INDUSTRY STANDARD FOR FLANGE GASKETS AND O-RINGS

WSA 109–2011

Replaces WSA 109–2001 issued on 24 July 2001

WATER SERVICES ASSOCIATION
OF AUSTRALIA

PREFACE

This Standard was prepared by the Water Services Association of Australia (WSAA). It was first published on 30 July 2001.

WSAA acknowledges the significant technical input of:

- its utility members;
- Standards Australia WS-022 committee member Peter Pittard; and
- Various divisions of Tyco Water.

Other organizations that contributed included:

- Hultec Asia Pacific; and
- Sealing Devices Pty Ltd.

This revision includes a number of changes related to:

(a) Material properties.

(b) Finished requirements for O-rings.

(c) Gasket dimensions.

(d) Flange jointing procedures.

The information provided in the informative Appendix E Flanged Joints has been sourced from various documents resulting in some inconsistencies in terminology and prescriptive recommendations. Nevertheless it provides guidance that may assist the designer, constructor, system asset manager and system maintainer.

Comments or suggestions for improvements should be forwarded to info@wsaa.asn.au.

CONTENTS

2 SCOPE AND GENERAL

2.1 SCOPE

This Standard specifies requirements for materials used in unreinforced elastomeric and reinforced and unreinforced compressed non-asbestos fibre flange gaskets and elastomeric O-rings suitable for jointing flanges that comply with AS 4087, AS/NZS 4331.1, AS/NZS 4331.2, AS/NZS 4331.3, AS 2129 and other flange standards, for—

(a) cold potable water supply (up to 40°C); and

(b) drainage and sewerage systems (continuous flow up to 45°C and intermittent flow up to 95°C).

While recognising that elastomeric gaskets are often reinforced with fabric (commonly known as ‘insertion gaskets’), this Standard does not address fibre reinforced or composite elastomeric gaskets.

Gaskets and O-rings manufactured in materials complying with this Standard may be used for PN 14, 16, 21 and 35 flange joints for all metallic pipeline materials, including iron, steel, copper and copper alloys.

Compressed non-asbestos fibre sheet used to manufacture gaskets can be classified as a Type 7 Class 1 material as described in ASTM Classification F 104.

General requirements for finished flange gaskets and O-rings are also given. Any additional requirements called for by the particular application are specified in the relevant product Standards taking into account that the performance of pipe joints is a function of the seal material properties, seal geometry and pipe joint design.

This Standard should be used, where appropriate, with product Standards that specify performance requirements for joints.

Means for demonstrating compliance with this Standard are given in Appendix A. Type tests are conducted at fluid temperatures up to 25°C. Where fluid operating temperatures up to 50°C are applicable, additional type testing should be carried out at temperatures that reflect the actual equilibrium operating temperature of the gasket taking into account heat transfer between the fluid and the pipeline components and the surrounding environment.

For information on purchasing guidelines see Appendix B.

While gasket and O-ring dimensions are outside the scope of this Standard, guidance on gasket dimensions for ductile iron and steel flanges complying with AS 4087 is given in Appendix C.

2.2 REFERENCED DOCUMENTS

AS

681-1	Elastomeric seals–Material requirements for pipe joints used in water and drainage applications Part 1: Vulcanized rubber
1199	Sampling procedures and tables for inspection by attributes
1290	Linear measuring instruments used in construction
1290.2	Part 1: Wooden and synthetic material folding rules
1646	Elastomeric seals for waterworks purposes
2129	Flanges for pipes, valves and fittings
2490	Sampling procedures and charts for inspection by variables for percent nonconforming

AS/NZS	
4020	Testing of products for use in contact with drinking water
4087	Metallic flanges for waterworks purposes
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
SA	
HB18	Guidelines for third-party certification and accreditation
HB18.28	Guide 28—General rules for model third-party certification system for products
ISO	
37	Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties
48	Rubber, vulcanized or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)
188	Rubber, vulcanized or thermoplastic—Accelerated ageing and heat resistance tests
815-1	Rubber, vulcanized or thermoplastic - Determination of compression set - Part 1: At ambient or elevated temperatures
815-2	Rubber, vulcanized or thermoplastic - Determination of compression set - Part 2: At low temperatures
1629	Rubber and latices—Nomenclature (Revision of second edition (ISO 1629:1987))
1817	Rubber, vulcanized—Determination of the effect of liquids
2230	Vulcanized rubber—Guide to storage
2285	Rubber, vulcanized or thermoplastic—Determination of tension set at normal and high temperatures
3384	Rubber, vulcanized or thermoplastic—Determination of stress relaxation in compression at ambient and at elevated temperatures
9691	Rubber—Recommendation for the workmanship of pipe joint rings—Description and classification of imperfections
23529	Rubber - General procedures for preparing and conditioning test pieces for physical test methods

2.3 DEFINITIONS

For the purpose of this Standard the definitions given in AS 1646 apply.

2.4 CLASSIFICATION

Elastomeric flange gaskets and O-rings shall be classified in accordance with nominal hardness and hardness range specified in Table 1.1.

NOTE: Physical properties are given in Tables 2.1 and 2.2. Designation of joint seals by type and application are given in Table 4.3.

TABLE 1.1

HARDNESS CLASSIFICATION APPLICATION

Gasket	Nominal Hardness IRHD	Hardness Range IRHD
O-ring	40	36–45
O-ring	50	46–55
O-ring or gasket	60	56–65
O-ring or gasket	70	66–75

2.5 GASKET SELECTION

The selection of the gasket material should take into account the fluid, the operating conditions, the properties of the gasket material, the type and surface finish of the flange facing and the flange bolting. It is recommended that the selection of gaskets for any particular application is made in consultation with the gasket supplier.

3 MATERIALS

3.1 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 or O-ring, or on the flange or fasteners.

3.2 PREPARATION OF TEST PIECES

Unless otherwise specified, test pieces shall be cut from the finished product by the method specified in ISO 23529. If satisfactory test pieces cannot be prepared in accordance with the instructions given for the appropriate test method they shall be taken from test slabs or sheet, of suitable dimensions, made from the same batch of the material mix used to make the gaskets or O-rings and moulded under conditions that are comparable with those used in production.

For tests in which different sizes of test pieces are permissible, the same size of test piece shall be used for each batch and any size for comparative purposes.

3.3 TEST TEMPERATURE

Unless otherwise specified, tests shall be carried out at 23 ±2°C, in accordance with ISO 23529.

NOTES:

1 Two standard laboratory temperatures are given in ISO 23529.

2 For operating temperatures up to 50°C additional type testing should be carried out.

3.4 MATERIAL PROPERTIES

Gaskets and O-rings shall be manufactured from materials complying with the requirements of Table 2.1 or Table 2.2.

