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PLASTICS INDUSTRY
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POP007

Flanged Joints for
Polyethene (PE) Pipe

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FLANGED JOINTS FOR POLYETHYLENE (PE) PIPE

The purpose of this technical guideline is to discuss recommended guidance relating to the typical flange types, recommended practices for installation, calculated bolt torques for flange connections and provide dimensional tables for metal backing flanges. The guideline is separated into two sections plus appendices.

Section 1: Provides an overview of the typical flange types, configurations and relevant standards that apply.

Section 2: Recommended practice for installation including tables of calculated bolt torques for flange configurations common in waterworks applications.

Appendix A: Dimensional tables for metal backing flanges made to relevant AS/NZS and ISO Standards.

Appendix B: Bolt torque calculation methodology and worked examples.

PIPA recommends for critical water and fuel gas applications; the advice of a suitably qualified engineer be sought.

1. SECTION 1 – FLANGE OVERVIEW

1.1. INTRODUCTION

Where there is a need to join polyethylene pipe (PE) to pipe of another material or ancillary equipment such as valves and pumps a mechanical flange may be used. This provides a means of transition and a fully end load resistant joint that can be disassembled for maintenance purposes.

The four most typically encountered flange configurations are given below in Figure 1 to 4.

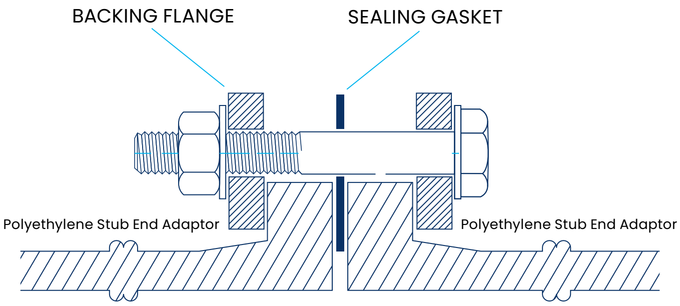


Figure 1 – PE Stub End Adaptor to PE Stub End Adaptor

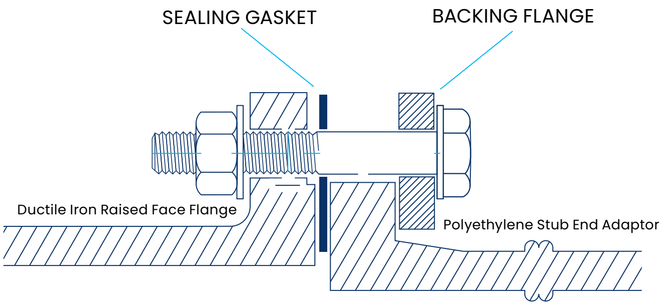


Figure 2 – Ductile Iron Raised Face Flange to PE Stub End Adaptor

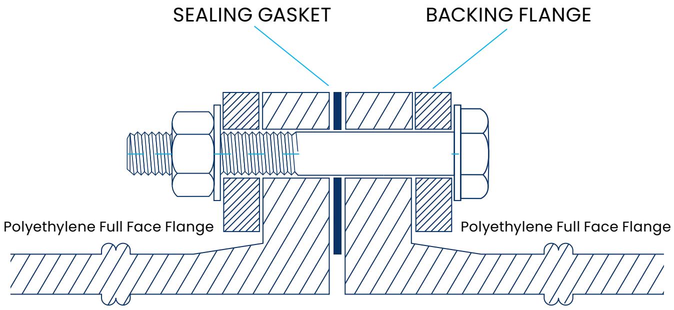


Figure 3 – PE Full Face Flange to PE Full Face Flange

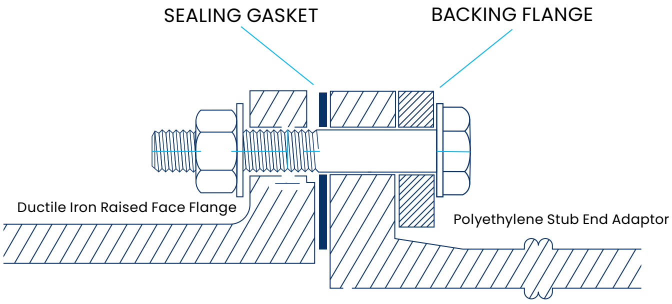


Figure 4 – Ductile Iron Raised Face Flange to PE Full Face Adaptor

1.2. FLANGE DIMENSIONS

The metal backing flange dimensions listed in Appendix A of this guideline conform to the following Standards:

