



WATER SERVICES
ASSOCIATION OF AUSTRALIA

WSA 109:2021

Flanged Gaskets and O-rings

Third Edition

Version 3.1



WSA 109:2021

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ACKNOWLEDGMENTS

WSAA acknowledges the significant technical input of Peter Pittard (WSAA Consultant) and Jason Hall (Reece Australia Pty Ltd) for their contribution to the revision of this Water Industry Standard.

Other organisations that contributed includes Plastics Industry Pipe Association of Australia(PIPA), Steel Mains Pty Ltd, Hultec Asia Pacific Pty Ltd, Clover Pipelines Pty Ltd, Daemco Australia Pty Ltd, Industrial Gaskets and Sealing Devices Pty Ltd.

The following individuals peer reviewed this revision and provided comments and suggestions.

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PUBLICATION DETAILS

Published by:

Water Services Association of Australia Limited
Level 8 Suite 8.02

401 Docklands Drive

Docklands VIC 3008

ISBN details to be inserted

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PUBLIC COMMENT DRAFT

PREFACE

This Standard was prepared by the Water Services Association of Australia (WSAA).

The objective of this Standard is to define material requirements for flange gaskets and O-rings and guidelines for joining flanges commonly utilized in water supply and sewerage pipelines.

The Standard will be withdrawn upon publication of an equivalent Australian Standard.

This revision is the result of a comprehensive review. The major amendments are detailed below:

- Material testing requirements that are contained within an alternative Standard have been removed from this document and appropriately referenced.
- The Scope of this Standard has been revised and clarified.
- Sealability tests have been removed. Sealability type tests were completed by Tyco Water in 2003 to demonstrate suitability of the gasket materials specified within this Standard. In addition the Industry has now been successfully utilising materials specified in WSA 109 for more than 15 years. It is considered unnecessary and impractical for gasket material suppliers or gasket manufacturers to undertake ongoing performance tests for gasket materials already proven to be fit for purpose.
- Gasket dimensions have been rationalised to specify the same dimensions regardless of flange material. A dimensional analysis verified that the internal flange dimensions specified in this Standard do not intrude into the waterway of flanges commonly utilised in the Australian water industry.
- The informative Appendix D includes additional and updated guidelines for flanged joint assembly. Estimated tightening torques are provided based on assumed variables regardless of flange material. An Excel spreadsheet calculator has been developed as a companion to this Standard. The methodology and assumptions to provide the estimated tightening torques contained in Appendix D are detailed in the calculator. Where alternative variables apply, alternative tightening torques may be calculated.

Comments or suggestions for improvements should be forwarded to:

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This Standard was issued on **Day Month** 2021 following a public review period that closed on **Day Month** 2021.

Originated as WSA 109-2001
Second edition: WSA 109-2011
Third edition: WSA 109-2021

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1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for solid elastomeric and compressed non-asbestos fibre gaskets and elastomeric O-rings suitable for jointing metallic flanges that comply with AS/NZS 4087.

Gasket materials may also be suitable for flanges that comply with AS/NZS 4331.1, AS/NZS 4331.2, AS/NZS 4331.3, AS 2129 and other metallic flange standards, however dimensions will be different and appropriate assembly torques will need to be assessed.

Fabric reinforced or composite elastomeric gaskets are not included.

Gaskets and O-rings complying with the material requirements of this Standard may be used for PN 14, 16, 21 and 35 flanged joints complying with AS/NZS 4087 for all metallic pipeline materials, including iron, steel, copper and copper alloys for drinking and non-drinking water supply, drainage and sewerage for operating temperatures up to 50°C (AS 681-1 Type WA). Material specifications for other operating temperatures are not included.

AS/NZS 4087 Appendix C provides recommendations for the selection of appropriate gasket materials (including thickness) and fasteners for various metallic flange materials, pressure classifications and flange face types.

Jointing guidelines for polyethylene flanges may be sourced from POP 007 published by the Plastics Industry Pipe Association of Australia (PIPA) or AS/NZS 4129:2020. A flange bolt torque calculator is also available from Iplex Australia at the following link:

<https://www.pocketengineer.com.au/Fbtc/step1wizard>

Means for demonstrating compliance with this Standard are given in Appendix A.