3.4.1 Effect on water

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

TABLE 2.1
MATERIAL PROPERTIES FOR ELASTOMERIC GASKETS AND O-RINGS

Material Property	Unit	Minimum value	Maximum value	Test Method
Hardness				
Gaskets	IRHD	56	75	ISO 48
O-rings	IRHD	36	55	ISO 48
Tensile strength		9		
Gaskets	MPa	9		ISO 37
O-rings	MPa	9		ISO 37
Elongation at break			-	
Gaskets	%	200		ISO 37
O-rings	%	375		ISO 37
Compression set[1] at -10±2˚C for 72 h				
Gaskets	%		50	ISO 815
O-rings	%		40	ISO 815
Compression set at 23±2˚C for 72 h				
Gaskets	%		15	ISO 815
O-rings	%		12	ISO 815
Compression set at 70±2˚C for 24 h				
Gaskets	%		20	ISO 815
O-rings	%		20	ISO 815
Stress relaxation 7 days at 23˚C	%	-		
Gaskets			16	ISO 3384 Method A
O-rings			14	ISO 3384 Method A
Change in properties after accelerated ageing in air at 7 days at 70°C by the normal oven method specified in ISO 188				
Tensile Strength	%		–20	ISO 37
Elongation	%		+10/–30	ISO 37
Hardness	IRHD	-	+8/–5	ISO 48
Volume change in water immersion in distilled or deionized water				
70±1˚C for 7 days	%	-	+8/–1	ISO 1817
Volume change in oil (Note 1)				
72 h at 70°C—Oil No. 1	%	-	±10	ISO 1817
72 h at 70°C—Oil No. 3	%	-	+50, –5	ISO 1817

NOTE:

1 Option test by agreement between purchaser and supplier

TABLE 2.2
MATERIAL PROPERTIES FOR COMPRESSED FIBRE GASKETS

Material Property	Unit	Minimum value	Maximum value	Test Method
Classification				ASTM F 104 Type 7 Class 1
Tensile Strength	MPa	3		ISO 37
Creep relaxation 22 h at 100˚C	%		25	ASTM F 38 Method B
Thickness change in water immersion in distilled or deionized water				
5 h at 100˚C	%		5	ASTM F 146
Recovery	%	40		ASTM F 36 Procedure J
Compressibility	%	15		ASTM F 36 Procedure J

4 MANUFACTURING REQUIREMENTS

4.1 FINISHED REQUIREMENTS

4.1.1 Form

Gaskets may be flat or profiled to the manufacturer's design requirements.

O-rings may be circular or profiled to the manufacturer's design requirements.

4.1.2 Splice joint of O-rings

When tested in accordance with Appendix D, each production splice of O-rings shall show no visible sign of separation.

4.1.3 Imperfections and defects

Limits on imperfections and defects for elastomeric gaskets and O-rings 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.

4.2 ELASTOMERIC GASKETS AND O-RINGS

4.2.1 Hardness

When determined by the micro-test method specified in ISO 48, the hardness shall comply with the requirements given in Table 2.1.

NOTE: If the dimensions of a seal are appropriate, the normal test method specified in ISO 48 may be used, provided that the micro-test method is used for reference purposes.

For the same seal, or along the greatest length of an extruded profile cut to make the seal, the difference between the minimum and maximum hardness values shall not be more than 5 IRHD. Each value shall be within the specified tolerances.

4.2.2 Tensile strength and elongation at break

The tensile strength and elongation at break shall be determined by the method specified in ISO 37. Dumb-bell-shaped test pieces of types 1, 2, 3 or 4 shall be used. Type 2 is the preferred type. The test report shall state the dumb-bell type whenever Type 2 is not used.

The tensile strength and the elongation at break shall comply with the requirements given in Table 2.1.

4.2.3 Compression set in air

4.2.3.1 General

Where the test piece is taken from a seal, the measurement shall be carried out as far as possible in the direction of compression of the seal in service.

4.2.3.2 Compression set at 23°C and 70°C

When determined by the method specified in ISO 815-1, at 23°C and 70°C, using the small Type B test piece, the compression set shall comply with the requirements given in Table 2.1.

Where the cross-section is too small to obtain compression buttons from the product, as an alternative to moulding buttons, the tension set of the product may be determined by using the method specified in ISO 2285 with strain of 50%, and shall comply with the same test conditions (except strain) and requirements as for the compression set.

4.2.3.3 Low temperature compression set at –10°C

When determined by the method specified in ISO 815-2 at –10°C using the small Type B test piece and the 30 ±3 min recovery measurement, the compression set of seals used in cold water supply, drainage and sewerage applications shall comply with the requirements given in Table 2.1.

4.2.4 Accelerated ageing in air

Test pieces prepared for the determination of hardness in accordance with Clause 2.2 and the determination of tensile strength and elongation at break (see Clause 3.2.2) shall be aged in air by the normal oven method specified in ISO 188 for 7 days at 70°C.

The changes in hardness, tensile strength and elongation at break shall comply with the requirements given in Table 2.1.

4.2.5 Stress relaxation in compression

The stress relaxation shall be determined by Method A of ISO 3384 using the small cylindrical test piece after applying mechanical and thermal conditioning.

Measurements shall be taken after 3 h, 1 d, 3 d, 7 d. The best-fit straight line shall be determined by regression analysis using a logarithmic time scale, and the correlation coefficients derived from these analyses shall not be lower than 0.93.

The stress relaxation in compression shall comply with the physical property requirements for materials given in Table 2.1.

The test temperature shall be maintained within the specified tolerance during the whole period of the test and verified by suitable recording equipment, on a continuous basis.

The requirement in respect of stress relaxation per logarithmic decade shall also be regarded as a type approval requirement.

Where the test piece is taken from a seal, the measurement shall be carried out as far as possible in the direction of compression of the seal in service.

4.2.6 Volume change in water

The change in volume shall comply with the requirements given in Table 2.1, when determined by the method specified in ISO 1817 after 7 days immersion in distilled or deionized water at the following temperatures:

(a) Joint seals for cold water supply ..... 70°C.

(b) Joint seals for drainage and sewerage systems ..... 95°C.

4.2.7 Volume change in oil

Where specified, the resistance to oil shall be determined in accordance with ISO 1817. The volume change of test pieces shall be determined after 72 h immersion in standard oils No. 1 and No. 3 at a temperature of 70°C.

The volume change in oil shall comply with the requirements given in Table 2.1.

4.2.8 Splices of prevulcanized O ring ends

Spliced joints shall be vulcanized.

When tested using the method specified in Annex C of AS 681.1–2008 (EN 681-1:1996) there shall be no visible separation in the cross sectional area of the splice, when viewed without magnification.

4.3 COMPRESSED FIBRE GASKETS

4.3.1 Tensile strength

The tensile strength shall be determined by the method specified in ISO 37. Dumb-bell-shaped test pieces of types 1, 2, 3 or 4 shall be used. Type 2 is the preferred type. The test report shall state the dumb-bell type whenever Type 2 is not used.

The tensile strength shall comply with the requirements given in Table 2.2.

4.3.2 Creep relaxation in compression

The creep relaxation shall be determined by Method B of ASTM F 38 using rectangular test specimens prepared from gasket sheets. The test specimen is subjected to a compressive stress between two platens, with the stress applied by a nut and bolt. The test is conducted for 22 h at 100 °C. The stress is determined by measuring the change in length of a calibrated bolt with a dial indicator. The bolt length is measured at the beginning of the test and at the end of the test; from this the percentage of relaxation is calculated.

The creep relaxation in compression shall comply with the physical property requirements for materials given in Table 2.2.

4.3.3 Thickness change in water

The change in thickness shall comply with the requirement given in Table 2.2, when determined by the method specified in ASTM F 146 except that the test condition shall be 7 days immersion in distilled or deionized water at the following temperatures:

(a) Joint seals for cold water supply ..... 70°C.

(b) Joint seals for drainage and sewerage systems ..... 95°C.

4.3.4 Recovery and compressibility

Recovery and compressibility shall be determined by Procedure J specified in ASTM F 36. The recovery and compressibility values shall comply with the requirements given in Table 2.2.

5 PERFORMANCE CRITERIA

5.1 GENERAL

Flange gaskets and O-rings shall meet the performance requirements given in Clause 4.2 for the conditions given in Table 4.1. Type testing of flange gaskets and O-rings for PN 16 and PN 35 flange joints are used to validate the suitability of flange gaskets and O-rings for PN 14 and PN 21 flange joints, respectively.