- → AS 2129 *Flanges for pipes, valves and fittings*
- → AS/NZS 4087 *Metallic flanges for waterworks purposes*
- → AS/NZS 4331.1 *Metallic flanges Part 1: Steel flanges* (identical to ISO 7005-1)
- → ANSI/ASTM B16.5 *Pipe Flanges and Flanged Fittings*
- → ISO 7005-1 *Pipe flanges – Part 1: Steel flanges for industrial and general service piping systems*

Note:

- → Metal backing flanges with reduced thickness are used by industry for non-critical, low performance applications. **These are not covered in this guide.**
- → The thicknesses for backing flanges in the tables within Appendix A are applicable to steel. Different metals demand different thicknesses for the same performance, so for metals other than steel, consideration should be given to thickness.
- → Tables 4, 5, 6 and 7 in Appendix A refer to pressure ratings (PN/Class), these pressure ratings are nominal only. Advice from the flange manufacturer should be sought to clarify the actual pressure rating of the assembly.

1.3. LOOSE BACKING FLANGE INSIDE DIAMETER

It should be noted that the inside diameter of the loose backing flange shall conform to the design of the flange adaptor. The inside diameter dimensions listed in Appendix A match those given in ISO Standard 9624 *'Thermoplastic piping systems for fluids under pressure – Flange adaptors and loose backing flanges – Mating dimensions'*, which specifies the mating dimensions for thermoplastic flange adaptors and corresponding backing flanges intended to be used in thermoplastic piping systems. In some applications, the inside diameter of the available loose backing flange may be larger than that given in the tables.

In such cases, the acceptance of a larger inside diameter is subject to the flange's 3% limit on compressive strain, as specified in AS/NZS 4129.

2. SECTION 2 – INSTALLATION

This section provides guidance by identifying key aspects that should be considered before and during installation.

2.1. CONSIDERATIONS PRIOR TO INSTALLATION

CORROSION PROTECTION

Flanges and fasteners should be coated in accordance with Australian standards or codes such as AS/NZS 4680 *Hot-dip galvanized (zinc) coatings on fabricated ferrous articles* for galvanising. Alternatively, stainless steel flanges and fasteners may be used, or flanges may be protected with polymeric coatings in accordance with AS/NZS 4158 *Thermal-bonded polymeric coatings on valves and fittings for water industry purposes* and be used in conjunction with stainless steel fasteners.

MARKING

Flanges and backing rings should be marked in accordance with AS/NZS 4129:2020 *Fittings for polyethylene (PE) pipes for pressure applications* Cl.7Marking.

TEMPERATURE RERATING

Standards such as AS 2129, AS/NZS 4087 and ANSI B16.5 provide guidance as to the working pressure of the backing flange at various temperatures. If the temperature is outside the range listed in these standards, material pressure derating guidance can be gained from standards such as ASME B31.1 *Power Piping* and ASME B31.3 *Process Piping Design.*

SURGE & FATIGUE ANALYSIS

It is recommended that, for pipelines where surge and fatigue conditions will occur, a detailed surge analysis is carried out to identify the peak surge pressures. In the case of polyethylene pressure pipeline systems further guidance is given in PIPA POP010A Part 1: Polyethylene Pressure Pipes Design for Dynamic Stresses and POP010B Part 2: Fusion Fittings for Use with Polyethylene Pressure Pipes Design for Dynamic Stresses.

Where the calculated pipeline system test pressure has taken into account an occasional surge pressure and if this test pressure is greater than or equal to the maximum expected occasional surge pressure, the transient surge factor can reasonably be set at 1.0.

Important: Qualified professionals should be contracted to consider all aspects of the design for pressure pipe design.

GASKETS

The following highlights areas a specifier of a PE flange joint should consider when making an informed choice about which gasket (if any) should be used. It is recommended that specifiers consult with the gasket supplier.