Purchasing guidelines are given in Appendix B.

Dimensions for gaskets and O-rings are given in Appendix C.

Guidelines for the assembly of flanged joints are given in Appendix D.

1.2 REFERENCED DOCUMENTS

AS

681-1 Elastomeric seals—Material requirements for pipe joints used in water and drainage applications Part 1: Vulcanized rubber

1646 Elastomeric seals for waterworks purposes

2129 Flanges for pipes, valves and fittings

AS/NZS

4020 Testing of products for use in contact with drinking water

4087 Metallic flanges for waterworks purposes

4129 Fittings for (PE) polyethylene pipes for pressure applications

4331.1 Metallic flanges - Steel flanges

4331.2 Metallic flanges - Cast iron flanges

4331.3 Metallic flanges - Copper alloy and composite flanges

ASTM

- F 36 Standard Test Method for Compressibility and Recovery of Gasket Materials
- F 37 Standard Test Method for Sealability of Gasket Materials
- F 38 Standard Test Methods for Creep Relaxation of a Gasket Material
- F 104 Classification System for Nonmetallic Gasket Materials
- F 146 Standard Test Methods for Fluid Resistance of Gasket Materials

ISO/IEC

- 17025 General requirements for competence of testing and calibration laboratories

ISO

- 37 Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties
- 2230 Vulcanized rubber—Guide to storage
- 9691 Rubber—Recommendation for the workmanship of pipe joint rings—Description and classification of imperfections.

PIPA

- POP 007 Metal backing flanges for use with polyethylene (PE) pipe flange adaptors

1.3 DEFINITIONS

For the purpose of this Standard the definitions given in AS/NZS 2280 and AS/NZS 4087 apply.

1.4 ALLOWABLE PRESSURES

Allowable pressures for flange gaskets and O-rings shall be as given in Table 1.1.

TABLE 1.1
ALLOWABLE PRESSURES

Component	PN	AOP kPa	MAOP kPa	ASTP kPa
Elastomeric gasket or O-ring	16	1600	1920	2000
Compressed fibre gasket or O-ring	35	3500	4200	4375

2 MATERIALS

2.1 GENERAL

The materials shall be free of any substances that may have a deleterious effect on the fluid being conveyed or on the life of the gasket, O-ring, flange or fasteners.

2.2 CONTAMINATION OF WATER

Flange gaskets and O-rings shall comply with AS/NZS 4020. A scaling factor of 0.01 shall be applied.

2.3 MATERIAL REQUIREMENTS

Gaskets and O-rings shall be manufactured from materials complying with the requirements of Table 2.1.

TABLE 2.1
MATERIAL REQUIREMENTS

Component	Material	Standard	Specification
Elastomeric gasket	EPDM, NBR, SBR	AS 1646 and AS 681.1	60 or 70 IRHD
O-ring	EPDM, NBR, SBR	AS 1646 and AS 681.1	40 IRHD
Compressed fibre gasket	Non asbestos fibre	ASTM F104	Type 7 Class 1

2.4 MATERIAL PROPERTIES

2.4.1 Elastomeric flange gaskets and O-rings

The material properties for the elastomeric gaskets and O-rings shall comply with AS 1646 and AS 681.1 Type WA for the applicable material specifications given in Table 2.1.

A sealing stress of no less than 2 MPa and a crushing stress greater than 16 MPa is nominated for the elastomeric flange gasket materials specified in this Standard.

2.4.2 Compressed fibre gaskets

The material properties for the ASTM F104 Type 7 Class 1 material shall comply with Table 2.2.

TABLE 2.2
MATERIAL PROPERTIES FOR COMPRESSED FIBRE

Material Property	Unit	Value	Test Method
Tensile Strength	MPa	> 3	ASTM F152
Creep relaxation 22 h at 100°C	%	< 25	ASTM F 38 Method B
5 h at 100°C	%	< 5	ASTM F 146
Recovery	%	> 40	ASTM F 36 Procedure J
Compressibility	%	> 15	ASTM F 36 Procedure J
Sealing stress	MPa	> 15	Manufacturer
Crushing stress	MPa	> 100	Manufacturer

3 MANUFACTURING REQUIREMENTS

3.1 FORM

Gaskets shall be solid without fabric reinforcement or other composite materials. The surfaces may be flat or profiled to the manufacturer's design requirements.

