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

*Industries du pétrole et du gaz naturel — Raccordements à brides
compactes avec bague d'étanchéité IX*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 27509:2012), which has been technically revised. It also incorporates the Technical Corrigendum ISO 27509:2012/Cor.1:2013. The main changes compared to the previous edition are as follows:

- [Annexes B and D](#) ([Annex E](#) in previous edition) have become normative annexes;
- more stringent quality requirements regarding manufacture of products and assembly instructions have been introduced. These include
 - a) ultrasonic testing of products in accordance with new requirements in ASME VIII div. 2 (in [Clause 7](#)),
 - b) requirements to material strength and machining strictly in accordance with given tolerances for IX seal rings (in [Clause 12](#)),
 - c) new and better coating requirements for IX seal rings (in [Clause 13](#) and [Annex D](#)),
 - d) excluding use of IX seal rings to assist alignment by transfer of significant shear load during assembly (in [Annex D](#)),
 - e) more comprehensive and detailed guidelines on the evaluation of damages to products and the repair of such damages (in [Annex D](#)),
 - f) more comprehensive requirements to qualification of bolt tensioning procedures (in [Annex D](#)), and

- g) the elastoplastic deformation of flanges by first assembly has been better explained in [5.3](#) and in [Annex D](#), in order to prevent unnecessary re-machining or rejection when flange bevel angles have changed.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document, which is originally based on NORSOK L-005, has been developed to provide an International Standard for compact flanged connections that constitutes an alternative to conventional flanges as specified in ASME standards, European standards and other 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 conform with the requirements of this document.

This document has been developed for use in process piping systems, which are designed in accordance with codes for pressure piping, e.g. ASME B31.3. See [5.7](#) 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 document.

The main body of this document 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, and
- requirements to designation and marking of finished products.

[Annexes A, B, C](#) and [D](#) cover the following topics:

- structural capacity equations for flange assemblies;
- how to apply the flanges to special geometries of valves and equipment nozzles;
- bolt dimensions and masses;
- installation and assembly instructions, and guidelines on how to repair damage and irregularities on sealing surfaces.

[Annexes E, F](#) and [G](#) cover the following topics:

- masses of all standard components;
- suitable dimensions of alternative metric bolting;
- additional information on bibliographical references.

In this document, the following verbal forms are used:

- "shall" indicates a requirement;
- "should" indicates a recommendation;
- "may" indicates a permission;
- "can" indicates a possibility or a capability.

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

1 Scope

This document 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 expressed in accordance with ASME B36.10M and ASME B36.19M.

This document 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 document is applicable within a temperature range from -196 °C to +250 °C.

This document is not applicable for external pressure.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 4288, *Geometrical 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*

EN 1591-4, *Flanges and their joints — Part 4: Qualification of personnel competency in the assembly of the bolted connections of critical service pressurized systems*

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

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 B31.3:2018, *Process Piping*

ASTM B568, *Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry*

ASTM B571, *Standard Practice for Qualitative Adhesion Testing of Metallic Coatings*

ASME VIII Div. 2: *Boiler and Pressure Vessel Code — Alternative Rules*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 class CL

pressure class in accordance with specific values

Note 1 to entry: The values shall be in accordance with ASME B16.5 and ASME B16.34

3.2 compact flanged connection CFL

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

3.3 gasket

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

3.4 purchaser

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

3.5 seal ring

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

3.6 supplier

individual or organization that takes the responsibility for the supply of the pipe connection

4 Abbreviations and symbols

4.1 Abbreviated terms

BL	blind flange
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 this document
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 (expressed in bar)
PS	paddle spacer
PTFE	polytetrafluoroethylene
RI	rigid interface
RT	reducing threaded flange
WN	weld neck

