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GUIDELINE
for
Bolted Flanged Joint Assembly in Process Plants

March 2016

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Contents

This document comprises Annexes A to C.

1 Scope

This document applies to the assembly and disassembly of metallic bolted flanged joints on piping, e.g. designed to DIN EN 13480, and vessels in process plants. Further requirements may have to be observed for the assembly of machine flanges, e.g. on pumps, compressors and vessels (designed to DIN EN 13445).

VDI 2290 is the applicable standard for the assessment of the leak tightness of flanged joints in applications involving liquid and gaseous fluids subject to emission limitations as per TA Luft.

With the application of this document, the requirements of VDI 2290 for the management system and joint tightness class L0,01 will be satisfied.

The use of bolted flanged joints is necessary to ensure access for inspection, maintenance and repair. This document applies to the assembly of bolted flanged joints at ambient temperature on depressurised systems.

It does not apply to flanged joints in enamelled, glass, plastic and plastics-lined piping, nor to metal-to-metal contact bolted flanged joints.

For vessel nozzles provided with a welding neck flange to DIN EN 1092-1, the flanged joint between the piping line and the vessel nozzle can be equated with a pipe-to-pipe flanged joint. Valves or pad flanges with tapped holes typically have a lower strength than the bolts used as a calculation basis for the specified tightening torques. Such joints will therefore require a correspondingly longer thread engagement length and tightening torques other than those specified in this Guideline.

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.

BImSchG	Bundesimmissionsschutzgesetz (Federal Air Pollution Control Act)
BetrSichV	Betriebssicherheitsverordnung (Industrial Safety Ordinance)
GefStoffV	Gefahrstoffverordnung (Hazardous Substances Ordinance)
TA Luft	Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft vom 24. Juli 2002) (Technical Instructions for Air Pollution Control)
DIN 78	Protrusions of bolt ends
DIN 2632 (W)	Welding neck flanges – PN 10 (withdrawn, superseded by DIN EN 1092-1 (2002-06))
DIN 2633 (W)	Welding neck flanges – PN 16 (withdrawn, superseded by DIN EN 1092-1 (2002-06))
DIN 2634 (W)	Welding neck flanges – PN 25 (withdrawn, superseded by DIN EN 1092-1 (2002-06))
DIN 2635 (W)	Welding neck flanges – PN 40 (withdrawn, superseded by DIN EN 1092-1 (2002-06))
DIN 2636 (W)	Welding neck flanges – PN 64 (withdrawn, superseded by DIN EN 1092-1 (2002-06))
DIN 2637 (W)	Welding neck flanges – PN 100

	(withdrawn, superseded by DIN EN 1092-1 (2002-06))
DIN 51818	Lubricants; consistency classification of lubricating greases; NLGI grades
DIN EN 1591-1	Flanges and their joints – Design rules for gasketed circular flange connections – Part 1: Calculation method
DIN EN 1092-1 (prEN 1092-1:2005)	Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 1 Steel flanges (withdrawn draft, superseded by DIN EN 1092-1 (2007-11))
DIN EN 1092-1	Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 1 Steel flanges
DIN EN 13480 series	Metallic industrial piping
DIN EN 13445 series	Unfired pressure vessels
DIN EN 13555	Flanges and their joints - Gasket parameters and test procedures relevant to the design rules for gasketed circular flange connections
DIN EN ISO 7089	Plain washers - Normal series, Product grade A
DIN CEN/TS 1591-4	Flanges and their joints - – Design rules for gasketed circular flange connections – Part 4 : Qualification of personnel competency in the assembly of the bolted connections of critical service pressurised systems
AD 2000-Merkblatt HP 100 R	Bauvorschriften; Rohrleitungen aus metallischen Werkstoffen (Design Code; Metal Piping)
TRBS 2141 Part 3	Gefährdung durch Dampf und Druck bei Freisetzung von Medien (Hazards due to steam and pressure on accidental fluid releases)
VDI 2290	Emission control – Sealing constants for flange connections
PAS 1057-6	Pipe classes for process plants; Part 6: Flanges for automated welding processes – Special styles

3 Terms and Definitions

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

Independent person: A person who has acquired through professional qualification, experience and recent job activities, the technical knowledge and skills required for inspecting bolted flanged joints. The independent person must have a high level of integrity and reliability, be in the possession of appropriate test facilities and equipment and must not be bound by instructions regarding the test results. The independent person may be an employee of either the operator, the installation contractor or another service provider.

Tightness class (as per DIN EN 13555) The tightness classes are defined in the form of specific leak rates in Table 1. If required, additional higher tightness classes can be specified by continuing the series.

