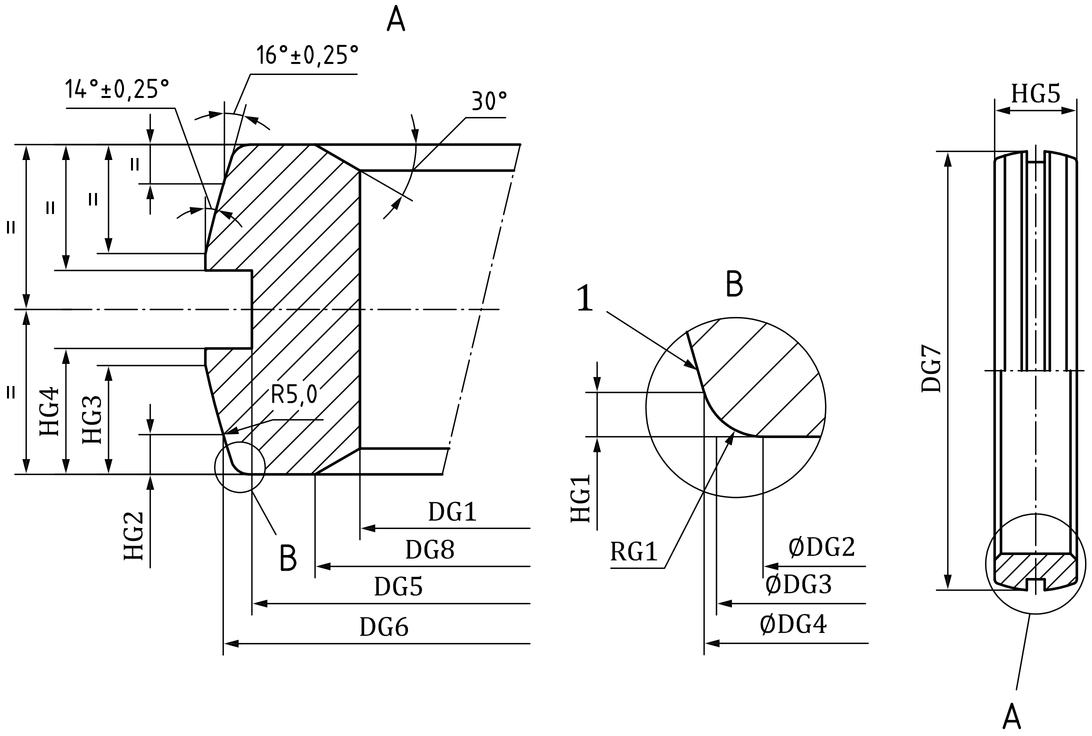
9.10 Stamping

Where steel stamps are used, the marking shall be positioned on the outer edge 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. low stress die stamps.

10 Dimensions of seal rings

The IX seal ring described in this clause is the only seal ring, which is accepted for use together with the flanges contained in this International Standard. The IX seal ring design exists in one size per DN covering all pressure classes included in this standard.

The dimensions and mass of the seal rings are defined by Figure 13 and Table 30. All seal ring surfaces shall be machined finished with maximum surface roughness in accordance with Table 31 (see ISO 4287). Dimensional tolerances shall be according to Table 32. Medium tolerances specified in ISO 2768-1 shall be used for non specified tolerances. It is not required to machine a specific corner radius inside the groove of the seal ring.



Key

1 R_a 0,8 both sides extending from ⌀DG7 to ⌀DG2

Figure 13 — IX seal ring nomenclatures

Table 30 — Dimensions of IX seal rings and their mass

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	Mass 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 31 — Surface finish for seal rings

Location	R_a max. µm
Sealing faces, both sides extending from DG7 to DG2, see Figure 13.	0,8
All other surfaces	6,3

Table 32 — IX seal ring dimensional tolerances

Dimension	Size range	Tolerance mm
ID (DG1)	≤ IX80	±0,2
	> IX80 ≤ IX350	±0,3
	> IX350	±0,4
Diameter bottom recess (DG5)	≤ IX80	±0,1
	> IX80 ≤ IX350	±0,2
	> IX350	±0,4
Diameter, DG6	≤ IX150	-0/+0,1
	> IX150	-0/+0,2
OD of ring (DG7)	≤ IX150	-0/+0,1
	> IX150	-0/+0,2
Height, HG2	≤ IX40	±0,05
	> IX40 ≤ IX200	±0,1
	> IX200 ≤ IX400	±0,2
	> IX400 ≤ IX600	±0,3
	> IX600 ≤ IX800	±0,4
	> IX800 ≤ IX1000	±0,5
	> IX1000	±0,6
Height to end angle (HG3)	≤ IX40	±0,05
	> IX40 ≤ IX200	±0,1
	> IX200 ≤ IX400	±0,2
	> IX400 ≤ IX600	±0,3
	> IX600 ≤ IX800	±0,4
	> IX800 ≤ IX1000	±0,5
	> IX1000	±0,6
Height of ring (HG5)	≤ IX150	-0,1/+0
	> IX150 ≤ IX350	-0,2/+0
	> IX350 ≤ IX550	-0,3/+0
	> IX550 ≤ IX700	-0,4/+0
	> IX700 ≤ IX900	-0,5/+0
	> IX900 ≤ IX1100	-0,6/+0
	> IX1100	-0,7/+0

11 Inspection and testing of seal rings

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

It is not acceptable to supply IX seal rings with any imperfections on sealing faces (i.e. outer chamfered facings) as shown in Figure 13.

12 Coating and colour coding

The application of coatings up to a thickness of 30 µm on the outer surface of the seal ring is allowed. The coating may be PTFE based, and it shall prevent galling between seal ring and the groove during assembly without impairing the sealing integrity. The type of coating should therefore be qualified to a procedure agreed with the purchaser. For appropriate initial sealing it is paramount that the coating is evenly distributed, and that it provides a smooth and even surface through the whole sealing circumference of the seal ring.

If seal rings are supplied without coating on sealing surfaces, reference is made to Annex F.7.3 on how to provide a good initial seal with the flange groove. .

If applying colour coding to identify material of seal rings, the colour coding may be included as pigment added to the coating if this would not impair the functional performance of the coating as outlined in first paragraph above.

13 Marking of seal rings

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

— suppliers name;

— designation;

— charge identification or suitable quality control number traceable to the cast number, e.g. F1245.

EXAMPLE (XXX supplier):

XXX/ISO 27509/F1245/IX250/A182F51

Engraving or other suitable marking shall be positioned on the inner diameter of the ring or on one of the edges facing the bottom of the ring grooves of the flanges. Care should be taken that the sealing faces are not damaged neither by the process of marking nor by the prolonged exposure to substances used.

14 Quality management systems

The product manufacturer may use a quality management system (QMS). Requirements relating to the QMS are described in Annex C.

15 Bolt dimensions and masses

Standard bolts to recognized standards for piping materials may be used to assemble flanges according to this International Standard (see 6.3). Dimensions, i.e. appropriate lengths, number off, and corresponding weights of sets of bolts and nuts for the different sizes and pressure classes can be found in Annex D, which also describes the dimensions of washers/sleeves where this should be used, in order to ensure sufficient length to control bolting load properly during assembly.

Annex A
(normative)

Pressure temperature ratings and shear capacity of seal rings

A.1 Flange structural capacity and shear capacity of seal rings

A.1.1 General

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 δ_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

A.1.2 Capacity

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

$$F_f = \frac{W_F}{e} \tag{A.1}$$

$$F_{fP} = \frac{W_F}{e_p} + F_{cB} \times \frac{e_B}{e_p} \tag{A.2}$$

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

$$W_F = \frac{\pi}{4} \times f_y \times \left[2 \times b \times HW3^2 + 2{,}2 \times c_S \times HW3 \times t \times \sqrt{d_P \times t} + c_M \times d_p \times t^2 \right] \tag{A.3}$$

where

$$\delta_Q = \frac{p \times d_P}{2 \times f_y \times t} \tag{A.4}$$

$$c_M = \sqrt{1 - 0{,}75 \times \delta_Q^2} \tag{A.5}$$

$$c_S = \sqrt{c_M \times \left(0{,}5 - 0{,}4 \times \delta_Q\right)} \tag{A.6}$$

$$b = \frac{\left(DW3 - B\right)}{2} - L \tag{A.7}$$

$$e_B = \left[\frac{(DW3 + DW2)}{2} - BCD\right] \times 0{,}5 \tag{A.8}$$

$$e_p = \left[\frac{(DW3 + DW2)}{2} - d_p\right] \times 0{,}5 \tag{A.9}$$

A.1.3 Loads

$$F_{End} = \frac{\pi \times DG4^2}{4} \times p \tag{A.10}$$

$$F_R = F_A + \frac{4}{BCD} \times M_A \tag{A.11}$$

A.1.4 Flange utilization ratio

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

A.1.5 Allowable utilization ratios

Table A.1 — Allowable utilization 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 ≤ 10^{-2}
ψ	< 0,9	Hydrostatic pressure test
ψ	< 1,0	Accidental loads, annual probability of ≤ 10^{-4}