3.2 DIMENSIONS

Dimensions for flange gaskets for use with AS/NZS 4087 flanges are given in Appendix C.

O-rings shall comply with the dimensional requirements specified in AS/NZS 4087 or where otherwise specified for alternative O-ring groove dimensions.

3.3 IMPERFECTIONS AND DEFECTS

Elastomeric gaskets and O-rings shall be free of defects and irregularities which could affect their function. Classification of imperfections shall be in accordance with ISO 9691.

Limits on imperfections and defects for compressed fibre gaskets shall be in accordance with the manufacturer's requirements.

3.4 O-RING SPLICE JOINT

Each O-ring splice joint shall show no visible sign of separation when tested in accordance with AS 1646 or AS 681-1.

3.5 MARKING

Each gasket shall be marked clearly and durably in accordance with the following such that identification is visible at the time of installation and the sealing capability is not impaired. A stick-on label may be utilised where practicable.

- (a) Manufacturer's identification.
- (b) Nominal size.
- (c) Flange compatibility and pressure classification
- (d) The number of this Standard with the type of application and hardness class as a suffix, e.g. WSA 109 WA/70.
- (e) Year of manufacture.
- (f) The abbreviation for the elastomer material, e.g. EPDM.

Example

Name/DN100/ASNZS4087PN16/WSA109/WA/70/2020/EPDM

NOTE: Manufacturers making a statement of compliance with this Water Industry Standard on a product, packaging or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

3.6 STORAGE

Gaskets and O-rings shall be stored under the following conditions:

- (a) at temperatures less than 25 °C
- (b) protected from light or other UV sources
- (c) not in a room with any equipment capable of generating ozone e.g. mercury vapour lamps, high voltage electrical equipment, electric motors or other equipment that could cause electrical discharges
- (d) in a relaxed condition free from tension, compression or other deformation.

NOTE: For additional information on the storage of elastomeric gaskets and O-rings see ISO 2230.

APPENDIX A
MEANS FOR DEMONSTRATING CONFORMITY WITH THIS STANDARD
(Normative)

A1 SCOPE

This Appendix sets out requirements for the consistent demonstration of conformity with this Standard through the use of a minimum sampling and testing frequency plan.

A2 RELEVANCE

The long-term performance of pipeline systems is critical to the operating efficiency of water agencies in terms of operating licences and customer contracts.

A3 TESTING

A3.1 General

Table A1 sets out the minimum sampling and testing frequency plan for a manufacturer to demonstrate conformity of product(s) to this Standard.

A3.2 Testing

Testing shall be conducted by a testing laboratory or facility accredited to ISO/IEC 17025.

NOTE: ISO/IEC 17025 can apply to first-party (i.e. manufacturer or supplier) second-party (i.e. user or purchaser) or third-party testing laboratories and facilities.

A3.3 Retesting

In the event of a test failure, the products within the production batch shall be 100% tested and only those items found to conform may be claimed and/or marked as conforming with this Standard.

A4 PRODUCT CONFORMITY ASSESSMENT REQUIREMENTS

Water Services Association of Australia Technical Note (WSA TN-08) sets out additional product conformity assessment requirements.

**TABLE A1
MINIMUM SAMPLING AND TESTING FREQUENCY PLAN**

Characteristic	Clause	Requirement	Test method	Frequency
Type Tests				
Material	2.2	Contamination of water	AS/NZS 4020	At any change in material or every 5 years
Material Properties - elastomeric gaskets and O-rings	2.4.1	Hardness	AS 1646 and AS 681-1	Annually (except tests with a duration of more than 28 days are repeated each 5 years) or where there is a change in formulation or manufacturing technique
		Tensile strength and elongation at break		
		Compression set in air		
		Accelerated aging in air		
		Stress relaxation in compression		
		Volume change in water		
Material properties – compressed fibre gaskets	2.4.2	Tensile strength	ISO 37	Annually or where there is a change in formulation or manufacturing technique
		Creep relaxation in compression	ASTM F38 Method B	
		Thickness change in water	ASTM F146	
		Recovery	ASTM F36 Procedure J	
		Compressibility	ASTM F36 Procedure J	
		Minimum sealing stress	Manufacturers method	
		Crushing stress	Manufacturers method	
Marking	3.4		Visual	At any change in design
Batch Release Tests				
Finished gaskets and O-rings	3.2	Dimensions - Gaskets - O-rings	Appendix C AS/NZS 4087	One per manufacturing batch
	3.3	Imperfections and defects	Visual	Each gasket or O-ring
	3.4	O-ring splice joint (elastomeric O-rings)	AS 1646 or AS 681-1	Each O-ring
	3.5	Marking	Visual	One per manufacturing batch