Table 1 — Tightness classes

Tightness class	L1,0	L0,1	L0,01
Specific leak rate [mg·s^{-1}·m^{-1}]	≤ 1.0	≤ 0.1	≤ 0.01

The specific leak rate is determined by dividing the measured leak rate by the mean compressed gasket circumference.

4 Requirements

4.1 Technical requirements

A bolted flanged joint typically consists of a flange pair, bolts, nuts, a gasket and, where applicable, washers. It constitutes a system serving the following functions:

1. It provides a non-permanent connection between vessel, machine or piping components.
2. It ensures compliance with the leak tightness requirements as defined for the specific application. Currently, only the calculation method given in DIN EN 1591-1 or the finite element method is available for evaluating flanged joint tightness by analysis.

Quality assurance measures must be in place to ensure the leak tightness of the bolted flanged joint. The quality assurance measures to be provided depend on the installation class defined as part of the risk assessment (see Table 2).

Tools must be suitable, calibrated and stored in a proper manner.

4.2 Organisational requirements

Operators and/or service providers must describe the procedures including quality assurance procedures for flanged joint assembly as part of their in-house quality assurance system, (e.g. in standard operating procedures, in-house standards and risk assessment documents (see also Section 4.3)).

Among other criteria, the following basic organisational requirements must be satisfied:

- As a matter of principle, flanged joints must be designed and calculated for their intended use (e.g. using pipe classes in the case of piping).
- Only the components (flanges, bolts, nuts, gaskets) used as a basis for the design of the flanged joint, e.g. components specified in the piping specification (pipe classes), vessel documentation, may be used in the flanged joints.
- The tightening method and the tightening torque or bolt preload must be indicated to the assemblers by the plant operator and/or service provider.
- The installation class determined, i.e. the associated scope of quality assurance (lot size), must be indicated by the operator to the service provider.
- The requirements for flanged joint assembly documentation must be described.

4.3 Risk assessment

The plant safety and occupational health and safety requirements to be satisfied by the flanged joint must be defined through a risk assessment according to the BetrSichV. This comprises the definition of procedures for the

- design,
- assembly, and
- the documentation of flanged joint assembly.

Furthermore, environmental protection requirements (e.g. BImSchG, TA Luft) must be complied with.

The procedure to be applied for the assembly and inspection/testing of the bolted flanged joint (installation classes) derives from the risk or occupational health and safety assessment. Factors to be considered include, for instance:

- properties of the fluid, e.g. for classification according to GefStoffV or TA Luft
- operating conditions of the piping line
- Will torque wrenches or another controlled bolt tightening/tensioning method be needed?
- To what extent will the tightening torques or bolt preloads of the flanged joints be subjected to random inspections?
- What maintenance and inspection intervals will be specified (in the piping operating instructions)?
- Will the operating conditions (high-pressure, high temperature service, pressure surges) allow bolts removed during a maintenance shutdown to be reused?
- What criteria have to be observed for disassembly? (see also Section 5.8)

Bolt retightening after the first hot startup requires separate consideration.

4.4 Installation classes

Flanged joints are grouped into different installation classes. The installation class determines the quality assurance measures needed (see Table 2) and the associated minimum inspection and documentation requirements (see Table 8)

The installation class derives from the responsibility assignment for the initial inspection prior to putting into service (BetrSichV § 14).

Table 2 — Minimum classification of piping lines into installation classes

	Installation class		
Piping line	**1**	**2**	**3**
BetrSichV, Section 3, subject to inspection/testing by a competent person		**x**	
BetrSichV, Section 3, subject to inspection/testing by an authorised inspection body			**x**
TA Luft fluids		**x**	
Other piping	**x**		
Quality assurance measures	No further inspection/testing needed	Random inspection/testing	Random inspection/testing with cross-check

4.5 Assembly personnel

Bolted flanged joints may only be assembled by competent and qualified personnel. Where flanged joints are assembled by the operator's own personnel, the operator will be responsible for the training and instruction of the assemblers.[1] The personnel in charge of flanged joint assembly must be nominated in writing.

If a service provider is commissioned with flanged joint assembly, they will be responsible for the qualification of their personnel and must submit a list of the assigned assemblers to the plant operator. At the operator's request, the service provider must furnish proof of qualification of their assembly personnel.

Qualification of personnel for flanged joint assembly can be carried out on the basis of VDI 2290, for example. Section 6 of the above standard says [2]:

- A training module covering the proper assembly of flanged joints as part of the professional qualification (of the employees/skilled personnel) with a certificate of completion along with successful regular application are considered to be sufficient proof.
- Other employees without a corresponding specialist qualification (e.g. plant personnel) to be assigned to bolted flanged joint assembly must be provided with (the necessary theoretical and practical) expertise by training measures. (Training measures must be documented.)