4.2 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
A_{C015}	cross-sectional area of the neck/pipe calculated from t_{015}
A_{Ceqv}	cross-sectional area of a special flange neck geometry calculated from Formula (B.1)
A_{Cb}	total cross-sectional area of bolting, based on root area
A_T	hub diameter of reducing threaded flange
a	maximum allowable alignment gap between mating flanges (see Figure D.4)
a_{Cb}	bolt root area
B	bore diameter, where the bore should not exceed the maximum listed bore in this document
B_{\max}	maximum listed bore diameter
B_{\min}	minimum bore diameter for which the face angles are valid
B_1	minimum bore diameter for flange to be blinded
	NOTE B_1 is also the start diameter for blind and reducing threaded flange face angles.
B_{CD}	bolt circle diameter
d_B	bolt size (nominal bolt diameter)
d_n	effective contact diameter of nut face (average between width of cross flats and diameter of bolt hole)

d_p	average diameter of neck end = $(A+B)/2$
d_t	effective (mean) contact diameter of bolting threads
D_{A1}	internal diameter of groove
D_{A3}	outer diameter of groove
D_{Gn}	seal ring seal dimension (see Figure 13)
D_{W1}	inner recess diameter
D_{W2}	outer recess diameter
D_{W3}	outside diameter of flange
D_{W4}	flange to neck fillet outer diameter
e	radial distance between B_{CD} and d_p
E_1	depth of groove
E_2	depth of recess
F_A	applied axial force
F_{CB}	bolt total plastic capacity (root area \times number of bolts \times 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_p	required bolt preload
F_R	resulting force from external tension force F_A and external bending moment M_A
f_y	flange material yield strength at temperature
f_{yb}	bolt material yield strength at temperature
H_{Gn}	seal ring seal dimension (see Figure 13)
H_{P1}	thickness of PB, PS and OS
H_{W3}	flange thickness
H_{W5}, H_{T5}	overall length
L	bolt hole diameter
L_1, L_2, L_3	bolt hole depths (see Figure 5 and Table 22)
l	clear bolt length between engaged threads with the nuts
M_A	applied bending moment
n	number of bolts
P_t	thread pitch of bolting

p	internal pressure in N/mm ²
R	Radius
R_C	radius (maximum value tabulated)
R_{V1}	neck to flange ring radius on integral flanges
T	torque applied to the bolt
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}	maximum neck thickness that can be used which is defined by A_{\max} and the minimum listed bore diameter
t_{015}	wall thickness giving the smallest possible face angle (0,15°)
t_{eqv}	equivalent wall thickness calculated from A_{Ceqv} over H_{W5}
W_f	Warping moment capacity of flange
X	half major ellipse axis
Y	half minor ellipse axis
α_{A2}	groove angle
α_{B1}	flange face bevel angle
α_{B2}	effective face angle/rear face bevel angle
Δ	fraction of the initially applied pre-stress lost in transfer of bolt load from tension tool to the nut
ψ	flange utilization ratio
μ_n	coefficient of friction of nut bearing surface
μ_t	coefficient of friction of bolting threads

5 Design

5.1 General

CFCs shall:

- be designed for face-to-face make-up for transfer of the bolt loading through the flange faces;
- be designed so that a static mode is maintained in the bolted joint up to 1,5 times the specified pressure/temperature rating, see 8.2. 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;
- be 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;

- d) be standardized to fit with commonly used standards by the valve industry [e.g. ASME B16.34, ISO 14313 and EN 12516 (all parts)], and other valve standards which make reference to these standards for pressure design;
- e) conform with the applicable requirements in the piping or pressure vessel code agreed between the supplier and the purchaser.

The weakest part of flanged connections in accordance with this document 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 [7.3](#).

Supplier specific CFCs may refer to this document when additional requirements to the minimum requirements specified in this document are agreed between purchaser and supplier. The intention is to allow alternative and additional designs to the products in this document without compromising any of the listed items a), b) and e) in this subclause as well as the requirements of [8.1](#) and [8.3](#).

5.2 Design principles

[Figure 1](#) shows the design principles of compact flanges and its seal system in accordance with this document.

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.