EXAMPLE Calculation of compact flanged connection WN/ISO 27509/DN200/CL1500/18.26

Design pressure: 250 bar

Design temperature: 100 °C

Design tension: 500 kN

Design bending moment: 40 kNm

<u>MATERIAL PROPERTIES @ 100 °C</u>

Yield strength of flange: f_{yb} = 395 MPa

Yield strength of bolts: f_{yb} = 672 MPa

FLANGE DIMENSIONS

Pipe outer diameter:	$A = 219{,}1$ mm	Pipe wall thickness:	$t = 18{,}26$ mm
Pipe bore diameter:	$B = A - 2t$		$B = 182{,}58$ mm
Bolt size	$d_B = 1.\text{in}$	Bolt root area:	$a_b = 355{,}41\ \text{mm}^2$
Number of bolts:	$n = 16$	Total bolt root area	$A_b = a_b.n$
			$A_b = 5686{,}56\ \text{mm}^2$
Bolt hole diameter:	$L = 29$ mm		
Outside diameter of flange:	$DW3 = 365$ mm	Outer recess diameter:	$DW2 = 355$ mm
Flange thickness:	$HW3 = 60$ mm	Bolt circle diameter:	$BCD = 317{,}4$ mm
Seal diameter:	$DG4 = 235{,}10$ mm		

CALCULATED GEOMETRICAL PROPERTIES:

Pipe cross-sectional area:	$A_R = \frac{\pi}{4} \cdot \left(A^2 - B^2\right)$	$A_R = 1{,}152 \times 10^4\ \text{mm}^2$
Average pipe diameter:	$d_p = 0{,}5\ (A + B)$	$d_p = 200{,}84$ mm
Effective flange width:	$b = \frac{DW3 - B}{2} - L$	$b = 62{,}21$ mm
Distance pipe wall centre to bolt circle:	$e = (BCD - d_p) \cdot 0{,}5$	$e = 58{,}28$ mm
Distance pipe wall centre to outer diameter:	$e_p = \left(\frac{DW3 + DW2}{2} - \frac{A + B}{2}\right) \cdot 0{,}5$	$e_p = 79{,}58$ mm
Distance outer diameter to bolt circle:	$e_B = \left[\left(\frac{DW3 + DW2}{2}\right) - BCD\right] \cdot 0{,}5$	$e_B = 21{,}3$ mm

LOADS:

Internal pressure:	$p = 250$ bar	
Applied axial tension:	$F_A = 500$ kN	
Applied moment:	$M_A = 40$ kN m	
Resulting applied tension	$F_R = F_A + \frac{4}{BCD} \cdot M_A$	$F_R = 1{,}004 \times 10^3$ kN
End cap force:	$F_{end} = \frac{\pi \cdot DG4^2}{4} \cdot p$	$F_{end} = 1{,}085 \times 10^3$ kN

CAPACITY CALCULATIONS:

Bolt capacity:	$F_{cB} = A_b \cdot f_{yb}$	$F_{cB} = 3{,}821 \times 10^3$ kN
Flange capacity:	$\delta_Q = \dfrac{p \cdot d_p}{2 \cdot f_y \cdot t}$	$\delta_Q = 0{,}348$
	$C_m = \sqrt{1 - 0{,}75 \cdot \delta_Q{}^2}$	$C_m = 0{,}953$
	$C_s = \sqrt{C_m \cdot (0{,}5 - 0{,}4 \cdot \delta_Q)}$	$C_s = 0{,}587$
Warping capacity:	$W_f = \dfrac{\pi}{4} \cdot f_y \cdot \left(2 \cdot b \cdot HW3^2 + 2{,}2 \cdot C_s \cdot HW3 \cdot t \cdot \sqrt{d_p \cdot t} + C_m \cdot d_p \cdot t^2\right)$	$W_f = 185{,}324$m kN
Tension capacity for flange only:	$F_f = \dfrac{W_f}{e}$	$F_f = 3{,}18 \times 10^3$ kN
Tension capacity for flange only:	$F_{fp} = \dfrac{W_f}{e_p} + F_{cB} \cdot \dfrac{e_B}{e_p}$	$F_{fp} = 3{,}352 \times 10^3$ kN
Flange utilization:	$\psi = \dfrac{F_{End} + F_R}{\min\left(\left(F_{fp} \quad F_{cB}\right)\right)}$	$\psi = 0{,}623$

A.2 IX seal ring shear force capacity

During installation the IX seal shall not be subjected to shear loads greater than the capacity values listed in Table A.2.

Table A.2 — Shear force capacity of IX seal rings

DN mm	NPS in	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 B
(informative)

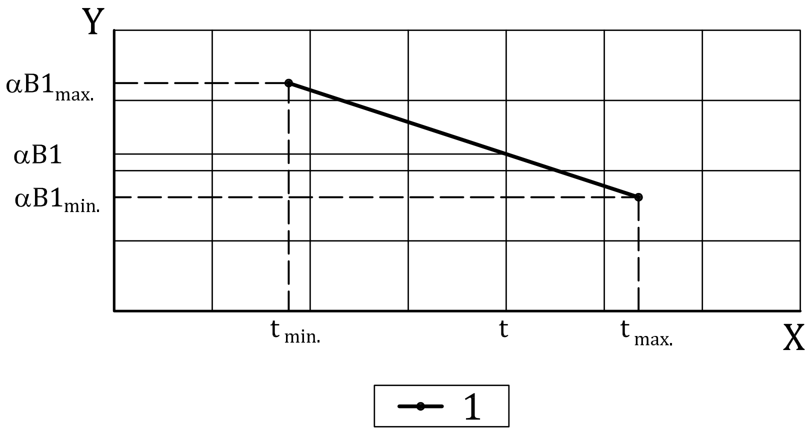
Integral flange angle selection

B.1 General

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

B.2 Method 1: Use flange length HW5 and interpolated face angle within thickness range given in Table 15 to Table 20

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 Table 15 to Table 20. DA3, αA2, αB1 and αB2 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}.



Key

X Wall thickness

Y Face angle

1 Standard range

Figure B.1 — Linear behaviour between wall thickness and flange face angle

B.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-sectional area approach gives background for calculating the equivalent wall thickness, from which a relevant face angle can be found.

Examples are given in B.4.

B.4 Examples

B.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

Optimized seal groove outer diameter:

$$\begin{aligned} DA3 &= \frac{(DA3_{max} - DA3_{min})}{(t_{max} - t_{min})} \times (t_{max} - t) + DA3_{min} \\ &= \frac{349{,}08 - 348{,}77}{56{,}35 - 14{,}27} \times (56{,}35 - 25{,}55) + 348{,}77 = 349 \text{ mm} \end{aligned} \tag{B.1}$$

Optimized seal groove angle:

$$\begin{aligned} \alpha A2 &= \frac{(\alpha A2_{max} - \alpha A2_{min})}{(t_{max} - t_{min})} \times (t_{max} - t) + \alpha A2_{min} \\ &= \frac{15{,}4 - 15{,}2}{56{,}35 - 14{,}27} \times (56{,}35 - 25{,}55) + 15{,}2 = 15{,}3^{\circ} \end{aligned} \tag{B.2}$$

Optimized face angle:

$$\begin{aligned} \alpha B1 &= \frac{(\alpha B1_{max} - \alpha B1_{min})}{(t_{max} - t_{min})} \times (t_{max} - t) + \alpha B1_{min} \\ &= \frac{0{,}57 - 0{,}24}{56{,}35 - 14{,}27} \times (56{,}35 - 25{,}55) + 0{,}24 = 0{,}48^{\circ} \end{aligned} \tag{B.3}$$

Optimized rear face bevel angle:

$$\begin{aligned} \alpha B2 &= \frac{(\alpha B2_{max} - \alpha B2_{min})}{(t_{max} - t_{min})} \times (t_{max} - t) + \alpha B2_{min} \\ &= \frac{0{,}38 - 0{,}16}{56{,}35 - 14{,}27} \times (56{,}35 - 25{,}55) + 0{,}16 = 0{,}32^{\circ} \end{aligned} \tag{B.4}$$

All other dimensions shall be according to specified values.