[1] This also applies to seconded employees under the Arbeitnehmerüberlassungsgesetz (AÜG) (Temporary Employment Act).

[2] The texts in brackets have been added to the original text of VDI 2290.

4.6 Storage of gaskets

As a matter of principle, gaskets must be stored such as to rule out damage due to external forces. Generally, gaskets or sheet gaskets must be stored flat to avoid tensions and warping.

Positive identification of the gaskets must be ensured.

The following ideal storage conditions are recommended:

- room temperature < 25 °C
- relative humidity 50 to 60 %
- darkened room (protection from direct solar radiation)

Table 3 provides an overview of the shelf lives of different gasket materials.

Table 3 — Shelf life of gasket materials

Gasket	Shelf life
Fibres and elastomers	Fibre gaskets are subject to an ageing process due to their elastomer content. Under optimum conditions, they may have a shelf life of approx. 4 - 5 years; prolonged storage at elevated temperature (> 30 °C) may lead to a deterioration in quality after two years already. Fibre gaskets must not be exposed to UV radiation (solar) or heat for extended periods.
Graphite	Graphite gaskets basically have an infinite shelf life. The sole limiting factor can be the durability of bonded joints. Graphite gaskets must be protected from excessive moisture absorption. This applies in particular during installation. A good graphite gasket can tolerate some rain, but if it has fallen into a puddle it should be discarded.
PTFE	PTFE gaskets generally have an infinite shelf life. The sole limiting factor is the durability of bonded joints (e.g. in the case of PTFE gaskets with adhesive backing).
Spiral-wound gasket with PTFE filler	Proper storage conditions provided, spiral-wound gaskets can be stored for up to 5 years without any quality loss. Flash rust or ferrite particles in the storage rooms may, however, affect gasket integrity. If these particles deposit on the gaskets, they will cause corrosion. It is therefore important to ensure proper storage conditions and provide for routine inspections.

4.7 Use of washers

The use of hardened washers (200 HV at a minimum) offers the following advantages:

- defined friction surface for assembly
- defined surface roughness for bolted joint design and analysis, and hence
- reduced tightening torque scatter, resulting in a higher theoretical bolt load.

With austenitic/ferritic flange/fastener material combinations, there is a potential risk of contact corrosion. Hardness class 200 HV steel and stainless steel washers are described in DIN EN ISO 7089. The material of the washer should be compatible with that of the flanged joint. Austenitic steel washers are required for ferritic flange/austenitic bolt combinations.

5 Assembly Procedure

5.1 Surface finish of flange sealing faces

Where the flange sealing faces are provided with a temporary coating, e.g. for corrosion protection, the coating must be completely removed (using a cleaning agent, suitable wire brush, for example).

Note: When replacing gaskets, care must be taken to ensure that old gasket fragments/debris are completely removed from the flange face, taking care not to damage the gasket contact face.

Note: Residual anti-corrosion agents on the sealing face (of new flanges) have an adverse effect on both the leak rate of the flanged joint and the removal of gasket debris on gasket replacement.

5.2 Visual inspection prior to assembly

Due care must be exercised to ensure that the flange sealing faces are clean, flat and free from damage. In particular, flange facings must not exhibit any radial surface irregularities such as scores or dents. In the case of doubt, the damage must be field-inspected by a competent person and the flange be replaced or re-machined, if necessary.

Bolts, nuts and washers must be clean and free from damage. Special attention must be given to the threads and load bearing surfaces.

Bolts, nuts and washers, removed during disassembly work must be replaced by new ones if indicated by the risk assessment or if found to be damaged on inspection. Used bolts, nuts and washers may only be reused if they are "as-new".

The gasket must be clean, dry and free from damage. Coating gaskets with adhesives and anti-seize compounds is not allowed. Used gaskets must not be reused. Kinked gaskets in particular pose a safety risk and must not be used under any circumstances.

Care must be taken to ensure that the gaskets provided to the assemblers are free from the flaws and defects listed in Table 4, for example. The manufacturer's instructions must be followed.