Note: This list does not attempt to cover all aspects and therefore specifiers should not be limited to only those listed below.

Aspects to consider in gasket selection:

- Operating pressure, including surge allowance
- The ability of the gasket to seal at the clamping pressure imposed and resist blow-out without suffering excessive stress relaxation
- Operating temperature
- Materials of mating flanges and the potential impact of surface finish, flatness, surface roughness and coatings
- Compatibility of the gasket materials with the fluid being transported within the pipe at the operating temperatures and pressures.
- For flanged joints intended for use with potable water the gasket material shall conform to AS/NZS 4020 *Testing of products for use in contact with drinking water*

- Where gasket materials with high sealing stress are nominated, calculations shall be performed to ensure that the compression strain of the polyethylene flange shall be limited to a maximum of 3% as per AS/NZS4129. Refer to Appendix B for further guidance.

Note: Water Services Association of Australia (WSAA) specifies elastomeric gaskets in flanged joints of pipes and fittings up to 16 bar and compressed fibre gaskets for higher pressure applications.

Gaskets may not be necessary when using PE flanges provided sufficient compressive load can be applied (i.e. sufficient bolt tension) and the sealing surfaces are not excessively rough or damaged.

"In theory gaskets are not necessary to provide a seal with PE flanges since the viscoelastic and creep properties of the polymer will ensure that the flange face is forced into parallelism with its opposite number even under modest long term bolting loads, and that the PE will "flow" into any surface imperfections and thus seal off potential leakage paths" High Integrity Polyethylene Stub Flange Connections, A.L Headford, Stewarts and Lloyds Plastics[1]."

Non-gasketed joints are commonplace in the US and to a lesser extent in the UK and Europe. Historical Australian practice has been to use gaskets. It must be recognised that the sealing stress and interfacial contact area where no gasket is used, is significantly greater.

BOLT TORQUE

With the vast range of application conditions, bolt types, lubrication and gasket combinations for PE flange assemblies it is impractical to nominate bolt torques that are applicable for all applications.

The sealing pressure in a flange joint must be sufficient to prevent leakage under service internal pressures and axial loads. During assembly, when the bolts are tightened, the bolt tension applies a force through the flange assembly to compress the gasket and provide this sealing pressure. In practice, bolt torque is often specified as a way to measure that the correct sealing force has been applied. However, it is important to note that there are a number of variables that determine the relationship between the bolt torque and the bolt tension. Typically:

- Approximately 10% to 20% of the applied torque is transmitted into bolt elongation
- Approximately 50% of the bolt torque is consumed by friction from the bolt-head contact face or the nut-face being rotated against its mating part
- About 10% is used up in reversible twist of the bolt length.
- Another 30% is dissipated to overcome the friction in the bolt/nut threads.

The tightening process exerts an axial pre-load tension on the bolt. This tension load is equal and opposite to the compression force applied on the assembled components.

When excessive torque is needed to overcome friction, there is a risk of insufficient bolt extension pre-load being applied. Therefore, it is important to reduce friction on the bolt-threads by lubrication.

For a given nominal torque value, the deviation in the final tightening load of the bolt can vary between +/-20% even when conditions are good (ref: SKF Bolt Tightening Handbook[2]). This wide range is due to the combination of multiple factors including:

- accuracy of the torque wrench
- the presence of geometric defects
- corrosion
- thread and load bearing surface roughness
- lubrication of the load bearing surfaces

BOLT TORQUE GUIDANCE

The following variables have a significant impact on the required bolt torque:

- flange type and face
- gasket sealing area
- gasket material
- operating and test pressure
- number, size & grade of bolts
- condition of bolts

The following tables provide calculated bolt torques for common installations. The calculated torque values nominated in the tables are based on nut factors (K-factors) appropriate to a "well lubricated" bolt condition, where all mating threads and nut load bearing faces are coated with molybdenum disulphide or equivalent grease.