APPENDIX B PURCHASING GUIDELINES (Informative)

B1 GENERAL

Standards are intended to define the technical provisions necessary for the supply of products included in the Standard but do not purport to contain all the necessary provisions of a supply contract. The purchaser is generally required to provide specific requirements or choose from nominated options. These are contractual matters to be agreed upon between the purchaser and the manufacturer.

This Appendix contains advice and recommendations for information to be supplied by the purchaser to the manufacturer at the time of enquiry or order. Its aim is to avoid misunderstanding and to result in the purchaser receiving satisfactory products and services.

B2 INFORMATION TO BE SUPPLIED BY THE PURCHASER

At the time of enquiry or when calling for tenders or quotations a purchaser should supply the following information:

- (a) The specification of the flanges to be joined including the Standard, material and pressure classification.
- (b) Form e.g. flat gasket, profiled gasket or O-ring.
- (c) Designation other than WA e.g. WC or WG.
- (d) The material to be used in the manufacture of the gaskets or O-rings and, where applicable, the nominal elastomer hardness. Unless otherwise specified, the nominal gasket or O-ring hardness will be that of the original material.

NOTE: The gasket or O-ring hardness and the elastomer hardness for the material from which it is manufactured may differ due to differences in the configuration of the test pieces and the methods of measurement.

- (e) Any particular requirements relating to the properties of the gaskets or O-rings or formulation of the elastomeric compound.

NOTE: Changes to the formulation may affect compliance of the gaskets or O-rings with this Standard.

- (f) Where gaskets are required for operating conditions outside of the scope of this standard
- (g) Requirements for packaging and labelling.
- (h) Whether a certificate of compliance or a test certificate is required (see Paragraph B3).

B3 CERTIFICATES

B3.1 Certificate of compliance

A certificate of compliance should state that the gaskets and O-rings comply with the requirements of this Standard as outlined in Appendix A.

B3.2 Test certificate

A test certificate should show the results of type tests completed to establish compliance with this Standard and any other agreed tests in accordance with Table A1.

B4 INFORMATION TO BE SUPPLIED BY THE MANUFACTURER

Where requested, the manufacturer should supply the following information for gaskets and O-rings:

- (a) Applicable flange standard(s) and pressure classification for the gaskets and/or O-rings.
- (b) Material details including designation, compound description, relevant properties and service application advice and limitations.
- (c) Dimensions for the gaskets and/or O-rings
 - (i) Gasket dimensions should nominate nominal diameter (DN) and/or pipe OD, gasket OD, gasket ID, gasket thickness and compatible flange standard.
 - (ii) O-ring dimensions should nominate nominal diameter (DN), actual ID and cross-section (diameter or critical dimensions for other profiles).
 - (iii) O-ring groove design and surface finish including dimensions of groove depth and width, compression (actual and percentage), groove radius, diametral clearance and lead-in. Extrusion curves to determine maximum diametral clearance should also be available for each O-ring material and hardness.

**APPENDIX C
GASKET DIMENSIONS
(Normative)**

C1 DIMENSIONS

Dimensions of gaskets for jointing AS/NZS 4087 flanges are given in Tables C2 and C3, irrespective of the flange material.

Gaskets may be specified as full-face or ring type (also known as IBC, narrow face or partial face gaskets).

The outside diameter of full-face gaskets is the same as the outside diameter of the adjoining flanges and incorporates holes to facilitate the location of the gasket over the bolts during assembly. The external shape may be circular or polygon shaped in accordance with the alternative external shape requirements of AS/NZS 4087.