Table 4 — Common gasket flaws and defects by the example of a typical selection of gaskets

Gasket	Defect / deficiency
Graphite gaskets	Continuous rips around gasket edge due to blunt punching tool Radial kinks across the gasket
Gasket with inner flare	Inner flare insufficiently contoured Outer edge bulged due to blunt cutting or punching tool
PTFE envelope gasket with corrugated ring insert	Corrugated ring insert: too large an inside diameter, not deburred Corrugations taper off off-centre Corrugated ring torn Corrugated ring deformed, not flat Cracks in the area of the diffusion barrier PTFE envelope deformed
Spiral-wound gasket	Non-uniform fabric protrusion on inner and outer edges Radial scores
Grooved metal gasket	Radial scores

5.3 Lubrication and lubricants

To minimise friction forces, the sliding faces of the bolts, nuts and washers must be coated with suitable lubricants prior to bolt-up[3]. Optimal lubrication is deemed to be given if all sliding faces, such as the thread, the nut bearing surface and, if the bolt head is turned to tighten the joint, also the bolt head bearing surface are lubricated (see Figure 1). This is a prerequisite to attain the necessary bolt preload at the specified tightening torque and ensure ease of bolted joint disassembly after exposure to thermal stresses.

As a matter of principle, lubricants should be applied as a thin film, making certain that the complete surface is covered. Over-lubrication offers no advantages, nor does it reduce the friction coefficient. An anti-shedding, medium-stiff brush or a sponge will be appropriate for lubricant application.

[3] Assembly tests have shown that optimum lubrication of the bolts and nuts prior to assembly can increase the bolt loads by a factor of up to 3 compared to the unlubricated condition at identical torque.

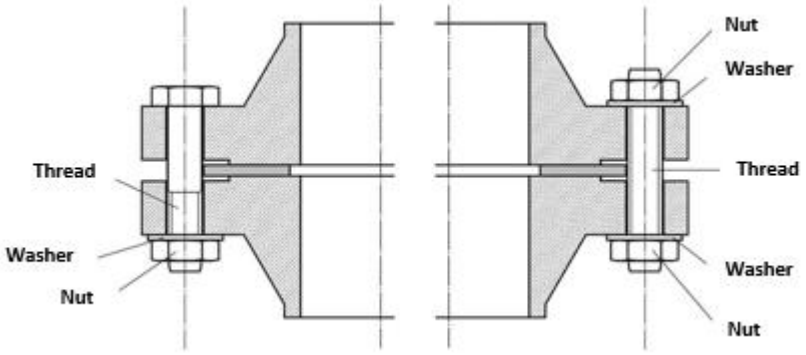


Figure 1 — Components to be lubricated in a bolted flanged joint
(left: flanged joint with bolt, right: flange joint with threaded stud)

Where bolts are exposed to service temperatures of > 250 °C, heat-resistant lubricants will be needed.

Lubricants must be properly stored.

A lubricant is considered to be suitable, if

1. it has the right lubricity (consistency class, NLGI grade as per DIN 51818),
2. it is compatible with the construction materials and service fluids, and
3. the recommended service temperatures are in the range of the operating temperatures.

Moreover, an FDA approval may be required (H1 lubricant). This information will not always be indicated in the material safety data sheet, but can frequently be found in the manufacturers' technical data sheets or catalogues.

Table 5 provides an overview of some common lubricants. Please note that this list is not exhaustive, but only intended as an example.

Table 5 — Examples of lubricants

Lubricants	Manufacturer	Temp. [°C][a]
725 NICKEL ANTI-SEIZE COMPOUND[d]	A. W. Chesterton Co	up to 1425
785	A. W. Chesterton Co	-34 to +1204
Chesterton Sliding Paste 78[d]	A. W. Chesterton Co	-23 to +538
Molykote 1000[d]	Dow Corning GmbH	-30 to +650
Molykote P-74 Paste	Dow Corning GmbH	-40 to +1500
Klüber Paste HEL 46-450[d]	Klüber Lubrication München KG	-40 to +1000
Wolfrakote Top-Paste	Klüber Lubrication München KG	-25 to +1000
OKS 235	OKS Spezialschmierstoffe GmbH	-40 to +1100
OKS 250	OKS Spezialschmierstoffe GmbH	-40 to +1400
High-Tech Paste ASW 040 P[d]	PH Industrie-Hydraulik GmbH & Co. KG	-40 to +1400
Mi-Setral – 9C Screw Paste (copper paste)[d]	Setral Chemie GmbH	up to 1180
For oxygen service		
Klüberalfa YV 93-302, 60 g	Klüber Lubrication München KG	-60 to + 60[c]
Oxigenoex FF450	Klüber Lubrication München KG	-60 to +60[b]
FDA-approved lubricants		
785 FG	A. W. Chesterton Co	-34 to +1204
VA lubricants		
PASTE HT-600	Gelubol GmbH	up to + 650° C
WEICON Anti-Seize "High-Tech"	WEICON GmbH & Co. KG	-40 to + 1400

[a] Service temperature ranges indicated by manufacturer
[b] O_2 concentration > 21 % by vol., max. oxygen pressure 450 bar
[c] O_2 concentration > 21 % by vol., max. oxygen pressure 310 bar (for other oxygen concentrations and pressures, see data sheet)
[d] Also suited for austenitic steels