NOTE: Where fluid operating temperatures outside the temperature range of 0–30°C are applicable, additional type testing should be carried out at temperatures that reflect the actual equilibrium operating temperature of the gasket taking into account heat transfer between the fluid and the pipeline components and the surrounding environment.

TABLE 4.1

FLANGE JOINT PERFORMANCE CRITERIA

	PN 16	PN 35
Temperature Range, ^{o}C	15–25	15–25
Minimum sealing stress, MPa	2	15
Crushing stress, MPa	>15	>60

5.2 TYPE TESTS

5.2.1 Sealability test

Sealability tests shall be carried out in accordance with ASTM F 37 Method A for the conditions specified in Table 4.1, except that for each gasket material the default test flange materials surface finishes given in Table 4.2 shall be tested. Alternatively, the manufacturer may verify the sealability of flanges by testing assembled joints using the combinations of default flange material, size and surface finish given in Table 4.2. Any combination of fittings or appurtenances may be used to enable two flanges to be jointed such that a hydrostatic pressure can be applied to test the joint under free-end conditions. Assembly shall be carried out in accordance with Appendix D.

TABLE 4.2

TESTING CRITERIA

Flange material	Default test material	Sizes	Surface finishes	Test pressures MPa	
				PN 16 flanges	PN 35 flanges
Grey cast iron, ductile cast iron and steel	Ductile cast iron	DN 80, DN 375, DN 750	Bitumen coated Fusion-bonded polymeric coated	2.4	4.7
Copper and copper alloy	Copper alloy	DN 80, DN 200	As machined Fusion-bonded polymeric coated	2.4	NA

6 DESIGNATION

The following information shall be used for a full designation of the flange gaskets and O-rings:

(a) Description, e.g. ‘O’ ring.

(b) Standard No., i.e. WSA 109.

(c) Nominal size e.g, DN 150.

(d) Type of application, e.g. WA (see Table 5.1).

(e) Rubber type, e.g. SBR (see ISO 1629) or compressed fibre type, e.g. Type 7 Class 1.

(f) Joint name, e.g. ‘Tradename’.

Example:

‘O’ ring/WSA109/DN 150/WA/SBR/Tradename

TABLE 5.1

DESIGNATION OF JOINT GASKETS AND O-RINGS BY TYPE, APPLICATION AND REQUIREMENTS

Type	Application
WA	Cold drinking water supply (up to 50°C)
WC	Cold non-drinking water supply, drainage, sewerage and rainwater pipes (continuous flow up to 45°C and intermittent flow up to 95°C)
WG	Cold non-drinking water supply, drainage, sewerage and rainwater pipes (continuous flow up to 45°C and intermittent flow up to 95°C) with oil resistance

7 MARKING AND STORAGE

7.1 MARKING

Each O-ring, gasket, or parcel of O-rings or gaskets where the marking of individual O-rings or gaskets is not practicable, shall be marked clearly and durably, as follows, such that the sealing capability is not impaired:

(a) Nominal size.

(b) Manufacturer's identification.

(c) The number of this Standard with the type of application and hardness class as a suffix, e.g. WSA 109 WC/50.

(d) Third party certification mark.

(e) The quarter and year of manufacture.

(f) Low temperature resistance (L) if appropriate, e.g. WAL.

(g) Oil resistant (O) if appropriate, e.g. WCO.

(h) The abbreviation for the rubber, e.g. SBR.

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.

7.2 STORAGE

The requirements for the storage of gaskets and O-rings, by a manufacturer, between manufacture and delivery to a purchaser, shall comply with the following:

(a) Gaskets and O-rings shall be protected from ozone from mercury vapour lamps, high voltage electrical equipment, electric motors, or other equipment that could cause electrical discharges.

(b) Gaskets and O-rings shall be stored and handled 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 COMPLIANCE WITH THIS STANDARD

(Normative)

A1 SCOPE

This Appendix sets out two means by which compliance with this Standard can be demonstrated by a manufacturer.

(a) The use of a product certification scheme.

(b) 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. The long-term performance of plumbing systems is similarly critical to the durability of building infrastructure, protection of public health and safety and protection of the environment.

Product certification schemes provide independent assurance of the claim by the manufacturer that products comply with standards and are thereby fit for their intended use in pipeline and plumbing systems.

A3 PRODUCT CERTIFICATION

The certification scheme should meet the criteria described in SAA HB18.28/ SANZ HB18.28 (ISO/IEC Guide 28) in that, as well as full type testing from independently sampled production and subsequent verification of conformance, it requires the manufacturer to maintain effective planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of this Standard.

Product certification shall be conducted by a certification body accredited by the Joint Accreditation System for Australian and New Zealand (JAS-ANZ) or by another accreditation body that is acceptable to JAS-ANZ.

The frequency of the sampling and testing plan as detailed in Paragraph A4, shall be used by the certifying body for product compliance auditing. However, where the manufacturer can demonstrate adequate process control to the certifying body, the frequency of sampling and testing nominated in the manufacturer's quality plan and/or documented procedures shall take precedence for the purpose of product certification.

A4 TESTING

A4.1 General

Table A4 sets out the minimum sampling and testing frequency plan for a manufacturer to demonstrate compliance of product(s) to this Standard.

A4.2 Sampling

Where specified, batch release tests shall be carried out on lots of finished components using sampling procedures in accordance with either:

(a) AS 1199 with a specified inspection level of S2 and an acceptable quality level (AQL) of 2.5% for attributes; or

(b) AS 2490 (ISO 3591) with a specified inspection level of S3 and an acceptable quality level (AQL) of 2.5% for variables.

These requirements do not preclude the use by manufacturer of more stringent combinations of inspection levels and AQL values from AS 1199 or AS 2490.

A4.3 Retesting

In the event of a test failure, the products manufactured since the previous test(s), conforming to the requirements outlined in Table A1, shall be quarantined as a batch. A further set of samples shall be selected randomly from the quarantined batch using a sampling plan to AS 1199 for an acceptable quality level (AQL) of 2.5 and an inspection level of S3. If the retest requirements are met, the batch may be released and compliance with this Standard for the quarantined batch may be claimed.

Should failure on retesting occur, then the quarantined batch shall be rejected and claims and/or marking indicating compliance to this Standard shall be suspended until the cause of the failure has been identified and corrected.

A4.4 Rejection after retest

In the event of a quarantined batch being rejected after retesting in accordance with the procedures set out in Paragraph A4.3, it may be subjected to 100% testing for the failed requirement(s), and only those items found to comply may be claimed, and/or marked, as complying with this Standard.