The outside diameter of ring type gaskets allows the gasket to locate within the inside bolt circle of the flanges and are calculated as PCD - Bolt Hole Diameter - 1mm.

The inside diameters of the gaskets have been specified to co-incide with the inside diameter of unlined K12 (Flange Class) ductile iron pipe. This diameter represents the largest bore size for flanged components commonly used in the Australian Water Industry and avoids intrusion of the gasket into connecting pipes, fittings and valves.

Nevertheless, installation personnel should ensure that gaskets do not intrude into the waterway of flanged components.

C2 TOLERANCES

The tolerances for gasket dimensions are given in Table C1.

TABLE C1 TOLERANCES

Attribute	Tolerance
Outside diameter	± 5
Inside diameter	± 1
Pitch circle diameter	± 1.5
Hole diameter	+ 2, - 0.5
Thickness	± 0.1

TABLE C2
FLANGE GASKET DIMENSIONS FOR AS/NZS 4087 PN 16 FLANGES

NOMINAL SIZE	MATERIAL	OD mm		ID mm	NUMBER OF HOLES	PITCH CIRCLE DIAMETER mm	HOLE DIAMETER mm
		Full Face	Ring				
80	Elastomeric	185	127	82	4	146	18
100		215	159	108	4	178	18
150		280	216	161	8	235	18
200		335	273	216	8	292	18
225		370	305	241	8	324	18
250		405	333	268	8	356	22
300		455	383	325	12	406	22
350		525	443	375	12	470	26
375		550	468	406	12	495	26
400		580	494	430	12	521	26
450		640	557	485	12	584	26
500		705	614	536	16	641	26
600		825	725	641	16	756	30
700		910	814	750	20	845	30
750		995	893	796	20	927	33
800		Compressed Fibre	1060	947	860	20	984
900	1175		1055	970	24	1092	36
1000	1255		1138	1075	24	1175	36
1200	1490		1364	1290	32	1410	36
Thickness mm		Elastomeric 3 Compressed Fibre 1.5					

**TABLE C3
FLANGE GASKET DIMENSIONS FOR AS/NZS 4087 PN21 AND PN 35 FLANGES**

NOMINAL SIZE	Gasket Material	OD mm		ID mm	NUMBER OF HOLES	PITCH CIRCLE DIAMETER mm	HOLE DIAMETER mm
		Full Face	Ring				
80	Compressed Fibre	205	146	82	8	165	18
100		230	172	108	8	191	18
150		305	237	161	12	260	22
200		370	301	216	12	324	22
225		405	329	241	12	356	26
250		430	354	268	12	381	26
300		490	411	325	16	438	26
350		550	464	375	16	495	30
375		580	490	406	16	521	30
400		610	521	430	20	552	30
450		675	576	485	20	610	33
500		735	639	536	24	673	33
600		850	744	641	24	781	36
700		935	820	750	24	857	36
750		1015	903	796	28	940	36
800		1060	947	860	28	984	36
900		1185	1065	970	32	1105	39
1000	1275	1154	1075	36	1194	39	
1200	1430	1398	1290	40	1441	42	
Thickness mm		1.5mm					

APPENDIX D

FLANGED JOINT ASSEMBLY

(Informative)

D1 SCOPE

This Appendix sets out recommendations, principles and procedures for the assembly of AS/NZS 4087 metal flange joints in pipeline systems for water industry purposes.

Estimated tightening torques are provided in Tables D1, D2 and D3 based on methodology and assumptions detailed in a spreadsheet calculator available from WSAA. [\(insert link\)](#)

Where alternative variables apply for a particular installation the spreadsheet calculator may be used to estimate alternative tightening torques.

D2 DISCLAIMER

This Appendix has been prepared to assist engineers and contractors in the correct assembly of flange joints and is not intended to be an exhaustive statement on flange joint design or installation. Recommendations contained in this Appendix represent best estimates only and may be based on assumptions which are not necessarily correct for every installation.

Successful flange jointing depends on many factors outside the scope of this Appendix, including site preparation and installation workmanship. It is recommended that users of this Appendix should check technical developments from research and field experience and utilise their knowledge, skill and judgement, particularly in regard to the quality and suitability of the products and conditions surrounding each specific installation.