5.4 Gasket installation and centring

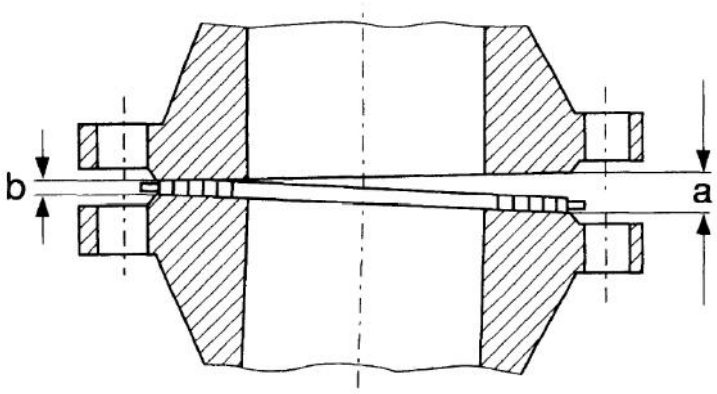
Proper assembly of flanged joints presupposes that the mating flanges are in exact parallel alignment without any centreline offset so that the gasket can be inserted in the correct position without being damaged. Centring pins should be used as a mounting aid in particular with reduced-shank bolts.

Recommendation: Use plastic centring pins to avoid unallowable stresses through lever arm effects.

Spread the sealing faces apart to obtain a sufficient clearance so that the gasket can be mounted without application of force and without suffering damage.

The gap (non-parallelism of sealing faces) prior to bolt-up is considered to be acceptable if the maximum allowable gap difference shown in Figure 2 is not exceeded. To bring the flanges into proper alignment, always align from the "gaping" side (a).

Gaps are particularly problematic in very stiff piping (e.g. heated/cooled jacketed piping, thick-walled high-pressure piping). Experience has shown that pulling together the flanges is extremely difficult, if at all possible in such applications. In the case of doubt, the flanges should be pulled together by provisional bolt-up without inserted gasket. Parallelism and the allowable sealing face gap should be attained when applying approx. 10 % of the rated torque. If the correct flange position cannot be attained without the use of heavy means, such as chain pulleys, grip hoists or similar, the gap will not be allowable. Should this not be possible, the gap must be eliminated prior to gasket installation by straightening or, if required, by removing and re-welding the flanges.



DN	a–b [mm]
10 – 25	0.4
32 – 150	0.6
200 – 300	0.8
350 – 500	1.0

Figure 2 — Flange gap and reference values for allowable gap = a–b

5.5 Application of required tightening torques

To ensure tightness class L0,01 performance, tightening torques have been determined using the calculation method given in DIN EN 1591-1 (see Table 6). Details underlying the calculation are summarised in Annex C to this document. Calculations in the individual case may lead to other tightening torques.

For simplification, the tightening torque calculation for a group of gaskets, nominal diameters and PN ratings has been optimised such as to be able to specify a single tightening torque per bolt size as a function of the gasket group. In the majority of cases, the allowable stresses will be fully exploited for at least one component of the flanged joint. The simplification achieved with this procedure for application in practice compensates for the few cases where the maximum allowable stresses are not fully exploited.

Gasket group A

Flat gasket: PN 10 to PN 25 (without inner flare)
PN 40 (with inner flare)

This will also cover gaskets with corrugated ring inserts up to PN 40.

Flat gaskets with inner flare for PN 10 – PN 25 will likewise be covered if they have the required sealing characteristics. Normally, flare gaskets have poorer leakage curves than non-flare gaskets so that finding flare gaskets with appropriate sealing characteristics may be a problem in practice.

Gasket group B

Gaskets for tongue-and-groove flanges (with fibre gaskets and metal-reinforced graphite gaskets):	PN 10 to PN 40
Grooved metal gasket:	PN 10 to PN 100
Spiral-wound gasket with graphite filler:	PN 10 to PN 100

Table 6 — Required tightening torques for the assembly of Type 11 flanges to DIN EN 1092-1 and fasteners (e.g. bolts, threaded studs) made of 25CrMo4 / A2-70 or other steel grades of comparable strength

Thread	Tightening torque [Nm][a]		Tightening method
	Gasket group A	Gasket group B	
M12	50	50	Manual wrench using a suitable extension, if required
M16	125[b]	80	
M20	240[c]	150	
M24	340	200	Torque wrench or other controlled torqueing methods
M27	500	250	
M30	700	300	
M33	900	500	
M36	1200	750	
M39	1400	900	
M45	2000	1200	
M52	3000	-	

[a] These tightening torques have been calculated by BASF SE and generally confirmed by the companies involved in the development of this Guideline.
[b] Recommended lever length 300 mm
[c] Recommended lever length 550 mm

Note: Austenitic and ferritic steel flanges to DIN EN 1092-1 have identical dimensions.