Note:

- Bending forces potentially applied to a flanged joint as a resulted of curved pipe alignment or cantilevered valves are not accounted for in the bolt torque estimates. Where an application does not fully conform to the variables given in the table a specific torque must be calculated.
- Over tightening bolts to the point where the compressive stress on the flange causes yield is a common cause of flange joint leakage, especially where PE stub adaptor or non-raised face flanges are used with compressed fibre gaskets.

Table A: PE100 Stub Flange Adaptor to PE100 Stub Flange Adaptor – PN10/SDR17 and PN16/SDR11

DN	PN10			PN16		
	Carbon Steel Grade 4.6 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 50 Bolt Estimated Torque N.m (K=0.2)	Initial Flange Adaptor Shoulder Compression	Carbon Steel Grade 4.6 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 50 Bolt Estimated Torque N.m (K=0.2)	Approximate Flange Adaptor Shoulder Compression Refer 2*
This table applies under the following conditions. For other conditions, bolt torques shall be caluclated (Refer to Appendix B for guidance): 1 Bolt threads and nut bearing surfaces shall be well lubricated with molybdenum disulphide or equivalent grease. 2* Maximum 3% recommended in AS/NZS 4129:2020 Cl.7.5.2. 3 Elastomeric gaskets conforming to WSA109:2023. Flange adaptors conforming to ISO 9624:2019.						
110	33	44	0.9%	38	51	1.%
160	27	36	0.9%	33	43	1.1%
200	44	59	1.1%	50	67	1.3%
225	33	44	1.0%	46	61	1.3%
250	68	91	1.2%	87	116	1.6%
315	56	75	1.3%	74	99	1.8%
355	91	121	0.9%	121	161	1.2%
400	110	147	1.0%	149	199	1.4%
450	176	235	0.6%	226	301	0.8%
500	115	153	1.2%	161	215	1.6%
630	169	225	1.7%	242	323	2.4%
710	183	245	1.3%	264	352	1.9%

Table B: PN16/SDR11 PE100 Stub Flange Adaptor to PN16 Ductile Iron Raised Face Flange

DN	PN16		
	Carbon Steel Grade 4.6 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 50 Bolt Estimated Torque N.m (K=0.2)	Approximate Flange Adaptor Shoulder Compression Refer 2*
This table applies under the following conditions. For other conditions, bolt torques shall be calculated (Refer to Appendix B for guidance). 1 Bolt threads and nut bearing surfaces shall be well lubricated with molybdenum disulphide or equivalent grease. 2* Maximum 3% recommended in AS/NZS 4129:2020 Cl.7.5.2. 3 Elastomeric gaskets conforming to WSA109:20213. Flange adaptors conforming to ISO 9624:2019. 4 Ductile iron raised face flange dimensions conforming to AS/NZS 4087:2011 Figure B5.			
110	36	47	0.9%
160	32	42	1.1%
200	50	66	1.3%
225	45	60	1.3%
250	86	115	1.6%
315	74	98	1.7%
450	198	264	0.7%
500	159	213	1.6%
630	241	321	2.4%
710	262	349	1.9%

Table C: PE100 Full Face Flange to PE100 Full Face Flange – PN20/SDR9 and PN25/SDR7.4

This table applies under the following conditions. For other conditions, bolt torques shall be calculated (Refer to Appendix B for guidance).

1* Maximum 3% recommended in AS/NZS 4129:2020 Cl.7.5.2.

2 Bolt threads and nut bearing surfaces shall be well lubricated with molybdenum disulphide or equivalent grease.

3 Compressed fibre gaskets conforming to WSA109:2021[3].

DN	PN20			PN25		
	Carbon Steel Grade 8.8 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 70 Bolt Estimated Torque N.m (K=0.2)	Approximate Flange Shoulder Compression Refer 1*	Carbon Steel Grade 8.8 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 70 Bolt Estimated Torque N.m (K=0.2)	Approximate Flange Shoulder Compression Refer 1*
110	190	254	2.5%	192	257	2.5%
160	256	341	2.4%	260	346	2.4%
200	359	479	2.6%	366	488	2.6%
225	502	669	2.3%	512	683	2.3%
250	545	727	2.6%	558	744	2.6%
315	493	657	2.5%	507	676	2.6%
355	670	894	2.4%	691	922	2.5%
400	626	835	2.4%	648	865	2.5%
450	827	1102	2.3%	858	1144	2.4%
500	795	1060	2.4%	827	1102	2.5%
630	1114	1485	2.6%	1164	1552	2.7%
710	1188	1584	2.6%	1256	1675	2.7%
800	1279	1706	2.5%	1356	1808	2.7%
900	1480	1973	2.5%	1573	2098	2.7%
1000	1393	1858	2.6%	1495	1994	2.8%
1200	1974	2632	2.6%	2117	2823	2.8%