Water Agency or manufacturer's codes, standards, specifications or drawings, if at variance to any recommendation made in this Appendix, override any recommendations made herein.

D3 FLANGED JOINTS

Flanged joints are completely rigid and should not be used for applications where movement of the pipeline is expected, unless special provision is made to accommodate it by, for example, the inclusion of expansion joints.

Flanged joints are used predominantly in above ground applications, e.g. pump stations, water and sewage treatment plants and for pipeline networks. They are also commonly used to facilitate the installation and removal of valves in elastomeric seal jointed and welded pipelines and for valve bypass arrangements.

Where flanged joints are utilised in buried applications additional corrosion protection systems should be considered.

Field welding or other special equipment is not required for the assembly of flanged joints.

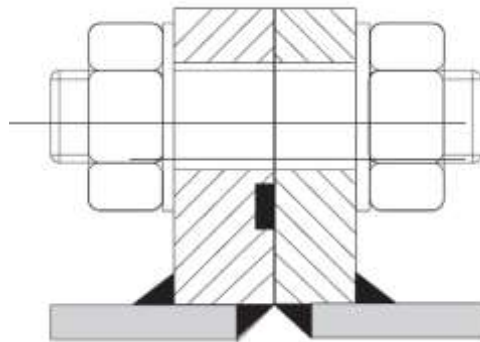
Flanges are specified in accordance with AS/NZS 4087 with pressure classifications of PN 14, PN 16, PN 21 or PN 35.

Flanges may be supplied with a raised face or flat face, with or without an O-ring groove, depending on the flange material and pressure classification. Details are given in AS/NZS 4087.

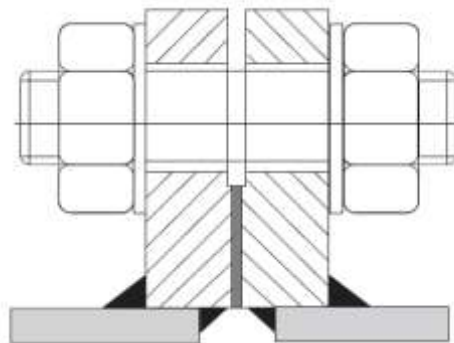
The most common flange joint types are shown in Figure D1 and D2.

Full-face gaskets are commonly used for jointing two raised face flanges or a flat face flange to a raised face flange. Only the raised face area inside the bolt holes is clamped during assembly.

The use of ring type gaskets is recommended when jointing two flat face flanges.



**FIGURE D1
O-RING FLANGED JOINT- STEEL SHOWN**



**FIGURE D2
RAISED FACE FLANGED JOINT- STEEL SHOWN**

D4 GASKETS

Gaskets may be elastomeric or compressed fibre type.

AS/NZS 4087 Appendix C provides recommendations for the selection of appropriate gasket materials (including thickness) for various metallic flange materials, pressure classifications and flange face types.

It should be noted that where compressed fibre gaskets are used high strength fasteners are required to accommodate the higher compression forces necessary for sealing.

D5 FASTENERS

Fasteners specified for jointing of flanges may be galvanised carbon steel or Grade 316 stainless steel.

AS/NZS 4087 Appendix C provides recommendations for the selection of appropriate fasteners for various metallic flange materials, pressure classifications, flange face types and recommended gasket material type.

D6 ASSEMBLY OF FLANGED JOINTS

Successful flange assembly involves selection of the correct jointing materials and competent installation in accordance with the principles detailed below.

The bolt acts like a spring. Bolt tensions are calculated to overcome the hydrostatic end force generated by the internal fluid pressure trying to push the flanges apart in addition to the force required to provide sufficient load on the gasket at the nominated internal pressure, without exceeding the maximum allowable gasket stress at the time of installation.

A torque wrench is most commonly utilized to achieve the required bolt tensions even though it is commonly accepted that the use of a torque wrench to measure bolt tension has an accuracy of only $\pm 25\%$.

The translation of torque to bolt tension is directly influenced by the nominated bolt torque co-efficient, sometimes called the nut factor or k factor.

Torque = Bolt Tension x Bolt Diameter x k

The k factor is an assigned co-efficient to attempt to summarise the many variables that may influence the torque-tension relationship. Such variables include fastener material, coatings, surface finish and condition, thread form, efficacy of lubrication, speed and continuity of assembly.