5.5.1 p/T rating and strength

The p/T rating has been considered in the calculation of the tightening torques. In flanged joints with nominal diameters above DN 150 in particular, the flange is frequently the limiting component.

Regarding material strength, flange material P245GH has been selected as a basis for the tightening torque calculations. In this way, higher-strength materials will also be covered.

The calculated tightening torques are based on the maximum possible temperatures. Usually, the service temperatures are limited by the maximum allowable temperature of the flange/fastener materials and/or gaskets. For low temperature service, the calculated torques will thus be on the safe side any way.

In the case of austenitic steels, it has been assumed that the strength will not be affected by low temperatures so that the calculations cover temperatures down to -200 °C.

The flange-bolt-gasket material combination must be suitable for the specific operating temperature.

5.5.2 Use of DIN flanges

The tightening torques given in Table 6 also apply to DIN flanges with dimensions identical to those covered by DIN EN 1092-1 for the nominal diameters and PN ratings shown in Table 7.

Table 7 — Nominal diameters and PN ratings of former DIN flanges

Pressure rating	Standard	Nominal diameter
PN 10	DIN 2632	™DN 500
PN 16	DIN 2633	™DN 400
PN 25	DIN 2634	™DN 400
PN 40	DIN 2635	™DN 400
PN 63	DIN 2636	™DN 400
PN 100	DIN 2637	™DN 300

The smaller flange thickness of DIN flanges < DN 50 as compared to EN flanges has no influence on the tightening torques.

Austenitic steel welding neck flanges for automated welding processes according to PAS 1057-6 with reduced "s" dimension (hub wall thickness) are covered by the DIN flanges.

5.6 Bolt tightening procedure

5.6.1 General

The sequence in which the bolts and nuts are tightened has a major influence on the distribution of the loads acting on the gasket (gasket seating stress). Improper bolt tightening leads to a broad preload scatter and may result in the required minimum gasket seating stress not being reached through to ultimate leakage problems.

After the nut has been tightened, a minimum of two, but not more than five thread turns should project at the bolt end (see also DIN 78). Threaded studs must be mounted such that the protrusions on either end are about the same. Bolt heads, nuts and washers must rest flat against the flange surface.

Bolts must be run down and snugged up by hand. For this purpose, proceed as follows:

- Place hardened washers to DIN EN ISO 7089, minimum hardness class 200 HV, under the nuts.
- Insert bolts such that all bolt heads are located on one flange side.
- In bolted joints in which the bolt head is turned to tighten the joint (pocket hole), place the washers under the bolt heads.
- Insert bolts from the top on horizontal flanges.
- Replace hard-to-turn bolts with smooth-turning ones.

The simultaneous use of several bolt tensioning tools is allowed.

Annex A to this document provides brief bolt tightening instructions for the assembly personnel.

5.6.2 Bolt tightening method 1

Round 1: Tighten the bolts in a criss-cross pattern as shown in Figure 3 applying 30 % of the target torque.

Round 2: Repeat Round 1, applying 60 % of the target torque.

Round 3: Repeat Round 1, applying the full target torque (100 %).

Round 4: In a final check pass, tighten the bolts in a circular pattern bolt by bolt at the final torque value. Repeat this procedure until no additional turning can be observed in the nuts when applying the full tightening torque.