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

Specifications:

Pressure class CL 1500

Pipe size DN 750

Valve dimensions (see Figure B.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

Dimensions in millimetres

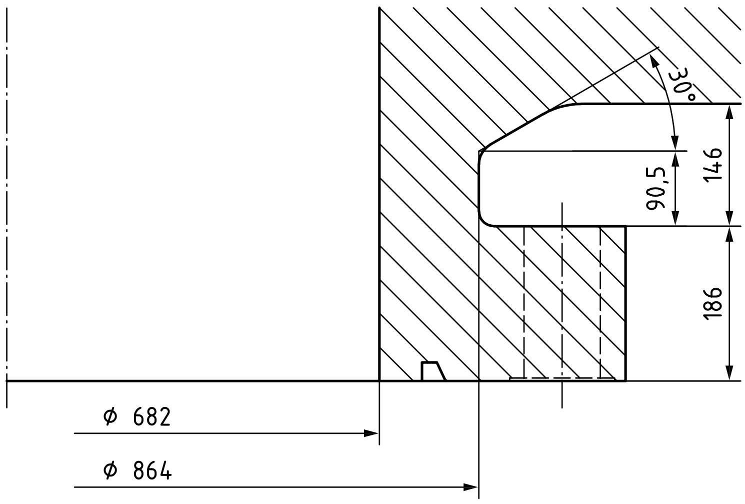
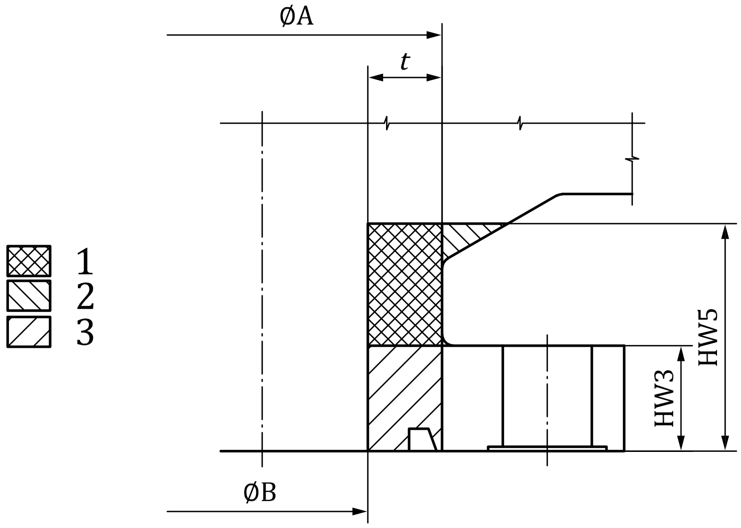


Figure B.2 — Valve design, example B.4.2

<u>Other essential dimensions:</u>

Flange overall length, HW5 304,0 mm

Flange thickness, HW3 186,0 mm



Key

1 $A_{n/p}$ = Area neck/pipe

2 A_{viv} = Area additional from valve body

3 A_r = Area flange ring, pipe part

Figure B.3 — Cross-sectional areas, example B.4.2

True cross-sectional area for actual wall thickness (see Figure B.3.):

$$\text{Area}_{eqv} = A_r + A_{n/p} + A_{v/v} =$$

$$= HW3 \times t + \left[(HW5 - HW3) \times t\right] + \left[\frac{(HW5 - HW3 - 90{,}5) \times \frac{HW5 - HW3 - 90{,}5}{\tan(30^\circ)}}{2}\right] =$$

$$= 186{,}0 \times 91{,}0 + \left[(304{,}0 - 186{,}0) \times 91{,}0\right] + \left[\frac{(304{,}0 - 186{,}0 - 90{,}5) \times \frac{304{,}0 - 186{,}0 - 90{,}5}{\tan(30^\circ)}}{2}\right] = 28319 \ \text{mm}^2 \quad \text{(B.5)}$$

Equivalent wall thickness:

$$t_{eqv} = \frac{\text{Area}_{eqv}}{HW5} = \frac{28\,319}{304} = 93{,}15 \text{ mm} \quad \text{(B.6)}$$

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

Optimized seal groove outer diameter:

$$DA3 = \frac{(DA3_{max} - DA3_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + DA3_{min}$$
$$= \frac{802{,}49 - 801{,}76}{116{,}0 - 36{,}0} \times (116{,}00 - 93{,}15) + 801{,}76 = 801{,}97 \text{ mm} \quad \text{(B.7)}$$

Optimized seal groove angle:

$$\alpha A2 = \frac{(\alpha A2_{max} - \alpha A2_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + \alpha A2_{min} = \frac{15,4 - 15,2}{116,0 - 36,0} \times (116,0 - 93,15) + 15,2 = 15,3° \quad (B.8)$$

Optimized face angle:

$$\alpha B1 = \frac{(\alpha B1_{max} - \alpha B1_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + \alpha B1_{min} = \frac{0,62 - 0,28}{116,0 - 36,0} \times (116,0 - 93,15) + 0,28 = 0,38° \quad (B.9)$$

Optimized rear face bevel angle:

$$\alpha B2 = \frac{(\alpha B2_{max} - \alpha B2_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + \alpha B2_{min} = \frac{0,41 - 0,19}{116,0 - 36,0} \times (116,0 - 93,15) + 0,19 = 0,25° \quad (B.10)$$

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 in B.4.4 for procedure).

B.4.3 Special flange neck geometries with interpolated face angle from effective inner diameter and cross-sectional area estimation

Pipe requirements:

Pressure class	CL 1500
Pipe size	DN 700

Valve dimensions (see Figure B.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, ht	90,0 mm

Dimensions in millimetres

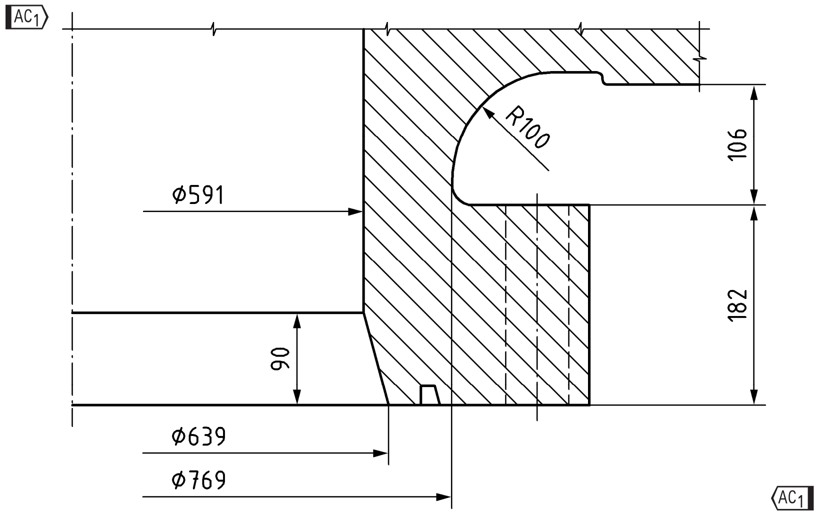
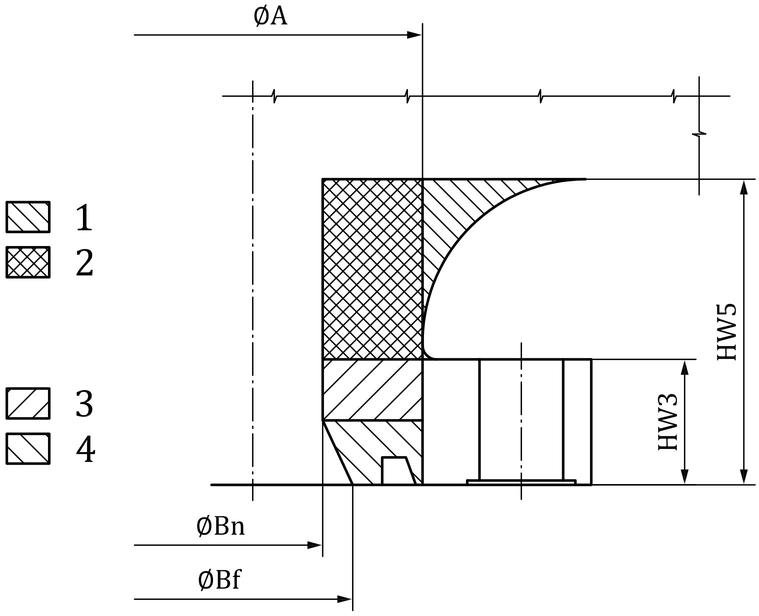


Figure B.4 — Valve design, example B.4.3



Key

1 A_{viv} = Area additional from valve body

2 $A_{n/p}$ = Area neck/pipe

3 A_{r2} = Area flange ring, pipe part

4 A_{r1} = Area flange ring ID transition, pipe part

Figure B.5 — Cross-sectional areas, example B.4.3

True cross-sectional area for actual wall thickness (see Figure B.5):

$$Area_{eqv} = A_{r1} + A_{r2} + A_{n/p} + A_{vlv} = 26431 \, mm^2 \tag{B.11}$$

where

$$A_{r1} = h_t \times \frac{\frac{A - B_n}{2} + \frac{A - B_f}{2}}{2} = 90 \times \frac{\frac{769{,}0 - 591{,}0}{2} + \frac{769{,}0 - 639{,}0}{2}}{2} = 6930 \, mm^2 \tag{B.12}$$

and

$$A_{r2} = (HW3 - h_t) \times \frac{A - B_n}{2} = (182{,}0 - 90) \times \frac{769{,}0 - 591{,}0}{2} = 8188 \, mm^2 \tag{B.13}$$

and

$$A_{n/p} = (HW5 - HW3) \times \frac{A - B_n}{2} = (285{,}0 - 182{,}0) \times \frac{769{,}0 - 591{,}0}{2} = 9167 \, mm^2 \tag{B.14}$$

and

$$A_{vlv} = r \times r - \pi \times r^2 \times \frac{90}{360} = 100 \times 100 - \pi \times 100^2 = 2146 \, mm^2 \tag{B.15}$$

