INTERNATIONAL STANDARD

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 27509 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*.

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.

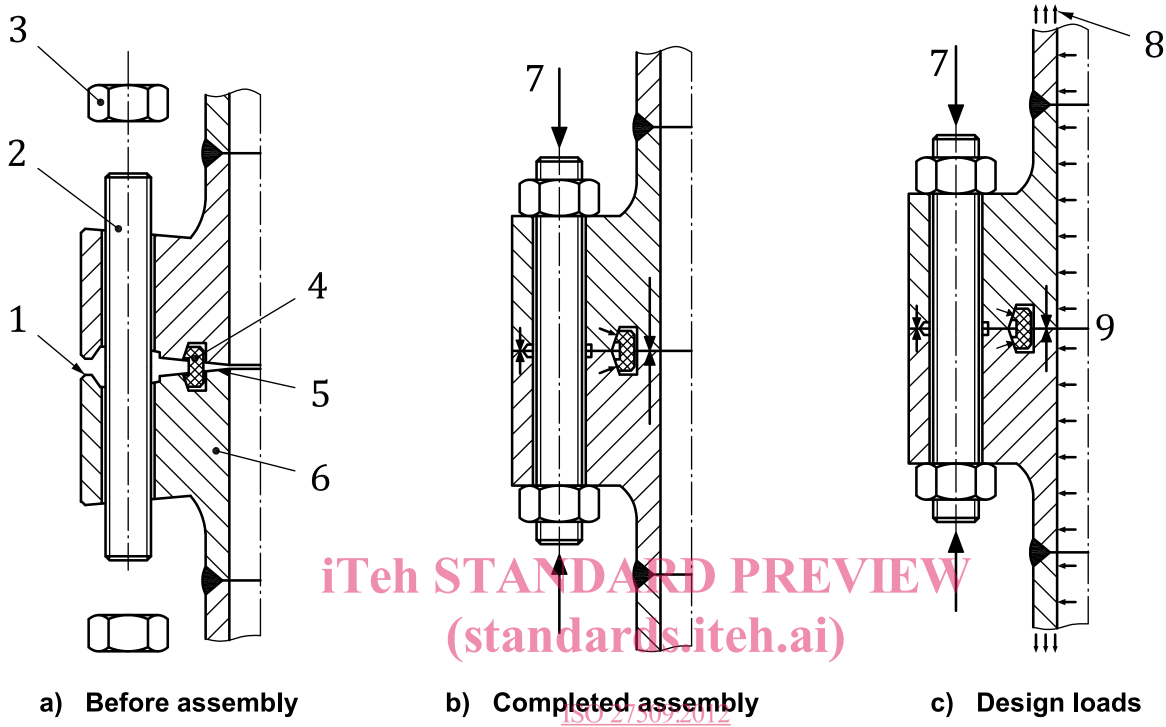
The flange face includes a slightly convex bevel with the highest point, called the heel, adjacent to the bore and a small outer wedge around the outer diameter of the flange. The assembly is made up by tightening/tensioning the flange bolting which pulls the two connector halves together. The bevel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



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