TABLE A1

MINIMUM SAMPLING AND TESTING FREQUENCY PLAN

Feature	Clause	Requirement	Test method	Frequency
Type tests				
Material	2.4.1	Effect on water	AS/NZS 4020	At any change in formulation or at least every 5 years
Elastomeric gasket and O-ring material type tests	3.2.1	Hardness	ISO 48	At any change in formulation or tooling
	3.2.2	Tensile strength and elongation at break	ISO 37	
	3.2.3.2	Compression set	ISO 815	At any change in formulation
	3.2.3.3 (optional)	Low temperature compression set	ISO 815	
	3.2.4	Accelerated ageing in air	ISO 188	
	3.2.5	Stress relaxation in compression	ISO 3384 Method A	
	3.2.6	Volume change in water	ISO 1817	
	3.2.7 (optional)	Volume change in oil	ISO 1817	
	3.2.8	Splices of prevulcanized O ring ends	Annex C of AS 681-1:2008	At an change in formulation or tooling
Compressed fibre gasket material type tests	3.3.1	Tensile strength	ISO 37	At an change in formulation or tooling
	3.3.2	Creep relaxation in compression	ASTM F 38 Method B	At any change in formulation
	3.3.3	Thickness change in water	ASTM F 146	
	3.3.4	Recovery and compressibility	ASTM F 36 Procedure J	
Performance type tests	4.2.1	Sealability test	ASTM F 37 Method A and Appendix D	At an change in formulation or tooling
Marking	5	Designation	Review of test data	At any change in formulation

Batch release tests

Finished elastomeric gasket and O-ring requirements	3.1.1	Form	Manufacturer's drawings	One per cavity or extrusion line per 8 h
	3.1.2	Splice joint of O-rings	Appendix D	Each O-ring with a splice joint
	3.1.3	Imperfections and defects	ISO 9691	Each gasket and O-ring
	3.2.1	Hardness	ISO 48	One per cavity or extrusion line per 8 h
	3.2.2	Tensile strength and elongation at break	ISO 37	One per cavity or extrusion line per month
	3.2.3.2	Compression set	ISO 815	
	6.1	Marking	Visual	Each gasket and O-ring
Finished compressed fibre gasket requirements	3.1.2	Dimensions	Tables 3.1 and 3.2	Each gasket
	3.1.3	Imperfections and defects	Manufacturer's requirements	
	3.3.1	Tensile strength	ISO 37	One per moulding or calender line per month
	3.3.4	Recovery and compressibility	ASTM F 36 Procedure J	
	6.1	Marking	Visual	Each gasket

APPENDIX B

PURCHASING GUIDELINES

(Informative)

B1 GENERAL

Standards are intended to include the technical provisions necessary for the supply of materials referred to in the particular Standard, but do not purport to contain all the necessary provisions of the contract. In a number of cases the purchaser is either asked to state requirements or is given a choice of options, and these are contractual matters to be agreed upon between the purchaser and the manufacturer.

This Appendix contains advice and recommendations for the 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 calling for tenders or quotations, or order, a purchaser should supply to the manufacturer the following information:

(a) Form e.g. flat gasket, profiled gasket or O-ring.

(b) Designation e.g. WA, WC or WG.

(c) The gasket or O-ring 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.

(d) Whether the low temperature compression set is to be determined.

(e) Whether elastomeric material that is subject to provisional approval will be accepted.

(f) 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.

(g) Whether a certificate of compliance or a test certificate is required (see Paragraph B3).

(h) Requirements for packaging and labelling.

(i) Whether the optional tests for low temperature or high temperature performance below or above the range of 15–25°C and volume change in oil given in Clause 3.2.7 are required.

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 tests carried out 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) for each dimensional range of gaskets and/or O-rings.

(b) Material details including designation, compound description, relevant properties and service application advice and limitations.

(c) Tables of dimensions for each dimensional range of gaskets and/or O-rings.

  (i) Gasket dimensions should include nominal pipe size (DN) and/or pipe OD, gasket OD, gasket ID, number of holes, pitch circle diameter and hole diameter.

  (ii) O-ring dimensions should include 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 including 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

(Informative)

C1 GENERAL

The gasket dimensions given in Appendix C have been developed by Tyco Water and have been found to perform satisfactorily in a range of applications using flanges in its supply of ductile iron and steel pipeline systems to the Australian urban water industry over many years.

C2 DUCTILE IRON FLANGES

Gaskets for ductile iron flanges should conform to the dimensions given in Tables C3.1 and C3.2.

The gasket IDs shown in Table C3.1 and C3.2 for DI flanges were derived from the ID of Class K12 (roughly equivalent to PN 35) unlined pipe. This ID was chosen as it represents the largest bore for a particular DN, thereby avoiding intrusion of the gasket into the bore for other connecting fittings or valves.

TABLE C3.1

FLANGE GASKET DIMENSIONS FOR PN 16 DUCTILE IRON FLANGES

NOMINAL SIZE	OD mm	ID mm	NUMBER OF HOLES	PITCH CIRCLE DIAMETER mm	HOLE DIAMETER mm
80	185	82	4	146	18
100	215	108	4	178	18
150	280	161	8	235	18
200	335	216	8	292	18
225	370	241	8	324	18
250	405	268	8	356	22
300	455	325	12	406	22
375	550	406	12	495	26
450	640	485	12	584	26
500	705	536	16	641	26
600	825	641	16	756	30
750	995	796	20	927	33
Tolerances mm	+0, -5	DN 80-300: +0, -10 >DN300: +0, -20	-	±0.5	±1
Thickness mm	3 ±0.1				

TABLE C3.2

FLANGE GASKET DIMENSIONS FOR PN 35 DUCTILE IRON FLANGES

NOMINAL SIZE	OD mm	ID mm	NUMBER OF HOLES	PITCH CIRCLE DIAMETER mm	HOLE DIAMETER mm
80	205	82	8	165	18
100	230	108	8	191	18
150	305	161	12	260	22
200	370	216	12	324	22
225	405	241	12	356	26
250	430	268	12	381	26
300	490	325	16	438	26
375	580	406	16	521	30
450	675	485	20	610	33
500	735	536	24	673	33
600	850	641	24	781	36
750	1015	796	28	940	36
Tolerances mm	+0, -5	DN80-300: +0, -10 DN300: +0, -20	-	±0.5	±1
Thickness mm	1.5mm ± 0.1				

C3 STEEL FLANGES

Gaskets for steel flanges should conform to the dimensions given in Tables 3.3 or 3.4 where:

gasket ID = pipe OD + 2 mm

TABLE C3.3 FLANGE GASKET DIMENSIONS FOR PN 16 RAISED FACE STEEL FLANGES

NOMINAL SIZE	PIPE OD mm	GASKET OD mm	GASKET ID mm	NUMBER OF HOLES	PITCH CIRCLE DIAMETER mm	HOLE DIAMETER mm
50	60	150	62	4	114	18
65	73	165	75	4	127	18
80	90	185	92	4	146	18
100	114	215	116	4	178	18
150	168	280	170	8	235	18
200	178 190 219	335 335 335	180 192 221	8 8 8	292 292 292	18 18 18
225	219 235 240	370 370 370	221 237 242	8 8 8	324 324 324	18 18 18
250	240 257 273	405 405 405	242 259 275	8 8 8	356 356 356	22 22 22
300	290 305 324	455 455 455	292 307 326	12 12 12	406 406 406	22 22 22
350	337 356	525 525	339 358	12 12	470 470	26 26
375	368 406	550 550	370 408	12 12	495 495	26 26
400	406 419	580 580	408 421	12 12	521 521	26 26
450	457	640	459	12	584	26
500	502 508	705 705	504 510	16 16	641 641	26 26
600	559 610 648 660	825 825 825 825	561 612 650 662	16 16 16 16	756 756 756 756	30 30 30 30
700	660 700 711	914 914 914	662 702 713	20 20 20	845 845 845	30 30 30
750	762 800 813	995 995 995	764 802 815	20 20 20	927 927 927	33 33 33
800	813	1060	815	20	984	36
900	889 914 959 965	1175 1175 1175 1175	891 916 961 967	24 24 24 24	1092 1092 1092 1092	36 36 36 36
1000	972 1016 1035	1255 1255 1255	974 1018 1037	24 24 24	1175 1175 1175	36 36 36
1200	1067 1086 1124 1145 1200 1219	1490 1490 1490 1490 1490 1490	1069 1088 1126 1147 1201 1219	32 32 32 32 32 32	1410 1410 1410 1410 1410 1410	36 36 36 36 36 36