Here the area A_{vlv} 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:

$$t_{eqv} = \frac{Area_{eqv}}{HW5} = \frac{26431}{285{,}0} = 92{,}74 \, mm \tag{B.16}$$

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

Optimized seal groove outer diameter:

$$\begin{aligned} DA3 &= \frac{(DA3_{max} - DA3_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + DA3_{min} \\ &= \frac{749{,}22 - 748{,}71}{106{,}90 - 36{,}0} \times (106{,}90 - 92{,}74) + 748{,}71 = 748{,}81 \, mm \end{aligned} \tag{B.17}$$

Optimized seal groove angle:

$$\begin{aligned} \alpha A2 &= \frac{(\alpha A2_{max} - \alpha A2_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + \alpha A2_{min} \\ &= \frac{15{,}3 - 15{,}2}{106{,}90 - 36{,}0} \times (106{,}90 - 92{,}74) + 15{,}2 = 15{,}2^\circ \end{aligned} \tag{B.18}$$

Optimized face angle:

$$\begin{aligned}\alpha B1 &= \frac{(\alpha B1_{max} - \alpha B1_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + \alpha B1_{min} \\ &= \frac{0{,}49 - 0{,}25}{106{,}90 - 36{,}0} \times (106{,}90 - 92{,}74) + 0{,}25 = 0{,}30^{\circ}\end{aligned} \quad \text{(B.19)}$$

Optimized rear face bevel angle:

$$\begin{aligned}\alpha B2 &= \frac{(\alpha B2_{max} - \alpha B2_{min})}{(t_{max} - t_{min})} \times (t_{max} - t_{eqv}) + \alpha B2_{min} \\ &= \frac{0{,}33 - 0{,}16}{106{,}90 - 36{,}0} \times (106{,}90 - 92{,}74) + 0{,}16 = 0{,}19^{\circ}\end{aligned} \quad \text{(B.20)}$$

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 B.2).

B.4.4 Special flange neck geometries with extrapolated face angle from effective inner diameter in “extended range” and cross-sectional area estimation

Pipe requirements:

Pressure class	CL 1500
Pipe size	DN 700

Valve dimensions (see Figure B.6):

Flange neck outer diameter, A	769,0 mm
Flange face inner diameter, Bf	581,0 mm
Flange neck inner diameter, Bn	555,0 mm
Height of inner diameter transition, ht	73,7 mm

The cross-sectional area estimation follows the previous example.

True cross-sectional area for actual wall thickness (see Figure B.5).

$$\text{Area}_{eqv} = A_{r1} + A_{r2} + A_{n/p} + A_{vlv} = 3\ 2162\ \text{mm}^2 \quad \text{(B.21)}$$

where

$$A_{r1} = h_t \times \frac{\frac{A - B_n}{2} + \frac{A - B_f}{2}}{2} = 73{,}7 \times \frac{\frac{769{,}0 - 555{,}0}{2} + \frac{769{,}0 - 581{,}0}{2}}{2} = 7\ 407\ \text{mm}^2 \quad \text{(B.22)}$$

Dimensions in millimetres

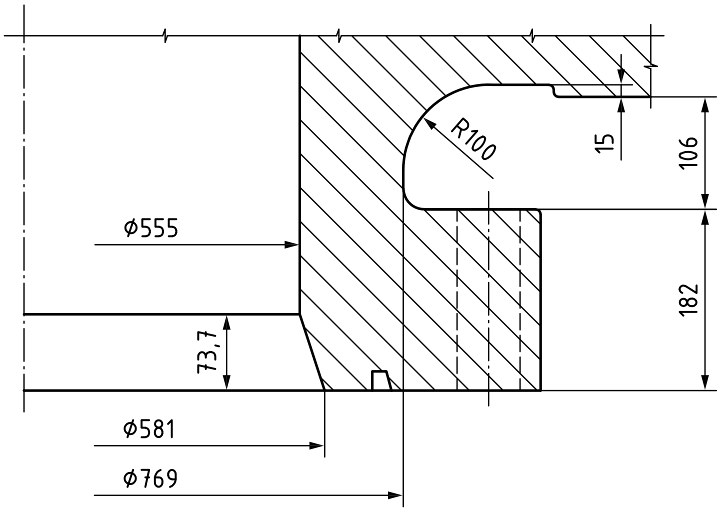


Figure B.6 — Valve design, example B.4.4

and

$$A_{r2} = (HW3 - h_t) \times \frac{A - B_n}{2} = (182{,}0 - 73{,}7) \times \frac{769{,}0 - 555{,}0}{2} = 11588 \text{ mm}^2 \quad \text{(B.23)}$$

and

$$A_{n/p} = (HW5 - HW3) \times \frac{A - B_n}{2} = (285{,}0 - 182{,}0) \times \frac{769{,}0 - 555{,}0}{2} = 11021 \text{ mm}^2 \quad \text{(B.24)}$$

and

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

Here the area A_{vlv} 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:

$$t_{eqv} = \frac{Area_{eqv}}{Hw5} = \frac{32162}{285} = 112{,}85 \text{ mm} \quad \text{(B.26)}$$

This equivalent wall thickness is outside standard range. Optimized 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:

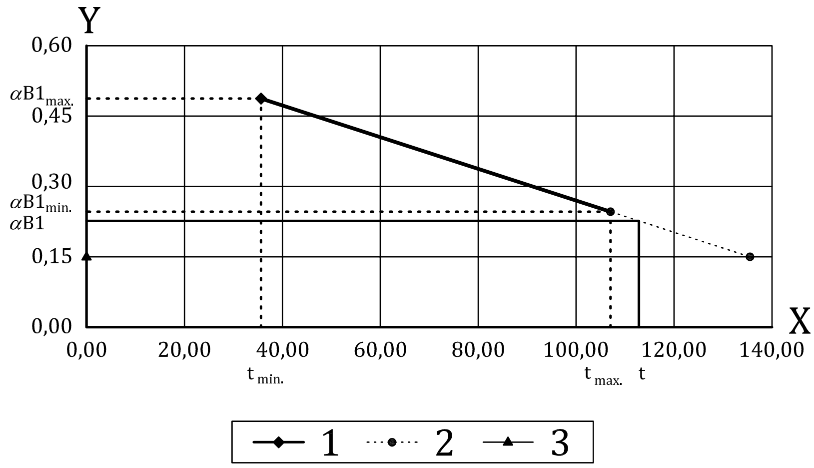
$$t_{015} = \frac{0{,}15^\circ - \alpha B1_{min}}{\frac{\alpha B1_{min} - \alpha B1_{max}}{t_{max} - t_{min}}} + t_{max} = \frac{0{,}15^\circ - 0{,}25}{\frac{0{,}25 - 0{,}49}{106{,}90 - 36{,}0}} + 106{,}90 = 136{,}44 \text{ mm} \quad \text{(B.27)}$$

Extrapolation in “extended range” for optimized face angle:

$$\alpha B1 = \alpha B1_{max} - \frac{\alpha B1_{max} - \alpha B1_{min}}{\frac{t_{max} - t_{min}}{t_{eqv} - t_{min}}} = 0{,}49 - \frac{0{,}49 - 0{,}25}{\frac{106{,}90 - 36{,}0}{112{,}85 - 36{,}0}} = 0{,}23^\circ \quad \text{(B.28)}$$

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

$$DA3 = DA3_{max} - \frac{DA3_{max} - DA3_{min}}{\frac{t_{max} - t_{min}}{t_{eqv} - t_{min}}} = 749{,}22 - \frac{749{,}22 - 748{,}71}{\frac{106{,}90 - 36{,}0}{112{,}85 - 36{,}0}} = 748{,}67 \text{ mm} \quad \text{(B.29)}$$



Key

X Wall thickness [mm]

Y Face angle [°]

1 Standard range

2 Extended range

3 Minimum angle

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

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

$$\alpha A2 = \alpha A2_{max} - \frac{\alpha A2_{max} - \alpha A2_{min}}{\frac{t_{max} - t_{min}}{t_{eqv} - t_{min}}} = 15{,}3 - \frac{15{,}3 - 15{,}2}{\frac{106{,}90 - 36{,}0}{112{,}85 - 36{,}0}} = 15{,}2^\circ \quad \text{(B.30)}$$

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

$$\alpha B2 = \alpha B2_{max} - \frac{\alpha B2_{max} - \alpha B2_{min}}{\frac{t_{max} - t_{min}}{t_{eqv} - t_{min}}} = 0{,}33 - \frac{0{,}33 - 0{,}16}{\frac{106{,}90 - 36{,}0}{112{,}85 - 36{,}0}} = 0{,}15^\circ \quad \text{(B.31)}$$

All other dimensions shall be according to specified values.