In most situations it is challenging to provide completely reliable torque values for bolted assemblies. For enhanced accuracy the k factor for particular fasteners should be determined experimentally.

Wherever possible it is recommended that a hydraulic tensioner be utilised to directly apply the estimated bolt tensions.

Please note that it is important to apply a good quality anti-seize compound to the moving parts of the assembly including the contact surfaces between the threads and between the nut, washer, bolt head and flange surfaces.

Tables D1 to D3 provides estimated torque requirements for jointing AS/NZS 4087 metal flanges in accordance with the methodology and assumptions provided in a spreadsheet calculator available from WSA. [\(insert link\)](#)

D7 PRECAUTIONS

Bolts should be long enough to ensure that two complete threads are exposed when the nut is tightened by hand.

A washer should be used under each bolt head and nut.

The flange jointing system should be correctly aligned in terms of parallelism and concentricity.

Extra care needs to be taken when using stainless steel bolts as they are subject to galling, which can significantly reduce bolt tension. The use of a nickel/graphite anti-seize lubricant for both galvanised steel and stainless-steel bolts is recommended to achieve the indicated k values. Note that copper based lubricants are not recommended for use with stainless steel fasteners.

The application of excessive torque at the time of installation may overstress the gasket or O-ring causing crushing or extrusion, which can lead to leakage at operating pressures. Excessive torques can also cause deformation of the flange material.

Special care should be taken when jointing screw-on flanges as excessive torques can cause damage to the epoxy seal.

D8 PROCEDURE

D8.1 JOINTING INSTRUCTIONS FOR FLANGED JOINTS

- 1 Use a scraper or wire brush to thoroughly clean the flange faces to be jointed, ensuring there is no dirt, particles or foreign matter, protrusions or coating build-up on the mating surfaces.
- 2 Ensure that the mating threads of all nuts and bolts are clean and in good condition.
- 3 Evenly apply a suitable lubricant (e.g. Loctite 771) to all mating threads, including the nut load bearing face and washer.
- 4 Align the flanges to be joined and ensure that the components are satisfactorily supported to avoid bending stress on the flanged joint during and after assembly.
- 5 Insert four bolts in locations 1 to 4 as indicated in Figure E3 and position the gasket on the bolts, taking care not to damage the gasket surface.
- 6 Offer the adjoining flange to the bolts, taking care to maintain support and alignment of the components.
- 7 Tighten nuts to finger tight and check alignment of flange faces and gasket.
- 8 Insert the remaining bolts and tighten nuts to finger tight.
- 9 Estimate the required bolt torque considering bolt type and allowable tension, flange type and rating, gasket material and maximum/minimum compression, and the pipeline's maximum pressure (operating/test pressure).
- 10 Tighten nuts to 20% of estimated torque using the star pattern as shown in Figure D3.
- 11 Tighten to 50 % of estimated torque using the same tightening sequence.
- 12 Tighten to 75 % of estimated torque using the same tightening sequence.
- 13 Tighten to 100 % of estimated torque using the same tightening sequence.
- 14 Repeat the tightening procedure on all nuts until little or no movement can be achieved on each nut (particularly important on elastomeric gaskets).

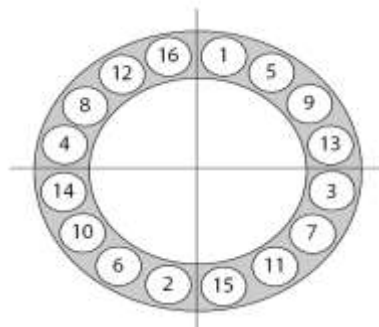


FIGURE D3 STAR PATTERN TIGHTENING SEQUENCE

D8.2 ESTIMATED TIGHTENING TORQUE VALUES

The estimated torques in Table D1 and Table D2 are based on gaskets specified within this Standard and are intended to provide adequate gasket sealing stresses for internal operating pressures ranging from zero to the allowable site test pressure ($ASTP = 1.25 \times AOP$) for AS/NZS 4087 metallic flanges, regardless of flange material. Table D3 provides

estimated torques for flat face flanges with O-ring sealing and are based on 65 % of the fastener proof load.