TABLE C3.4 FLANGE GASKET DIMENSIONS FOR PN 21 AND 35 RAISED FACE STEEL FLANGES

NOMINAL SIZE	PIPE OD mm	GASKET OD mm	GASKET ID mm	NUMBER OF HOLES	PITCH CIRCLE DIAMETER mm	HOLE DIAMETER mm
50	60	165	62	4	114	18
65	73	185	75	4	127	18
80	90	205	92	4	146	18
100	114	230	116	4	178	18
150	168 178	305 305	170 180	8 8	235 235	18 18
200	190 219	370 370	192 221	8 8	292 292	18 18
225	235 240 257	405 405 405	237 242 259	8 8 8	324 324 324	18 18 18
250	257 273 290	430 430 430	259 275 292	8 8 8	356 356 356	22 22 22
300	305 324 337	490 490 490	307 326 339	12 12 12	406 406 406	22 22 22
350	356 368	550 550	358 370	12 12	470 470	26 26
375	406 419	580 580	408 421	12 12	495 495	26 26
400	400 419	610 610	402 421	12 12	521 521	26 26
450	457 502 508	675 675 675	459 504 510	12 12 12	584 584 584	26 26 26
500	502 508 559	735 735 735	504 510 561	16 16 16	641 641 641	26 26 26
600	559 648 660	850 850 850	561 650 662	16 16 16	756 756 756	30 30 30
700	700 711 762	935 935 935	702 713 764	20 20 20	845 845 845	30 30 30
750	800 813	1015 1015	802 815	20 20	927 927	33 33
800	889	1060	891	20	984	36
900	959 965 972	1185 1185 1185	961 967 974	24 24 24	1092 1092 1092	36 36 36
1000	1035 1067 1086	1275 1275 1275	1037 1069 1088	24 24 24	1175 1175 1175	36 36 36
1200	1283 1290	1530 1530	1285 1292	32 32	1410 1410	36 36

APPENDIX D

TEST FOR SPLICE STRENGTH OF O-RINGS

(Normative)

D1 SCOPE

This Appendix sets out two methods for testing the spliced joint in O-rings using—

(a) the elongation method; or

(b) the stretch and twist method.

D2 PRINCIPLE

The joint in the test specimen is either elongated or stretched and twisted and then examined for any visible sign of separation.

D3 APPARATUS

D3.1 Elongation method

The following apparatus is required:

(a) A device, with suitable adaptors, for applying the specified elongation, at a rate of 500 ±50 mm/min, to the test specimen.

(b) A folding rule complying with AS 1290.2.

D3.2 Stretch and twist method

No apparatus is required.

D4 TEST SPECIMEN

The test specimen shall be either—

(a) a seal or section of seal not less than 200 mm long with the joint centrally located; or

(b) a whole seal where the position of the joint cannot be identified.

D5 PROCEDURE

D5.1 Elongation method

The procedure for the elongation method shall be as follows:

(a) Mark the test specimen with a reference line on each side of the joint and 50 ±50 mm from it.

(b) Mount the test specimen in the adaptors of the device.

(c) Apply the elongation, as given in Table D1, at the rate of 500 ±50 mm/min to the test specimen and maintain for 60 +5, –0 s.

(d) Release the test specimen, remove it from the device and visually examine, with the naked eye, for sign of separation.

TABLE D1

SUSTAINED ELONGATION FOR THE JOINT

Hardness, IRHD	Elongation of test piece
<75	100% of length of test piece
≥75 <85	Lesser of 75% of length of test piece or 50% elongation at break

D5.2 Stretch and twist method

The procedure for the stretch and twist method shall be as follows:

(a) Where the position of the joint can be identified—

(i) grasp the test specimen firmly with a hand on each side, and as close as practical to the joint, positioned so that the test specimen can be stretched and then twisted;

(ii) stretch and twist the test specimen through an angle of 200 ±22.5°; and

(iii) release the test specimen and examine, with the naked eye, the joint for any visible sign of separation.

(b) When the position of the joint cannot be identified—

(i) grasp the test specimen firmly with the hands, not more than 125 mm apart, positioned so that the test specimen can be stretched and then twisted;

(ii) stretch and twist the test specimen through an angle of 200 ±22.5°;

(iii) release the test specimen and examine, with the naked eye, the section of test specimen that was located between the hands for any visible sign of separation; and

(iv) repeat Steps (i) to (iii) for the whole length of the test specimen.

D6 REPORT

If required the report should include the following information for each test specimen:

(a) The marking on and the core diameter of the test specimen or the O-ring from which the test specimen was cut.

(b) The method used, i.e. Paragraph D5.1, D5.2(a) or D5.2(b).

(c) Whether there was any visible sign of separation.

(d) Reference to this test method, i.e. Appendix D, WSA 109.

APPENDIX E

FLANGED JOINTS

(Informative)

E1 SCOPE

This Appendix sets out recommendations, principles and procedures for making flange joints in ductile iron and steel pipeline systems for water industry purposes.

E2 DISCLAIMER

This Appendix has been prepared to assist qualified Engineers and Contractors in the use of the flange joints and flange jointed products, and is not intended to be an exhaustive statement on flange joint design, installation or technical matters. Any recommendations the like contained in this Appendix represent best estimates only and may be based on assumptions which, while reasonable, may not necessarily be correct for every installation.

Successful flange jointing depends on numerous factors outside the scope of this Appendix, including site preparation and installation workmanship. Users of this Appendix must check technical developments from research and field experience, and rely on their knowledge, skill and judgement, particularly with reference to the quality and suitability of the products and conditions surrounding each specific installation.

When pipeline construction is being carried out for any Water Agency, as Principal or as part of developer works covered by a Deed of Agreement, that Water Agency's codes, standards, specifications or drawings, if at variance to any recommendation made in this Appendix, override the recommendations made herein.

E3 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 mainly for above ground applications, e.g. pumping stations, water and sewage treatment plants and for pipeline networks. They are also used to facilitate the installation and removal of valves in elastomeric seal (rubber ring) jointed and welded pipelines and for valve bypass arrangements.

If buried, flanges should have an additional corrosion protection system applied, such as Petrolatum tape wrapping.

For assembly of flanged joints no field welding or other special equipment is required. Flange dimensions are normally in accordance with AS 4087 and are generally supplied in PN 16, PN 21 or PN 35.

For access covers and other blank flange joints ring type joints (see Figure E1) are recommended because of their low requirement for assembly stress and trouble free operation. Ring type joints have these same advantages in other flanged joint situations. It must be remembered that the use of ring type joints requires full knowledge of all of the mating components to avoid a joint situation with two O-ring groove ends joining each other.

Where it is not possible or desirable to use a ring type joint, a narrow face joint employing raised face steel flanges as shown in Figure E2 is recommended.