Annex C
(informative)

Quality management system

The products may be manufactured in accordance with the principles of an appropriate quality management system (QMS) standard. In such a case, a determination of the need for registration and/or certification of the product manufacturer's QMS by an independent organization shall be the responsibility of the manufacturer.

The detailed documentation demonstrating QMS compliance shall be available to the purchaser at the manufacturer's facility. A written summary description of the QMS utilized by the product manufacturer shall be available to the purchaser upon request. The product manufacturer is defined as the entity whose name or trademark appears on the product in accordance with the marking or identification requirements of this International Standard.

Annex D
(normative)

Bolt dimensions and masses

Table D.1 to Table D.6 give all dimensional data for the bolts to be used except when connecting to wafer type valves and special flange nozzles using extra flange thickness exceeding HW3; see 8.4 and Figure 4. 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.

Table D.1 — Length of stud bolts for CL 150

Bolting				Torque tool		Tension tool					Mass of stud bolt and nuts			
				Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"	Torque tool		Tension tool	
DN	Nom. size NPS	Number	Nominal diameter in	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	70	85	110	110	28	10	26 / 14	0,5	0,5	0,6	0,6
20	¾	4	½	70	85	110	110	28	9	26 / 14	0,5	0,5	0,6	0,6
25	1	4	½	70	90	110	110	28	8	26 / 14	0,5	0,6	0,6	0,6
40	1½	4	½	70	90	110	110	28	5	26 / 14	0,5	0,6	0,6	0,6
50	2	4	½	70	90	110	110	28	4	26 / 14	0,5	0,6	0,6	0,6
65	2½	4	½	70	95	110	110	26	4	26 / 14	0,5	0,6	0,6	0,6
80	3	8	½	75	100	110	110	22		26 / 14	1,0	1,2	1,3	1,3
100	4	8	½	85	110	110	120	14		26 / 14	1,1	1,3	1,3	1,3
125	5	12	½	90	120	110	130	7		26 / 14	1,7	2,0	1,9	2,1
150	6	12	½	95	125	105	140				1,7	2,1	1,8	2,2
200	8	12	½	90	125	110	135	5		26 / 14	1,7	2,1	1,9	2,2
250	10	16	½	105	140	115	155				2,5	3,0	2,6	3,2
300	12	20	½	110	150	120	165				3,2	3,9	3,3	4,2
350	14	20	½	115	160	125	170				3,3	4,1	3,4	4,2
400	16	20	⅝	130	180	145	195				5,8	7,2	6,2	7,6
450	18	20	⅝	140	190	155	205				6,1	7,5	6,5	7,9
500	20	24	⅝	145	205	165	220				7,5	9,5	8,1	10,0
550	22	28	⅝	155	215	170	230				9,1	11,4	9,7	12,0
600	24	24	¾	170	235	190	255				12,4	15,6	13,4	16,5
650	26	24	¾	180	250	200	265				12,9	16,3	13,9	17,0
700	28	28	¾	190	260	210	280				15,6	19,6	16,8	20,7
750	30	32	¾	200	270	215	290				18,5	23,0	19,5	24,3
800	32	36	¾	205	280	225	300				21,2	26,6	22,6	28,1
850	34	40	¾	210	290	230	310				24,0	30,4	25,6	32,0
900	36	32	⅞	230	310	250	335				28,8	35,8	30,6	38,0
950	38	36	⅞	240	325	260	345				33,4	41,8	35,4	43,8
1000	40	40	⅞	245	335	270	355				37,7	47,5	40,4	49,7
1050	42	44	⅞	250	345	275	365				42,0	53,5	45,0	55,9
1100	44	44	⅞	260	355	280	375				43,2	54,7	45,6	57,1
1150	46	48	⅞	265	365	290	385				47,8	61,0	51,1	63,6
1200	48	52	⅞	275	375	295	395				53,2	67,5	56,1	70,3

NOTE See E.11.2 for “Torque tool” and see E.11.3 for “Tension tool”.

Table D.2 — Length of stud bolts for CL 300

Bolting				Torque tool		Tension tool					Mass of stud bolt and nuts			
				Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"	Torque tool		Tension tool	
DN	Nom. size NPS	Number	Nominal diameter in	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	70	85	110	110	28	10	26/14	0,5	0,5	0,6	0,6
20	¾	4	½	70	85	110	110	28	9	26/14	0,5	0,5	0,6	0,6
25	1	4	½	70	90	110	110	28	8	26/14	0,5	0,6	0,6	0,6
40	1½	4	½	70	90	110	110	28	5	26/14	0,5	0,6	0,6	0,6
50	2	4	½	70	90	110	110	28	4	26/14	0,5	0,6	0,6	0,6
65	2½	4	½	70	95	110	110	26	4	26/14	0,5	0,6	0,6	0,6
80	3	8	½	75	100	110	110	22		26/14	1,0	1,2	1,3	1,3
100	4	8	½	85	110	110	120	14		26/14	1,1	1,3	1,3	1,3
125	5	12	½	90	120	110	130	7		26/14	1,7	2,0	1,9	2,1
150	6	12	½	95	125	105	140				1,7	2,1	1,8	2,2
200	8	12	⅝	115	155	135	170				3,2	3,9	3,6	4,1
250	10	20	⅝	130	175	145	190				5,8	7,1	6,2	7,5
300	12	20	⅝	140	190	155	205				6,1	7,5	6,5	7,9
350	14	24	⅝	145	200	165	215				7,5	9,3	8,1	9,8
400	16	24	¾	170	225	190	245				12,4	15,1	13,4	16,1
450	18	28	¾	180	240	200	260				15,1	18,5	16,2	19,6
500	20	24	⅞	200	265	220	290				19,6	23,9	21,0	25,6
550	22	28	⅞	210	280	230	305				23,7	29,0	25,2	31,0
600	24	28	1	230	310	260	335				33,9	41,9	36,9	44,4
650	26	32	1	240	325	270	350				39,8	49,6	43,3	52,4
700	28	32	1	250	335	280	365				41,0	50,7	44,4	54,2
750	30	32	1 ⅛	275	365	300	390				57,1	70,1	60,7	73,8
800	32	32	1 ⅛	285	375	310	405				58,5	71,6	62,2	75,9
850	34	32	1¼	300	400	335	430				76,5	94,4	82,8	99,8
900	36	32	1¼	310	415	345	445				78,3	97,1	84,6	102,5
950	38	36	1¼	320	430	355	460				90,1	112,3	97,2	118,3
1000	40	40	1¼	335	445	365	480				103,5	128,1	110,2	136,0
1050	42	36	1⅜	350	465	385	500				118,6	146,6	127,1	155,2
1100	44	40	1⅜	360	480	395	515				134,5	167,0	144,0	176,5
1150	46	36	1 ½	380	505	420	540				153,0	189,3	164,6	199,4
1200	48	36	1 ½	390	515	425	555				155,9	192,2	166,1	203,8

NOTE See E.11.2 for “Torque tool” and see E.11.3 for “Tension tool”.

Table D.3 — Length of stud bolts for CL 600

Bolting				Torque tool		Tension tool					Mass of stud bolt and nuts			
				Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"	Torque tool		Tension tool	
DN	Nom. size NPS	Number	Nominal diameter in	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	⅝	110	140	135	155	10		31/17	3,1	3,6	3,6	3,9
125	5	12	⅝	115	150	135	170				3,2	3,8	3,6	4,1
150	6	12	⅝	120	155	135	170				3,3	3,9	3,6	4,1
200	8	20	⅝	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	⅞	180	240	205	260				15,3	18,6	16,6	19,7
350	14	24	⅞	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	1⅜	315	415	350	450				97,9	119,5	105,4	127,1
750	30	36	1⅜	325	435	360	470				112,5	139,3	121,1	147,9
800	32	32	1 ½	350	460	385	500				128,3	156,6	137,3	167,0
850	34	32	1 ⅝	370	485	410	530				159,0	193,8	171,1	207,4
900	36	32	1 ⅝	390	515	435	560				165,1	202,9	178,7	216,5
950	38	32	1 ¾	400	535	445	580				207,5	257,4	224,1	272,3
1000	40	36	1 ¾	415	550	460	595				239,6	295,9	258,4	314,6
1050	42	32	1 ⅞	445	585	490	63				259,3	318,8	278,4	344,3
1100	44	36	1 ⅞	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

NOTE See E.11.2 for “Torque tool” and see E.11.3 for “Tension tool”.