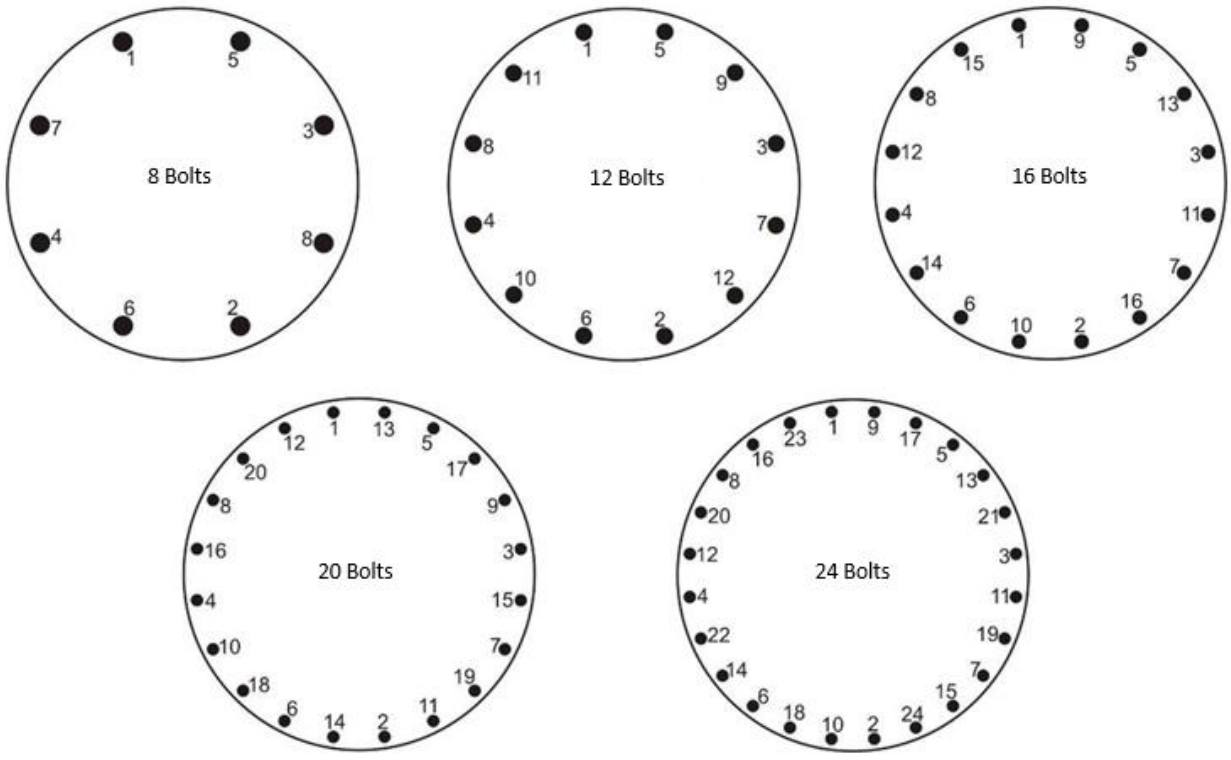


Figure 3 — Bolt tightening method 1: Criss-cross tightening pattern

In individual cases, retorqueing will be needed for gasket seating (to flow the gasket into the imperfections in the gasket seating surfaces). In such cases, the bolts must be retorqued at ambient temperature and in the depressurised condition of the flanged joint several hours after initial torqueing or after the first thermal cycle. If flanged joints are retightened at elevated temperatures during operation, TRBS 2141 Part 3 prescribes a separate risk assessment.

5.6.3 Bolt tightening method 2

Alternatively, the following bolt tightening method may be used for nominal diameters from DN 200[4]:

Round 1: Tighten 4 bolts as shown in Figure 4, applying 20 % of the target torque.

Round 2: Torque the four bolts to 60 % of the target torque.

Round 3: Torque the four bolts to 105 % of the target torque.

Round 4: Tighten all remaining bolts to 105 % of the target torque in a circular pattern.

Round 5: Repeat circular torqueing at 105 %.

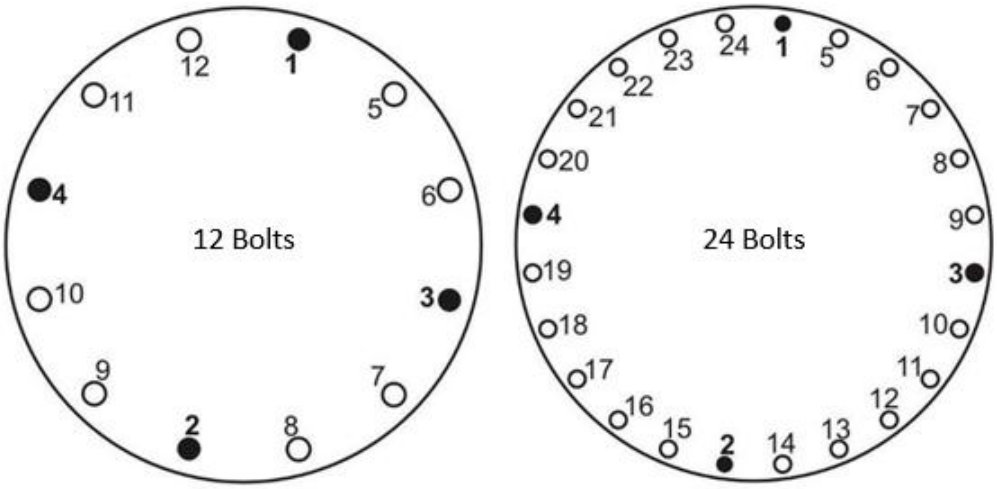


Figure 4 — Bolt tightening method 2: Alternative bolt tightening method

5.7 Quality assurance and documentation of flanged joint assembly

5.7.1 Quality assurance

The installation class determines the quality assurance measures to be applied and the associated documentation requirements (see Table 8).