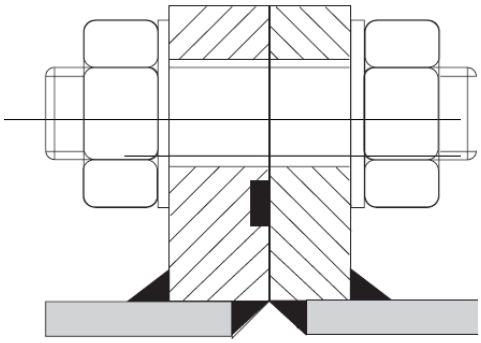

FIGURE E1 RING TYPE JOINT USING MATCHED O-RING TYPE FLANGES – STEEL SHOWN

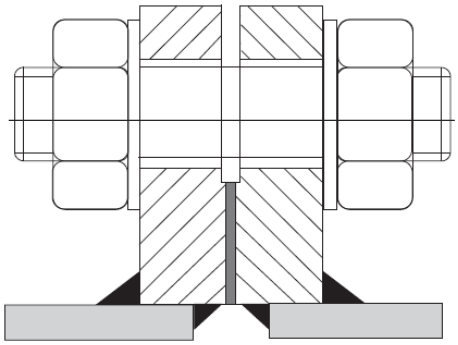

FIGURE E2 NARROW FACE JOINT USING RAISED FACE TYPE FLANGES – STEEL SHOWN

The use of flat-faced steel flanges is not recommended except when the mating flange is (grey) cast iron. This situation may occur at a pump housing, but current practice is for most pipeline components to be manufactured in steel or ductile iron. Experience has shown that flat-faced flanges are generally more susceptible to sealing problems and successful sealing is heavily dependent upon assembly technique.

Where the required flange sizes are larger than DN 1200 or are outside the normal pressure ratings, special flanges must be designed. In this situation a ring type joint (See Figure E1) is recommended.

E4 GASKETS

Gaskets may be elastomeric or compressed fibre type. Elastomeric gaskets are only recommended for the PN 16 flanges. Compressed fibre gaskets are recommended for PN 21 and PN 35 flanges as well as PN 16 flanges >DN 500.

Where compressed fibre gaskets are used with PN 16 flanges the use of high strength bolts will be required because of the higher initial compression necessary.

Table E1 details the recommended type of gasket to be used for various pressure classes of raised face steel flanges. Generally full face gaskets (that incorporate holes for the flange bolts) can be used with raised face flanges as only the raised face area inside the bolt holes is clamped. The full face gasket enables better location of the gasket compared

to a ring type gasket. If rigid compressed fibre type gaskets are used the use of ring type gaskets is normal.

TABLE E1

RECOMMENDED GASKET / O-RING COMPOSITION FOR TRANSPORT OF WATER, SEWAGE AND BRINE

Maximum operating pressure MPa	Maximum temperature °C	Gasket / O-ring composition
1.6	50	Solid EPDM elastomer 3 mm thick
3.5	50	Solid EPDM elastomer O-ring 10 mm thick
3.5	80	Compressed fibre gasket 1.5 mm thick

E5 FLANGE BOLTS AND ASSEMBLY TORQUE

Bolting used on flanges is usually galvanised steel or stainless steel. Commercial Grade 4.6 galvanised steel or Class 50 Grade 316 stainless steel bolts are used with PN 16 flanges with elastomeric gaskets and O-rings (PN 16 DN 300-DN 500), whilst high strength Grade 8.8 galvanised steel or Class 70 or 80 Grade 316 stainless steel bolts/studs are required for use with compressed fibre gaskets and O-rings (PN 16 DN 300-DN 1200, PN 21 DN 300-DN 1200 and PN 35 DN 100-DN 1200).

Poor assembly technique is by far the greatest single cause of flange joint failure and use of the correct technique and selection of the suitable bolt torque is critical.

Torque is directly related to the frictional coefficient (μ or k value), which is influenced by environmental factors, coatings, surface finish, material type and hardness, thread series and efficacy of lubrication etc. In most situations, it is challenging to give reliable allowable torque values for bolted assemblies. For the most accurate data field testing of the intended assemblies is recommended using a calibrated torque wrench and a load indicating device, e.g. Skidmore Wilhelm Load Indicating Device, to equate actual torque to the desired tension.

Bolt tensions have been calculated to counter the force due to expected internal pressure and to provide adequate sealing stress on the nominated gasket material, without exceeding the maximum allowable gasket stress at the time of installation. The necessary torque to induce these tensions are estimated for raised face and O-ring type flanges with common surface finishes used in the water industry. The flange faces are assumed to have a surface roughness of Ra = 10 – 12 μm.

The surface conditions of the threads of fasteners as a result of dirt, rust, plating, coating and lubrication are the predominant factors influencing the torque/tension relationship. However, there are many others including thread manufacturing process (machined versus rolled), thread fit, surface texture and the speed and continuity of tightening.

Tables E2 to E6 detail the combination for DN, gasket type, bolt size and bolt material. In addition, estimated torques are provided in Tables E2, E3 and E8. Torque values given in Tables E2 and E3 are only valid for a nominated gasket ID given in Tables C3.1 and C3.2. The sealing area, based on gasket ID and raised face OD, is a critical factor when calculating gasket stresses and resultant torque tightening values. However, it should be recognised that the required torque is difficult to calculate accurately.

E6 PRECAUTIONS

Bolts should be long enough 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 Loctite 771 (a nickel/graphite anti-seize lubricant) for both galvanised steel and stainless steel bolts is recommended to achieve the indicated μ or k values.

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.

A torque wrench is most commonly utilized to achieve the required bolt tension even though it is commonly accepted that the use of a torque wrench to measure bolt tension has an accuracy of ±25%. Therefore, in critical applications, an hydraulic tensioner should be used.

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

E7 PROCEDURE

E7.1 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 insertion 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 E3.
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).

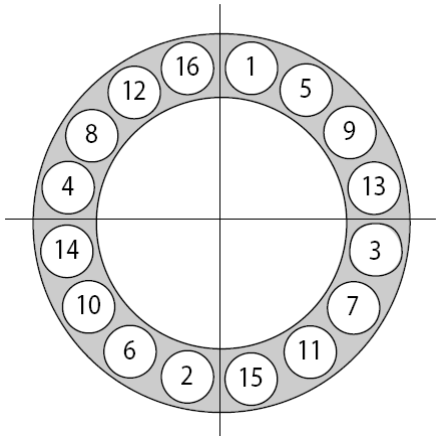

FIGURE E3 STAR PATTERN TIGHTENING SEQUENCE

E7.2 ESTIMATED TIGHTENING TORQUE VALUES

E7.2.1 Ductile iron flanges

The estimated torques provided in the Table E2 and Table E3 are based on the coefficients of friction (μ) indicated. Where other coefficients apply, alternative torques should be calculated.

"Lightly Oiled" refers to the application of a good quality lubricating oil and is the usual as-received condition of fasteners.

"Well-lubricated" refers to the use of anti-seize treatments such as PTFE coatings or application of anti-seize lubricants such as Loctite 771 (a nickel/graphite anti-seize lubricant).

TABLE E2 ESTIMATED TIGHTENING TORQUE VALUES FOR DUCTILE IRON FLANGES WITH A RAISED FACE JOINT USING A FULL FACE GASKET[1]

STANDARD PRESSURE FLANGES AS 4087 FIGURE B5 PN 16 GRADE 4.6 GALVANISED STEEL BOLTS AND NUTS OR GRADE 316 CLASS 50 STAINLESS STEEL BOLTS AND NUTS WITH FULL FACE GASKET—3 MM EPDM SEAL-162

Nominal size DN	Bolt size	Number of bolts	Length of bolts mm	Bolt tension kN	Estimated torques Nm		
					Lightly oiled Grade 4.6 galvanized steel bolts & nuts μ = 0.22	Well-lubricated Grade 4.6 galvanized steel bolts & nuts μ = 0.15	Well-lubricated Grade 316 Class 50 stainless steel bolts & nuts μ = 0.20
80	M16	4	65	20	70	40	65
100	M16	4	75	20	70	55	65
150	M16	8	75	20	70	40	65
200	M16	8	75	20	70	55	65
225	M16	8	75	25	90	60	80
250	M20	8	90	35	160	105	140
300	M20	12	100	35	160	85	140
375	M24	12	100	50	270	150	240
450	M24	12	120	55	290	190	270
500	M24	16	120	55	290	185	270
600	M27	16	130	70	420	270	380
750	M30	20	140	80	530	360	480
900	M33	24	195	200	1460[2]	990[2]	1320[2]

NOTES:

1 Reproduced with kind permission by Tyco Water.
Refer to http://www.tycowater.com/__data/page/11803/TECHNICAL_SHEET_-_Flange_Gasket_Kits.pdf.