Table D.4 — Length of stud bolts for CL 900

Bolting				Torque tool		Tension tool					Mass of stud bolt and nuts			
				Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"	Torque tool		Tension tool	
DN	Nom. size NPS	Number	Nominal diameter in	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		26/14	0,5	0,6	0,6	0,6
20	¾	4	½	80	95	110	110	18		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	⅝	110	140	135	155	10		31/17	3,1	3,6	3,6	3,9
125	5	12	⅝	115	150	135	170				3,2	3,8	3,6	4,1
150	6	16	⅝	125	165	145	185				4,5	5,4	5,0	5,9
200	8	20	¾	155	200	175	220				9,8	11,6	10,6	12,4
250	10	20	⅞	180	240	205	260				15,3	18,6	16,6	19,7
300	12	20	1	205	270	230	295				22,4	27,1	24,2	28,8
350	14	24	1	215	285	240	310				27,7	33,8	29,9	35,9
400	16	24	1 ⅛	240	315	270	345				39,0	47,2	42,3	50,4
450	18	24	1¼	265	345	295	375				52,7	63,5	56,7	67,5
500	20	24	1⅜	285	375	320	410				68,5	83,1	74,2	88,8
550	22	24	1 ½	310	405	350	445				88,5	106,9	96,2	114,6
600	24	24	1 ⅝	330	435	375	475				110,2	134,0	120,4	143,1
650	26	24	1 ¾	355	465	400	510				143,1	173,6	155,6	186,1
700	28	24	1 ¾	390	505	435	550				152,8	184,8	165,3	197,3
750	30	24	1 ⅞	410	535	460	585				183,3	223,1	199,2	239,1
800	32	24	2	435	565	485	615				223,0	270,1	241,1	288,3
850	34	24	2 ¼	450	585	505	640				297,9	359,9	323,2	385,2
900	36	24	2 ¼	485	625	540	685				314,0	378,3	339,3	405,8
950	38	24	2 ½	495	640	555	705				403,5	485,6	437,5	522,5
1000	40	24	2 ½	525	680	590	745				420,5	508,3	457,3	545,2
1050	42	28	2 ½	530	690	595	755				493,8	599,6	536,8	642,6
1100	44	28	2 ½	570	735	630	800				520,3	629,4	560,0	672,4
1150	46	28	2 ¾	595	770	665	840				663,7	803,7	719,7	859,7
1200	48	28	3	605	785	685	860				818,0	989,4	894,2	1060,9

NOTE See E.11.2 for “Torque tool” and see E.11.3 for “Tension tool”.

Table D.5 — Length of stud bolts for CL 1500

Bolting				Torque tool		Tension tool					Mass of stud bolt and nuts			
				Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"	Torque tool		Tension tool	
DN	Nom. size NPS	Number	Nominal diameter in	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		26/14	0,5	0,6	0,6	0,6
20	¾	4	½	80	95	110	110	18		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	⅝	105	135	135	150	12		31/17	3,1	3,6	3,6	3,8
100	4	12	¾	130	165	160	180	12			5,3	6,1	6,0	6,5
125	5	12	⅞	150	190	185	210	14			8,2	9,5	9,3	10,1
150	6	12	1	170	215	210	240	14			11,9	13,9	13,7	14,9
200	8	16	1	190	245	215	270				17,1	20,2	18,5	21,6
250	10	16	1¼	235	300	265	330				32,5	38,3	35,1	41,0
300	12	20	1¼	250	320	280	355				42,2	50,1	45,6	54,0
350	14	20	1⅜	265	345	300	380				54,4	65,2	59,1	70,0
400	16	20	1 ½	305	390	345	430				72,9	86,6	79,4	93,1
450	18	20	1 ¾	330	425	375	470				113,5	135,4	123,9	145,9
500	20	20	1 ⅞	365	470	415	520				140,8	168,7	154,1	182,0
550	22	20	2	405	515	455	565				176,8	210,0	191,9	225,1
600	24	20	2 ¼	425	545	480	600				238,7	284,6	259,8	305,7
650	26	20	2 ¼	475	605	535	665				257,9	307,6	280,8	330,5
700	28	24	2 ¼	495	635	555	690				318,6	382,9	346,2	408,1
750	30	24	2 ½	520	665	580	725				417,6	499,8	451,6	533,8
800	32	24	2 ½	550	705	615	765				434,6	522,5	471,5	556,5
850	34	24	2 ¾	585	750	655	820				562,0	675,2	610,0	723,2
900	36	20	3 ¼	630	800	710	885				720,1	855,8	784,0	923,7
950	38	20	3 ½	650	830	740	920				882,5	1050,1	966,3	1133,8
1000	40	24	3 ¼	685	875	765	955				916,8	1098,8	993,4	1175,5
1050	42	20	3 ¾	725	920	820	1020				1108,2	1317,6	1210,3	1425,0
1100	44	24	3 ½	745	955	835	1045				1169,5	1405,3	1270,5	1506,3
1150	46	24	3 ¾	770	990	865	1085				1387,9	1671,4	1510,3	1793,8
1200	48	24	3 ¾	815	1040	910	1135				1445,9	1735,8	1568,3	1858,3

NOTE See E.11.2 for "Torque tool" and see E.11.3 for "Tension tool".

Table D.6 — Length of stud bolts for CL 2500

Bolting				Torque tool		Tension tool					Mass of stud bolt and nuts			
				Length of stud bolts		Length of stud bolts		"Washer" (thickness)		"Washer"	Torque tool		Tension tool	
DN	Nom. size NPS	Number	Nominal diameter in	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		26/14	0,5	0,6	0,6	0,6
20	¾	4	½	80	95	110	110	18		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	⅝	100	125	135	140	18		31/17	2,0	2,3	2,4	2,4
65	2½	8	¾	120	145	160	165	22		37/21	3,3	3,7	4,0	4,1
80	3	8	⅞	135	165	185	190	28		42/24	5,1	5,8	6,2	6,3
100	4	8	1	160	195	210	225	26		48/28	7,7	8,7	9,1	9,5
125	5	12	1	170	215	210	240	14		48/28	11,9	13,9	13,7	14,9
150	6	12	1 ⅛	195	245	235	275	14		53/30	17,1	19,8	19,2	21,4
200	8	12	1⅜	235	295	280	330	14		64/36	30,2	35,1	33,9	37,9
250	10	16	1 ½	270	350	310	385				53,8	64,1	59,0	68,7
300	12	16	1 ¾	305	390	355	435	4		81 / 47	86,1	101,9	95,4	110,2
350	14	16	1 ⅞	330	425	380	470				105,2	125,4	115,8	134,9
400	16	16	2 ¼	385	485	450	545	7		103/60	178,7	209,3	198,6	227,7
450	18	16	2 ¼	405	520	465	575				184,9	220,1	203,2	236,9
500	20	16	2 ½	440	565	505	630				248,2	295,4	272,7	320,0
550	22	16	3	500	635	590	710	17		136/78	410,3	483,8	459,3	524,6
600	24	16	3 ¼	535	685	640	770	20		147/85	515,4	611,2	582,5	665,5

NOTE See E.11.2 for “Torque tool” and see E.11.3 for “Tension tool”.

Annex E
(informative)

Handling, installation, assembly and repair of flanges

E.1 General

This annex serves as a guide during handling, welding and assembly of flanges according to this International Standard. In addition, it contains procedures for preload qualification.

E.2 Protection

Flanges shall be supplied with suitable protection of the flange face from mechanical impacts, such as plywood boards or plastic caps. They should not be removed prior to field assembly to minimize the likelihood of accidental damage - except for inspection, welding and stress relieving of the weld area.

All sealing surfaces shall be suitably protected from corrosion before the mechanical protection is fixed to the flange. The extent of this protection should be agreed with the purchaser depending on flange material, etc.

Seal rings should be stored in their original packing until final installation. Careful handling is of critical importance.

E.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.

E.4 Welding

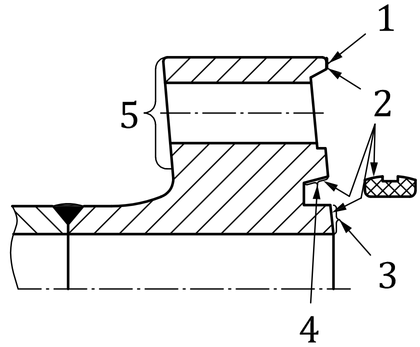
Protect the flange sealing faces with an inhibitor to prevent oxidization during pre-heating and stress relieving.

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 and provide adequate protection against mechanical impact.

High heat input for large class 150 and 300 WN flanges in high alloy materials may cause distortion of flange face angles when welding the flanges to pipes or fittings. This will normally not cause any sealing problem or problem to close the flange joint within target bolt preload values in Table E.2. However, in order to minimize risk of such problems, it is recommended to qualify special welding and assembly procedures for flanges in class 150 and class 300 if the material is austenitic stainless steel and if sizes will exceed DN 250 (NPS 10).

E.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.



Key

1 Wedge

2 Sealing faces

3 Heel

4 Seal ring seat

5 Nut bearing area

Figure E.1 — Flange areas to be protected

E.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 E.11. Ensure use of skilled workmen and correct equipment. Final preload tools should be well maintained and should have accuracy within +/- 2 % of the torque or tension to be applied (see Table E.2).