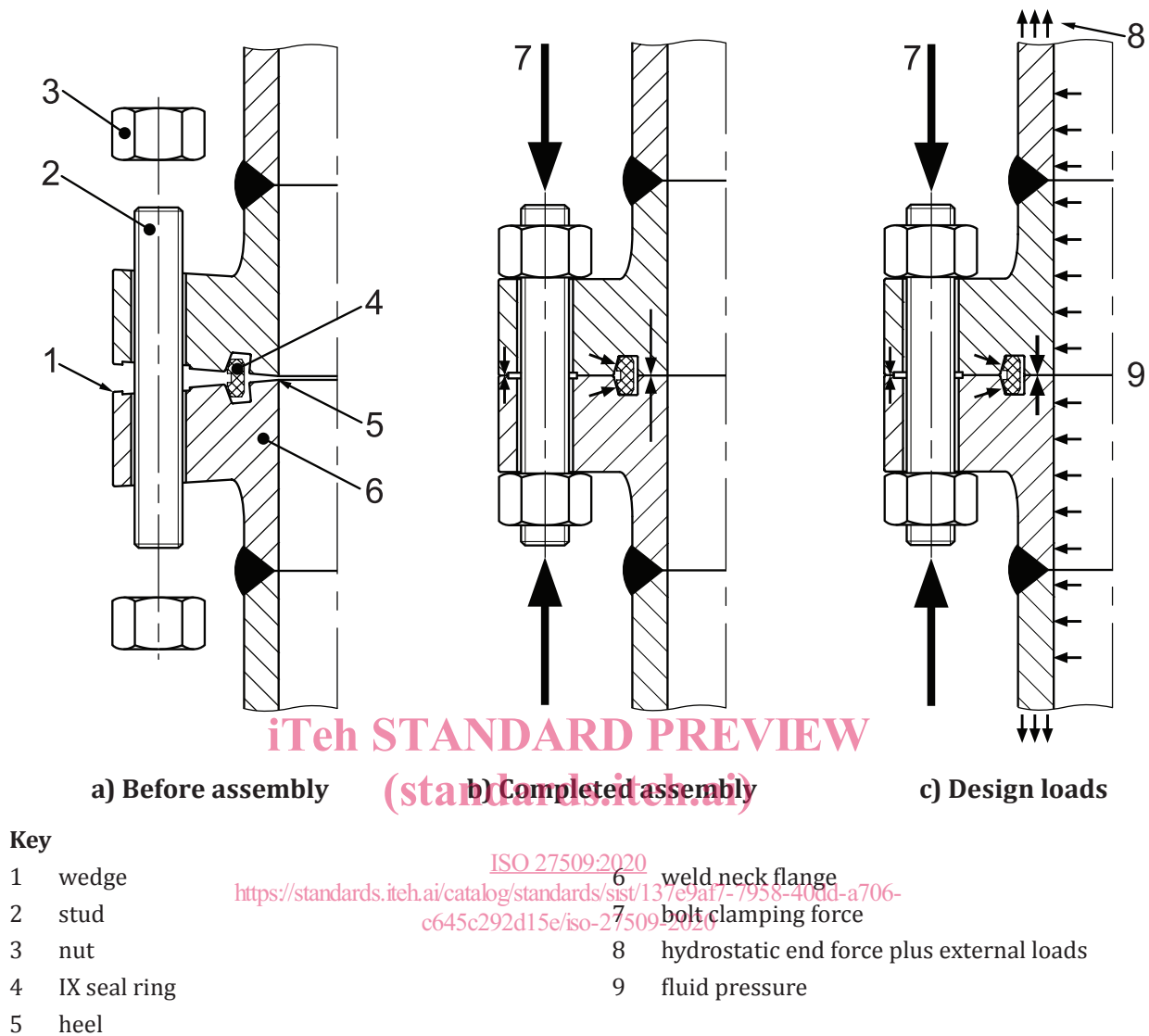


Figure 1 — Design principles of standard compact flange assemblies

The principle design of the flange face includes two independent seals, which are based on different principles, a force controlled heel seal, and a displacement controlled seal provided by the seal ring. The first seal is created by application of seal seating stress at the flange heel. However, an undamaged flange heel might 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.