2 For DN 900 AS 4087 Figure B5 PN 16 standard pressure flanges Grade 8.8 galvanised steel studs & nuts or Grade 316 Class 70 stainless steel studs & nuts should be used in combination with a full face 1.5 mm Teadit® style NA1000M compressed fibre gasket[3].

3 Teadit® style NA1000M is a compressed non-asbestos sheet gasket material produced from aramid fibers, reinforced with a woven wire mesh and bonded with nitrile rubber (NBR). The sheet is graphited on both sides. Refer to http://teadit-na.com/catalog/index.php?main_page=product_info&products_id=40.

TABLE E3 ESTIMATED TIGHTENING TORQUE VALUES FOR DUCTILE IRON FLANGES WITH A RAISED FACE JOINT USING A FULL FACE GASKET[1]

HIGH PRESSURE FLANGES AS 4087 FIGURE B6 PN 35
GRADE 8.8 GALVANISED STEEL STUDS AND NUTS OR GRADE 316 CLASS 70 STAINLESS STEEL STUDS AND NUTS WITH FULL FACE GASKET—1.5 MM TEADIT® NA1000M COMPRESSED FIBRE[2]

Nominal size DN	Stud size	Number of studs	Length of studs mm	Stud tension kN	Estimated torques Nm		
					Lightly oiled Grade 8.8 galvanized steel bolts & nuts μ = 0.22	Well-lubricated Grade 8.8 galvanized steel bolts & nuts μ = 0.15	Well-lubricated Grade 316 Class 70 stainless steel bolts & nuts μ = 0.20
80	M16	8	110	50	180	70	70
100	M16	8	110	50	180	70	70
150	M20	12	130	80	350	70	70
200	M20	12	130	80	350	70	70
225	M24	12	150	115	610	90	90
250	M24	12	150	115	610	160	160
300	M24	16	150	115	610	160	160
375	M27	16	170	150	900	270	270
450	M30	20	190	180	1190	290	290
500	M30	24	190	180	1190	290	290
600	M33	24	210	230	1670	420	420
750	M33	28	210	230	1670	530	530
900	M36	32	230	270	2140	1460	1460

NOTES:

1 Reproduced with kind permission by Tyco Water.
Refer to http://www.tycowater.com/__data/page/11803/TECHNICAL_SHEET_-_Flange_Gasket_Kits.pdf.

2 Teadit® style NA1000M is a compressed non-asbestos sheet gasket material produced from aramid fibers, reinforced with a woven wire mesh and bonded with nitrile rubber (NBR). The sheet is graphited on both sides. Refer to http://teadit-na.com/catalog/index.php?main_page=product_info&products_id=40.

E7.2.2 Steel flanges

From the pipe OD, pressure class PN and flange size, the required bolt size is determined. Choices in terms of bolt material and gasket can be made from Tables E4, E5 and E6.

The k value is determined either from Table E7 (indicative value) or by experiment. The k values provided in Table E7 are only estimates and are influenced by a number of factors. For the most accurate information, field testing is required. To achieve the “well lubricated” condition it is recommended that Loctite 771 be applied to all threads and the face of the nut and washer.

It should be noted that the k value estimated when using insulated compressed fibre washers is very much less than for metallic washers. This is due to the much lower coefficient of friction for compressed fibre washers. If a lower k value is not used there is the possibility of over-tensioning bolts and distorting flanges.

Finally, the required tension and torque is determined from Table E8.

TABLE E4 RECOMMENDED CLASS 16 BOLT SIZES, BOLT TYPES AND GASKET TYPES FOR AS 4087 FIGURE B7 PN 16 STEEL FLANGES[1]

Flange size DN	Bolt size	Pipe OD mm		Flange type[3]	Recommended gasket types	
		Grade 4.6 bolts[2]	Class 50 SS[2] bolts[2]		Full face	O-ring
100	M16	114	114	Raised face	EPDM	
150	M16	168, 178	168, 178	Raised face	EPDM	
200	M16	178, 190, 219	178, 190, 219	Raised face	EPDM	
225	M16	219, 235, 240, 257	219	Raised face	EPDM	
250	M20	235, 240, 257, 273,290	235, 240, 257, 273,290	Raised face	EPDM	
300	M20	290, 305, 324, 337	290, 305, 324, 337	Raised face	EPDM	EPDM
350	M24	324, 337, 356, 368	324, 337, 356, 368	Raised face	EPDM	EPDM
375	M24	356, 368, 406	356, 368, 406, 419	Raised face	EPDM	EPDM
400	M24	406, 419	406, 419, 457	Raised face	EPDM	EPDM
450	M24	457	457	Raised face	EPDM	EPDM
500	M24	457, 502, 508, 559	457, 502, 508	Raised face	EPDM	EPDM
		Grade 8.8 bolts/studs[2]	Class 70 SS bolts[2]			
100	M16	114	114	Raised face	CF[4]	
150	M16	168, 178	168, 178	Raised face	CF	
200	M16	190, 219	-	Raised face	CF	
225	M16	219	-	Raised face	CF	
250	M20	257, 273, 290	273	Raised face	CF	
300	M20	290, 305, 324, 337	305, 324, 337	Raised face	CF	EPDM
350	M24	324, 337, 356, 368	337, 356, 368	Raised face	CF	EPDM
375	M24	356, 368, 406	406, 419	Raised face	CF	EPDM
400	M24	406, 419	406, 419	Raised face	CF	EPDM
450	M24	457, 502, 508	502, 508	Raised face	CF	EPDM
500	M24	502, 508, 559	559	Raised face	CF	EPDM
600	M27	600, 610, 648, 660	648, 660	Raised face	CF	EPDM
700	M27	660, 700, 711, 762	-	Raised face	CF	EPDM
750	M30	762, 800, 813	-	Raised face	CF	EPDM
800	M33	800, 813	813, 889	Raised face	CF	EPDM
900	M33	889, 914, 959, 965, 972	914, 959, 965, 972	Raised face	CF	EPDM
1000	M33	959, 965, 972, 1016	-	Raised face	CF	EPDM
1000	M33	1035, 1067	-	Raised face	CF	EPDM
1200	M33	1200, 1219, 1283, 1290	-	Raised face	CF	EPDM

NOTES:

1 Reproduced with kind permission by Tyco Water. Refer to SINTAKOTE® Steel Pipeline Systems Handling & Installation Reference Manual Seventh Edition, 2011.