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 therefore be qualified according to E.11. All personnel assembling and tightening compact flanges must be trained and competent to the Country or industry standard with specific training on compact flanges. Equipment used for final preload must be fit for purpose, well maintained and calibrated.

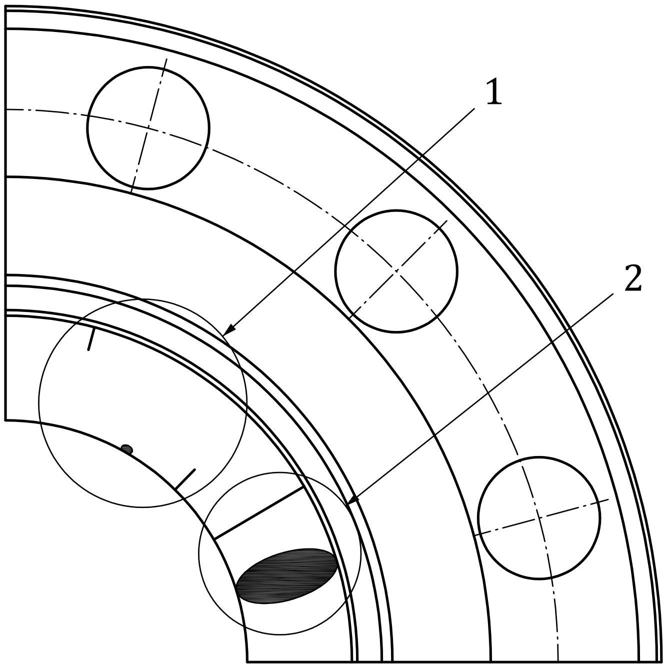
E.7 Preparation before final preloading

E.7.1 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.

For inspection and repair, see Figure E.1, Figure E.2 and Table E.1.

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.



Key

1 Grind flush

2 Grind smooth with maximum depth of 0,1 mm; repair with sealant

Figure E.2 — Repair of heel

Table E.1 — Damage repair guide

Damage and location	Remedy
Scratch or dent at the heel, covering less than ¾ 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 ¾ 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.

E.7.2 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 shall be unable to firmly contact the groove bottom. If this is not the case, the seal ring will not be able to seal, and shall be replaced.

Use a pull up cord as shown on Figure F.5 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.

Relative lateral displacement between flanges shall be minimized in order to keep shear force on IX seal ring below the limits of Table A.2.

E.7.3 Use of lubrication and sealant

Assembly of seal rings on compact flanges does not require use of lubricants or sealants if flange sealing surfaces are undamaged, and if pre-coated IX seal rings are used.

If uncoated seal rings are used, then lubricate the ring and the groove with a suitable lubricant in order to ease initial sealing and to prevent galling.

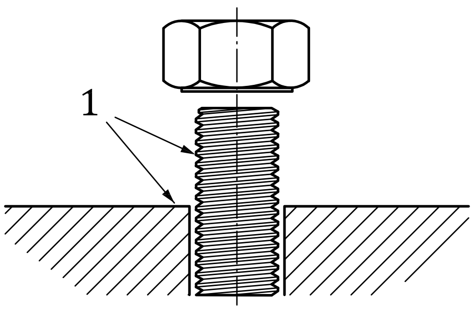
On repeated assembling operations it is recommended to lubricate all sealing surfaces including the flange heel by applying a layer of thin oil. Undamaged IX rings, coated or uncoated, can then be reused, but coated rings should then be reinstalled in same position “clockwise” as originally installed.

If flange sealing surfaces have been damaged, a layer of a suitable sealant should be applied to ensure tightness (see Figure E.2 and Table E.1).

Suitable sealants which will cure, and have been approved as compatible with the flange materials and service fluid or gas, may be used to refill material into dents and scratches, and assembly may be done after curing and grinding. However, if such sealant is used along a sealing surface solely as an extra precaution to prevent leakage from invisible scratches, the assembly shall be performed immediately after the sealant has been put on in order to allow excessive sealant to be squeezed into the void space between the seal ring and the ring grooves before the curing would prevent this. The sealant shall never obstruct contact between sealing surfaces.

E.7.4 Lubrication of nuts and bolts

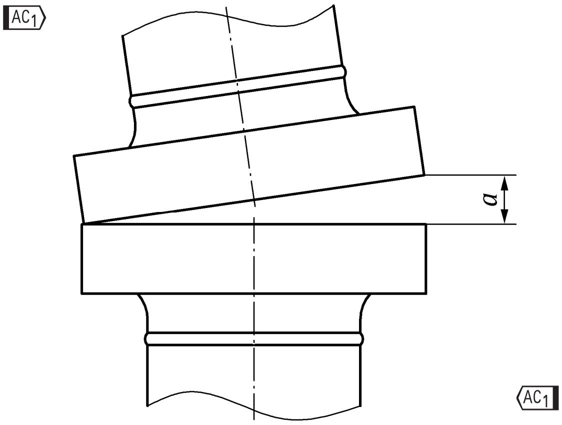
The nut thread and nut bearing surfaces on the flange should be lubricated in accordance to the qualified procedure when torque is used to achieve the final preload. It is imperative that both the nut threads and the bearing surface of the nut are lubricated as shown in the diagram.



Key

1 Lubrication

Figure E.3 — Thread lubrication



Alignment of facings "*a*" shall not be more than 1,5 mm for flange diameters ≤ 300 mm. For flange diameters > 300 mm, "*a*" shall not be more than 1 mm per 200 mm flange diameter

Figure E.4 — Flange assembly alignment

E.7.5 Alignment

With the seal ring in the groove of one of the flanges (parallel standoff), bring the other flange into alignment (see Figure E.4). The load to bring into alignment shall not exceed the maximum load given in E.7.6 below. The shear load capacity of the IX seal ring is given in A.2. The bolt holes should be positioned so that the bolts can be moved easily.

E.7.6 Fitting

For torque joints the stud shall protrude one to two threads from the nut on each side of the joint. For tension joints there must be at least one bolt diameter of thread protruding on the side where the tension tool is fitted.

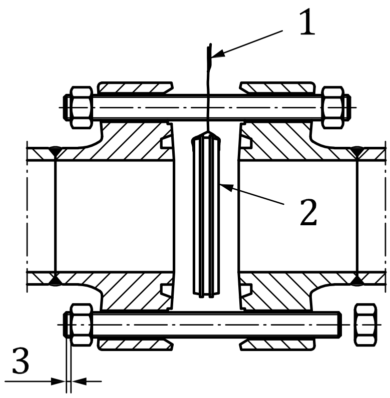
Loosely assemble the studs and nuts. As the flanges are drawn together by the tightening of the bolts, the IX ring will provide the final alignment of the flange prior to full make-up of the joint.

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 E.2 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 E.2.

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 E.2, this is cause to reject the alignment.

If final preload is not applied immediately, seal off the flange faces with adhesive tape to avoid foreign particles to enter the gap between the flange faces. It is recommended that, whenever possible, flanges are tightened immediately after assembly.



Key

1 Pull up cord

2 Seal ring

3 1-2 threads

Figure E.5 — Seal ring installation

a) Two tools **b) Four tools**

Figure E.6 — Bolt pre-loading sequence

E.8 Final pre-loading procedure

E.8.1 Torque tightening

Tighten bolts in a diagonal sequence as illustrated in Figure E.6 using the torque values for the specific flange and lubricant as given in Table E.2 for imperial standard bolting, see Annex G for metric bolts.

Firstly the flange should be aligned as in E7.

The flange shall then be torque tightened in stages up to the final pre-load value as follows:

Stage 1 is to 30 % of the final torque value using a diagonal sequence.

Stage 2 is to 60 % to 70 % of the final torque value using a diagonal sequence.

Stage 3 is to 100 % of the final torque value using a diagonal sequence.

Finally the carry out a check pass in a clockwise direction on all bolts until there is no further nut rotations.

At all times monitor the flange gap and start each pass with the bolt where the flanges have the largest gap.

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 E.2 due to misalignment, it is recommended to increase the final pre-load to 5 % above the target value of Table E.2.

E.8.2 Tightening by hydraulic tensioner

Tighten bolts using either a 50 % or 100 % cover technique to the bolt load values specified in Table E.2 for imperial standard bolting, see Annex G for metric bolts.

Firstly the flange should be aligned as in E7.

For 100 % cover apply suitable tensioners to every bolt ensuring there is sufficient bolt length for the tensioner to grip.

Determine the tool pressure to be applied to achieve the desired residual load in Table E.2.

Energize all of the tensioners to the required tool pressure.

Wind down the nuts firmly against the flange.

Release the tension pressure.

Repeat tension pressure and wind down the nuts again.

Release the tension pressure.

Repeat the tension pressure and wind down the nuts again.

Release the pressure.

For 50 % cover apply suitable tensioners to alternate bolts ensuring there is sufficient bolt length for the tensioner to grip. Consider these bolts as Set A

Determine the tool pressure to be applied to achieve the desired residual load in Table E.2.