The lot used as a basis for random inspection must be selected in a meaningful manner, e.g. plant-related, per contract scope or per assembler.

The minimum inspection scope is shown in Annex B. This annex can also be used for the documentation of flanged joint assembly in new plants.

[4] In theses cases, the stress reserves for the bolts and the flange will not be fully utilised in the bolted-up condition so that application of the elevated torque will not cause the allowable stress for any of the components to be exceeded.

The inspection must be carried out before the leak tests and before the pressure test if these tests are performed in the assembled condition.

Table 8 — Quality assurance measures per installation class

Installation class	Quality assurance measures
1	No further tests/inspections
2	Random inspection Z by assembly personnel (by a second assembler) Z Scope: 2 % of flanged joints Z In the case of deviations from the specified torque range, the inspection scope must be extended. Z Documentation
3	Random inspection Z by assembly personnel (by a second assembler) Z Scope: 10 % of flanged joints Z In the case of deviations from the specified torque range, the inspection scope must be extended. Z Documentation Cross-check Z by an independent person Z Scope: 2 % of flanged joints Z Documentation Z In the case of deviations from the specified torque range, the inspection scope must be extended.

The torques to be applied for verification are indicated in Annex B. Because of the gasket seating behaviour, the torque check should not be carried out earlier than 4 hours after joint assembly. For the determination of the check torques, the tightening torque is multiplied by the gasket P_{QR} value[5] at a Q_A value of 30 MPa at room temperature, taking into account the preload scatter on bolt tightening. If the flanged joint is checked directly after assembly, the tightening torques[6] must be used as check torques.

The tightening torque is verified at the point where the bolted joint was tightened. Normally, the nut will be tightened. For this reason, the washer will be placed under the nut. For torque verification, set the torque wrench to the check torque. If the nut cannot be turned any further, the required tightening torque has been applied.

[5] Gasket characteristics can be found in DIN EN 1591-2, the gasket manufacturers' data sheets or at www.gasketdata.org.

[6] Note: Studies have shown that the influence of static friction on the bolt tightening torque is minor directly after assembly (no coating, no corrosion).

5.7.2 Documentation

The type and scope of documentation must be consistent with the company's management system. The documentation may comprise, for example:

- New plant:
  - design documentation
  - isometric drawings
  - workshop drawings
  - specifications
  - schematic sketches
- Overhaul or small repairs:
  - job cards
  - repair specifications
- Plant-specific flange opening and closing
  - shift book
  - repair book

The manufacturer's certificate showing the names of the assemblers involved, for example, will be sufficient for documenting flange assembly. Allocation of the flanged joint to a specific assembler will not be necessary. Accordingly, indicating the names of the assemblers involved on the manufacturers' and piping test certificates would be sufficient for the assembly documentation of bolted flanged joints.

Annex B can be used for the documentation of flanged joint inspection. Identification marking of the individual flanged joints may be helpful.

5.8 Pressure and leak tests

A pressure test (referred to as strength test in the BetrSichV) and a leak test (referred to as external test in the BetrSichV) must be performed after quality inspection of the bolted flanged joint assembly.

6 Disassembly

Before a flanged joint is disassembled, an approved permit to work must be obtained. Care must be taken to ensure that the system has been depressurised and purged. The safety procedures of the specific site must be observed.

- Unless separately secured, internals or attachments must be secured in place before opening the flanged joint.
- Always start loosening the bolts or nuts on the side facing away from you.
- Loosen the bolts or nuts in a criss-cross pattern using a minimum of two passes. If a line is under mechanical tension, uncontrolled line movement is to be expected.

When replacing gaskets, any remaining debris and fragments of the old gasket must be completely removed, taking care not to damage the flange sealing face

7 Application of VDI 2290 to Existing Plants

The decision as to whether the VDI 2290 standard is to be used as a legal basis for existing plants rests with the permitting authority. The authority may require compliance with VDI 2290 for the permitting of proposed projects and, where applicable, as part of a permit review for existing plants.

Regardless of the fact that the permitting authority does not require compliance with the VDI 2290 standard for the time being, the requirements of VDI 2290 should be taken into account already now for installation, maintenance and repair work in existing plants.

Earlier editions

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Revision note

The following changes have been made relative to the previous edition:

a) Normative references updated
b) Editorially revised
c) Section 5.3 and Table 5 supplemented
d) New section 4.7: Use of washers
e) New section 5.5.1: p/T rating and strength
f) New Section 7: Application of VDI 2290 to existing plants
g) Figure 1 changed