2 Bolts or studs – Grade 8.8 galvanised steel or Class 70 Grade 316 stainless steel.

3 Full faced flanges are not recommended.

4 CF = Compressed fibre.

TABLE E5 RECOMMENDED CLASS 21 BOLT SIZES, BOLT TYPES AND GASKET TYPES FOR AS 4087 FIGURE B8 PN 21 STEEL FLANGES[1]

Flange size DN	Bolt size	Pipe OD mm		Flange type	Recommended gasket types	
		Grade 8.8 bolts/studs[2]	Class 70 SS[2] bolts		Full face[3]	O-ring
100	M16	114	114	Raised face	CF[4]	
150	M16	168,178	168,178	Raised face	CF	
200	M16	178,190,219	178,190,219	Raised face	CF	
225	M16	219,235,240,257	219,235,240,257	Raised face	CF	
250	M20	235,240,257,273,290	235,240,257,273,290	Raised face	CF	
300	M20	290, 305, 324, 337	290,305,324,337	Raised face	CF	EPDM
350	M24	324, 337, 356, 368	324, 337, 356, 368	Raised face	CF	EPDM
375	M24	356, 368, 406, 419	356, 368, 406, 419	Raised face	CF	EPDM
400	M24	406, 419	406, 419	Raised face	CF	EPDM
450	M24	457, 502, 508	457, 502, 508	Raised face	CF	EPDM
500	M24	502, 508, 559	502, 508, 559	Raised face	CF	EPDM
600	M27	610, 648, 660	610, 648, 660	Raised face	CF	EPDM
700	M27	648, 660, 700, 711	648, 660, 700, 711	Raised face	CF	EPDM
750	M30	762, 800, 813	762, 800, 813	Raised face	CF	EPDM
800	M33	800, 813	800, 813	Raised face	CF	EPDM
900	M33	889, 914, 959, 965, 972	889, 914, 959, 965, 972	Raised face	CF	EPDM
1000	M33	959, 965, 972, 1016, 1035, 1067	959, 965, 972, 1016, 1035, 1067, 1086	Raised face	CF	EPDM
1200	M33	1067, 1086, 1124, 1145, 1200, 1219, 1283, 1290	1145, 1200, 1219, 1283, 1290	Raised face	CF	EPDM

NOTES:

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2 Bolts or studs – Grade 8.8 galvanised steel or Class 70 Grade 316 stainless steel

3 Full faced flanges are not recommended.

4 CF = Compressed fibre.

TABLE E6 RECOMMENDED CLASS 35 BOLT SIZES, BOLT TYPES AND GASKET TYPES FOR AS 4087 FIGURE B9 PN 35 STEEL FLANGES[1]

Flange size DN	Bolt size	Pipe OD mm		Flange type	Recommended gasket types	
		Grade 8.8 bolts/studs[2]	Class 70 SS[2] bolts		Full face[3]	O-ring
100	M16	114	114	Raised face	CF[4]	EPDM
150	M20	168,178	168,178	Raised face	CF	EPDM
200	M20	178,190	178,190,219	Raised face	CF	EPDM
225	M24	219	219,235	Raised face	CF	EPDM
250	M24	235,240,257	235,240,257	Raised face	CF	EPDM
300	M24	273, 290, 305	273, 290,305	Raised face	CF	EPDM
350	M27	324, 337	324, 337, 356, 368	Raised face	CF	EPDM
375	M27	356, 368	356, 368	Raised face	CF	EPDM
400	M27	406, 419	406, 419, 457	Raised face	CF	EPDM
450	M30	457	457	Raised face	CF	EPDM
500	M30	502, 508	457, 502, 508	Raised face	CF	EPDM
600	M33	559, 610	559, 610	Raised face	CF	EPDM
700	M33	648, 660, 700, 711	648, 660	Raised face	CF	EPDM
750	M33	762, 800	700, 711	Raised face	CF	EPDM
800	M33	762, 800, 813		Raised face	CF	EPDM
900	M36	889, 914	889, 914, 959, 965	Raised face	CF	EPDM
1000	M36	959, 965, 972, 1016, 1035, 1067	959, 965, 972, 1016, 1035	Raised face	CF	EPDM
1200	M39	1124, 1145, 1200, 1219, 1283, 1290	-	Raised face	CF	EPDM

NOTES:

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2 Bolts or studs – Grade 8.8 galvanised steel or Class 70 Grade 316 stainless steel

3 Full faced flanges are not recommended.

4 CF = Compressed fibre.

TABLE E7 INDICATIVE FRICTION COEFFICIENT (K) VALUES FOR WELL-LUBRICATED BOLTS WITH AND WITHOUT BOLT INSULATION[1]

Lubrication/Bolt material	Indicative k value	
	without bolt insulation	with fibre reinforced bolt insulation
Well lubricated galvanised	0.12 - 0.14	0.08 - 0.1
Well lubricated stainless steel	0.12 - 0.14	0.08 - 0.1

NOTE:

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TABLE E8 REQUIRED TENSION AND TORQUE VALUES FOR STEEL FLANGE BOLTING[1]

Bolt size	Bolt Grade[2]			Tension	Torque for k Factor =						
	EPDM gasket	EPDM O-ring	Compressed fibre	kN	0.08	0.1	0.12	0.14	0.16	0.18	0.2
M16	Gr 4.6	Gr 4.6		18	23	29	35	40	46	52	58
M16	Cl 50 SS	Cl 50 SS		18	23	29	35	40	46	52	58
M16			Gr 8.8, Cl 80 SS	75	96	120	144	168	192	216	240
M16			Cl 70 SS	50	64	80	96	112	128	144	160
M20	Gr 4.6	Gr 4.6		30	48	60	72	84	96	108	120
M20	Cl 50 SS	Cl 50 SS		25	40	50	60	70	80	90	100
M20			Gr 8.8, Cl 80 SS	95	152	190	228	266	304	342	380
M20			Cl 70 SS	75	120	150	180	210	240	270	300
M24	Gr 4.6	Gr 4.6		40	77	96	115	134	154	173	192
M24	Cl 50 SS	Cl 50 SS		35	67	84	101	118	134	151	168
M24			Gr 8.8, Cl 80 SS	135	259	324	389	454	518	583	648
M24			Cl 70 SS	100	192	240	288	336	384	432	480
M27	Gr 4.6	Gr 4.6		50	108	135	162	189	216	243	270
M27	Cl 50 SS	Cl 50 SS		45	97	122	146	170	194	219	243
M27			Gr 8.8, Cl 80 SS	175	378	473	567	662	756	851	945
M27			Cl 70 SS	130	281	351	421	491	562	632	702
M30		Gr 4.6, Cl 50 SS		65	156	195	234	273	312	351	390
M30			Gr 8.8, Cl 80 SS	200	480	600	720	840	960	1080	1200
M30			Cl 70 SS	160	384	480	576	672	768	864	960
M33		Gr 4.6, Cl 50 SS		75	198	248	297	347	396	446	495
M33			Gr 8.8, Cl 80 SS	260	686	858	1030	1201	1373	1544	1716
M33			Cl 70 SS	195	515	644	772	901	1030	1158	1287
M36		Gr 4.6, Cl 50 SS		85	245	306	367	428	490	551	612
M36			Gr 8.8, Cl 80 SS	270	778	972	1166	1361	1555	1750	1944
M36			Cl 70 SS	205	590	738	886	1033	1181	1328	1476
M39		Gr 4.6, Cl 50 SS		100	312	390	468	546	624	702	780
M39			Gr 8.8, Cl 80 SS	320	998	1248	1498	1747	1997	2246	2496
M39			Cl 70 SS	260	811	1014	1217	1420	1622	1825	2028

NOTES:

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2 Gr 4.6 and Gr 8.8 refers to Grade 4.6 and Grade 8.8 galvanised steel bolts and/or studs, respectively. Cl 50, Cl 70 and Cl 80 refers to Grade 316 stainless steel bolts.