Energize all of the tensioners on Set A to the required tool pressure.

Wind down the nuts firmly against the flange.

Release the tension pressure.

Repeat tension pressure and wind down the nuts again.

Release the tension pressure.

Repeat the tension pressure and wind down the nuts again.

Release the pressure.

Move the tensioners to the second set of bolts and consider these as Set B.

Energize all of the tensioners on Set B to the required tool pressure.

Wind down the nuts firmly against the flange.

Release the tension pressure.

Repeat tension pressure and wind down the nuts again.

Release the tension pressure.

Repeat the tension pressure and wind down the nuts again.

Release the pressure.

Move the tools back to Set A and repeat the tightening process.

Check the bolts on Set B and continue repeating tensioning passes until there is no not movement.

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 E.2 due to misalignment, it is recommended to increase the final pre-load to 5 % above the target value of Table E.2.

E.9 Maintenance

Flanged connections according to this International Standard may not require any special maintenance if correctly assembled, and if material selection or appropriate coating methods prevent corrosion from the exposure to the fluid inside or the environment. The seal ring may be reused if it has sufficient standoff (see E.7.1), and is free from defects. Minor rust, burrs or scratches on sealing faces shall be removed, see E.7.1.

An observed gap between the flanges should call for immediate action. This may indicate insufficient bolt preload by installation or relaxation from corrosion or frequent load above yield stress due to different thermal expansion of bolts and flanges, see 6.3, last paragraph.

NOTE Although the wedge seal at the outer circumference of the flanged connections will prevent ingress of water, neither this seal nor bolt/nut connections may be gas tight, which means that water condensate from various temperatures may form in the hidden bolting area. If this condensate together with different materials could cause galvanic corrosion to the bolts, it is recommended to inspect or replace bolts at regular intervals of 5 years to 10 years. However, efficient corrosion preservation before assembly may eliminate any corrosion problem in this area.

Table E.2 — Final bolt tension and torque values

Stud bolt size in	Target residual preload [a c] kN	Applied tension with tension tool [a b c e] kN	Applied torque with torque tool and lubricant if μ = 0,12 [d e] Nm
½-UNC	44		98
⅝-UNC	71		192
¾-UNC	106	134	341
⅞-UNC	147	186	544
1-UNC	193	244	816
1 ⅛-8UN	255	323	1194
1 ¼-8UN	325	412	1671
1 ⅜-8UN	405	512	2261
1 ½-8UN	492	623	2989
1 ⅝-8UN	589	745	3840
1 ¾-8UN	693	878	4859
1 ⅞-8UN	807	1022	6020
2-8UN	929	1177	7351
2 ¼-8UN	1199	1519	10610
2 ½-8UN	1503	1904	14665
2 ¾-8UN	1667	2111	17766
3-8UN	2004	2539	23240
3 ¼-8UN	2373	3006	29736
3 ½-8UN	2773	3512	37258
3 ¾-8UN	3204	4058	46046
4-8UN	3666	4643	56008

[a] Target minimum pre-stress values are copied from Table 1. This value is 75 % of yield such that a minimum of 70 % of yield stress is achieved due to uncertainties in the make-up procedure. Bolt root diameter has been used for the calculations.

[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, see E.11.2.

[e] Bolting material: ASTM A193 gr.B7, ASTM A193 gr.B16 and ASTM A320, gr.L7 and gr.L43.

E.10 Disassembly

Before disassembling compact flanged connections, verify that all pressure has been bled form 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 exercized 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.

E.11 Bolt tensioning qualification procedure

E.11.1 General

This clause describes procedures for qualification of bolt preloading with hydraulic tensioning or manual/hydraulic torque methods. The target minimum residual load value to be achieved shall be the minimum value in Table E.2 or, for metric bolts, in Table G.2. This procedure applies to bolt sizes above ½ in or M12. Uncontrolled tightening of bolts is not advised.

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 recognized 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 in accordance with national or industry standards with specific training in compact flanged connections.

E.11.2 Torque preloading

E.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 to achieve a given pre-load is given by the following expression:

$$T = \frac{F_p}{2}\left(\mu_n \times d_n + 1{,}155 \times \mu_t \times d_t + \frac{p}{\pi}\right) \quad \text{(E.1)}$$

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 F.2, i.e. $\mu = \mu_n = \mu_t$. 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 such as

- 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.

E.11.2.2 Equipment

Use the following equipment:

a) 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;

b) 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 months old) calibration certificate;

c) two solid steel backing plates with one hole in each to suit the bolts;

d) a suitable sample of the bolt lubricant supplied in a closed container to be tested;

e) five sets of bolts with nuts for calibration test.

E.11.2.3 Calibration and qualification

The following procedure shall be followed:

a) 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;

b) apply specified torque value;

c) record bolt force achieved;

d) repeat steps in a), b) and c) with the remaining bolt sets;

e) calculate the mean tensile load achieved;

f) calculate the standard deviation of the tensile load achieved;

g) 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;

h) 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;

i) if the checks in b) or c) 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.

E.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 and the nut bearing face liberally coated with lubricant.

E.11.3 Hydraulic tension preloading

E.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_B = 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 Table D.1 to Table D.6 for details.

E.11.3.2 Equipment

The following equipment is required:

— a hydraulic tensioner;

— an electronic load cell with a valid calibration traceable to a recognized national standard;

— two solid steel backing plates;

— five bolts with nuts.

E.11.3.3 Qualification and calibration

The following procedure shall be followed:

a) place the load cell between the reaction plates, insert bolt and attach nuts;

b) install bolt tensioner and apply estimated initial tensile load;

c) make transfer and record achieved pre-load;

d) repeat step E.11.2.2 a) to step E.11.2.2 c) for all five bolts;

e) calculate the mean tensile load achieved;

f) calculate the standard deviation of the tensile load achieved;

g) calculate the minimum bolt tension as the mean value less one standard deviation and check to see that this value exceeds the minimum bolt load specified;

h) 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 F
(informative)

Mass of flanges

Table F.1 — Masses of CL 150 flanges

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	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	6,1	13	13	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

Table F.1 (*continued*)

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
20	500	10S	5,54	34	500	20	9,53
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	323	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 F.2 — Masses of CL 300 flanges

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
½	15	10S	2,11	0,7	0,7	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	300	10S	4,57
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	400	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	500	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

Table F.2 (*continued*)

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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	750	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 F.3 — Masses of CL 600 flanges

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
½	15	40	2,77	0,9	0,9	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	400	80	21,44
16	400	80	21,44	73			9,53
18	450	80	23,83	100			79
20	500	30	12,70	99	214	197	82
20	500	80	26,19	121	550	30	94
22	550	30	12,70	131	287	256	107
22	550	80	28,58	161			124

Table F.3 (*continued*)

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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	1087	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 F.4 — Masses of CL 900 flanges

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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

Table F.4 (*continued*)

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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 F.5 — Masses of CL 1500 flanges

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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

Table F.5 (*continued*)

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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 F.6 — Masses of CL 2500 flanges

Nominal size		Neck wall thickness		Approximate masses (each)			
				Weld neck (WN)	Blind	Paddle blank (PB)	Paddle spacer (PS)
NPS	DN	Schedule	mm	kg	kg	kg	kg
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.,7	870	1027	869	634
24	600	ISO	95,00	1035			707

Annex G
(informative)

Metric bolting

If metric bolts shall be used, their size shall be selected based on Table G.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 (see Table E.2 for comparison). In Table G.2, the bolt torque values for a friction coefficient of 0,12 are listed. The resulting loads as a fraction of bolt yield at 20 °C based on values in Table 3, are also given for information.

Table G.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	⅞-UNC	22,225	270,44
M24x3	24	324,27	1-UNC	25,4	355,41v
M30x3,5	30	518,99	1 ⅛-8UN	28,575	469,42
M33x3,5	33	647,19	1 ¼-8UN	31,75	599,26
M36x4	36	759,28	1 ⅜-8UN	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 G.2 — Bolt torque values for metric bolts

Bolt torque values 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 H
(informative)

Additional information on bibliographical references

This annex provides additional information on references listed in the Bibliography.

— Reference [38], British Gas report 4844

This report describes tests on a 30” class 600 SPO Compact Flange carried out at British Gas’ test facility.

— References [40] and [41], 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.

— References [42] and [43], DNV report nos 91-3193 and 91-3418

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.

— Reference [44], DNV report no 91-3458

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

— Reference [45], DNV report no 94-3567

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

— Reference [48], DNV report no 96-3426

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

— Reference [49], DNV report no. 97-3547

This 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.

— Reference [50], 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.

— Reference [51] DNV report no. 00-1008

This report deals with the hydrostatic pressure test and ULS and PLS load test of the 16” SPO CFS for Heidrun Gas Export Riser.

— Reference [53], DNV report no/DNV Reg No.:/12 FQG2F-6, Rev 01, 2010-03-12

This report confirms conclusions from DNV report no. 97-3547 (Reference [49]), but some figures have been adjusted based on new statistics and knowledge.

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