Nominated fastener torque co-efficients or k factors are indicated for the fastener materials that are assumed to be well lubricated. Well lubricated refers to the use of anti-seize treatments such as PTFE coatings and application of good quality nickel based anti-seize compounds.

The torques are estimated for raised face, flat face and O-ring type flanges with common surface finishes used in the water industry with an assumed surface roughness of Ra = 10 – 12 µm.

Full face gaskets or ring type gaskets may be used when jointing raised face flanges, however only ring type gaskets are recommended for use with full face flanges.

Where an alternative internal pressure or k factor applies, alternative bolt tensions and torques should be calculated. A spreadsheet calculator is available from WSAA.

**TABLE D1
ESTIMATED TIGHTENING TORQUES FOR AS 4087 PN 16 FLANGES**

Nominal Size DN	Fastener Size	Number of Fasteners	Fastener Tension kN Gal / SS	Estimated Torques Nm	
				Well-lubricated Grade 4.6 galvanized steel fasteners k = 0.15	Well-lubricated Grade 316 Class 50 stainless steel fasteners k = 0.20
80	M16	4	20	50	65
100	M16	4	20	50	65
150	M16	8	20	50	65
200	M16	8	25	60	80
225	M16	8	25	60	80
250	M20	8	35	105	140
300	M20	12	35	105	140
350	M24	12	50	180	240
375	M24	12	50	180	240
400	M24	12	50	180	240
450	M24	12	55	200	265
500	M24	16	55	200	265
600	M27	16	70	285	380
700	M27	20	60	245	325
750	M30	20	80	360	480
800	M33	20	240 / 200	1190 ²	1320 ²
900	M33	24	240 / 200	1190 ²	1320 ²
1000	M33	24	240 / 200	1190 ²	1320 ²
1200	M33	32	240 / 200	1190 ²	1320 ²

NOTE:

1. For DN 80 to DN 750 use Grade 4.6 galvanised carbon steel or Grade 316 Class 50 stainless steel fasteners with 3 mm thick elastomeric gasket

2. For DN > 750 use Grade 8.8 galvanised carbon steel or Grade 316 Class 70 stainless steel fasteners with 1.5mm compressed fibre gasket.

**TABLE D2
ESTIMATED TIGHTENING TORQUES FOR AS/NZS 4087 PN 35 FLANGES**

Nominal Size DN	Fastener Size	Number of Fasteners	Fastener Tension kN Gal / SS	Estimated Torques Nm	
				Well-lubricated Grade 8.8 galvanized steel fasteners k = 0.15	Well-lubricated Grade 316 Class 70 stainless steel fasteners k = 0.20
80	M16	8	50	120	160
100	M16	8	50	120	160
150	M20	12	80	240	320
200	M20	12	80	240	320
225	M24	12	115	415	550
250	M24	12	115	415	550
300	M24	16	115	415	550
350	M27	16	150	610	810
375	M27	16	150	610	810
400	M27	20	150	610	810
450	M30	20	185	835	1110
500	M30	24	185	835	1110
600	M33	24	230	1140	1520
700	M33	24	230	1140	1520
750	M33	28	230	1140	1520
800	M33	28	230	1140	1520
900	M36	32	270	1460	1945
1000	M36	36	270	1460	1945
1200	M39	40	320	1870	2500

NOTE:

1. Use Grade 8.8 galvanised carbon steel or Grade 316 Class 70 stainless steel fasteners with 1.5 mm compressed fibre gasket.

TABLE D3
ESTIMATED TIGHTENING TORQUES FOR FLAT FACE FLANGES WITH O-RING

Fastener Size	Estimated Torques Nm			
	PN 16	PN 35	PN 16	PN 35
	Well-lubricated galvanized steel fasteners k = 0.15		Well-lubricated Grade 316 stainless steel fasteners k = 0.20	
M16	55	140	70	150
M20	110	290	135	290
M24	185	500	230	495
M27	270	725	340	725
M30	370	985	460	985
M33	510	1340	625	1340
M36	-	1720	-	1720
M39	-	2230	-	2230

NOTE:

1. Torques are calculated to achieve 65 % proof load of the applicable fastener.



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