Note 1. – Shaded cells indicate pipe size/SDR combinations not explicitly defined in AS/NZS 4130:2018.

Table D: PE100 Full Face Flange to PN35 Ductile Iron Raised Face Flange – PN20/SDR9 and PN25/SDR7.4

DN	PN20			PN25		
	Carbon Steel Grade 8.8 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 70 Bolt Estimated Torque N.m (K=0.2)	Approximate Flange Shoulder Compression Refer 1*	Carbon Steel Grade 8.8 Bolt Estimated Torque N.m (K=0.15)	Stainless Steel Class 70 Bolt Estimated Torque N.m (K=0.2)	Approximate Flange Shoulder Compression Refer 1*
110	83	111	1.0%	85	113	1.0%
160	120	161	1.1%	125	166	1.1%
200	183	243	1.2%	190	253	1.2%
225	254	339	1.1%	265	353	1.1%
250	282	376	1.2%	295	393	1.3%
315	255	341	1.2%	270	360	1.3%
450	431	575	1.1%	463	617	1.1%
500	454	605	1.3%	486	648	1.4%
630	624	832	1.3%	674	899	1.4%
710	582	776	1.2%	651	869	1.3%

This table applies under the following conditions. For other conditions, bolt torques shall be calculated (Refer to Appendix B for guidance).

1* Maximum 3% recommended in AS/NZS 4129:2020 Cl.7.5.2.

2 Bolt threads and nut bearing surfaces shall be well lubricated with molybdenum disulphide or equivalent grease.

3 Compressed fibre gaskets conforming to WSA109:2021[3]. Ductile iron raised face flange dimensions conforming to AS/NZS 4087:2011 Figure B6.

Note 1. – Shaded cells indicate pipe size/SDR combinations not explicitly defined in AS/NZS 4130:2018.

2.2. INSTALLATION

Note: Polyethylene pipe systems are end load bearing. Care should be taken where connection is made to pipe with non-end load bearing joints in order to prevent pull-out.

Installation steps

1. Ensure the backing flange is placed over the pipe before the stub flange is fused to the pipe.
2. Ensure the mating faces are clean and free for contamination and damage.
3. Check that the mating faces are in true alignment and butted square to each other prior to bolting up.
4. The gasket should be centred properly between the two flanges before bolt tightening commences.
5. The nuts and bolts should be well lubricated with molybdenum disulphide or equivalent grease.
6. Progressively tension bolts to their calculated torque as per the bolt tightening sequence (details given below).
7. Re-tension bolts to the calculated torque after approximately 4 hours and again 12 to 24 hours later. This is to account for stress relation and creep.

BOLT TIGHTENING SEQUENCE

When tightening pipe flange bolts the aim is achieve even compression of the PE flange face without inducing compressive yield or excessive viscoelastic creep of the flange head. The accepted way of achieving this is through multiple rounds of tightening up to the target bolt torque value.

The Plastics Pipe Institute (PPI) Technical Note TN-38 Polyethylene Flanged Joints[4] recommends s minimum of three rounds of tightening following hand tightening.

For each progression the nuts should be tightened in a cross-pattern sequence to ensure the load is applied evenly (see figure 5 examples).

Round 1: tighten to 30% of the target bolt torque

Round 2: tighten to approximately 50-70% of the target bolt torque

Round 3: tighten to 100% of the target bolt torque – prior to tightening it is recommended to measure the gap between the flanges at eight (8) equally spaced locations to check that the flanges are being brought together evenly.

Final Check (recommendation): re-torque all bolts to 100% of target value in a sequential circular pattern. This checks that no bolts have inadvertently been missed.

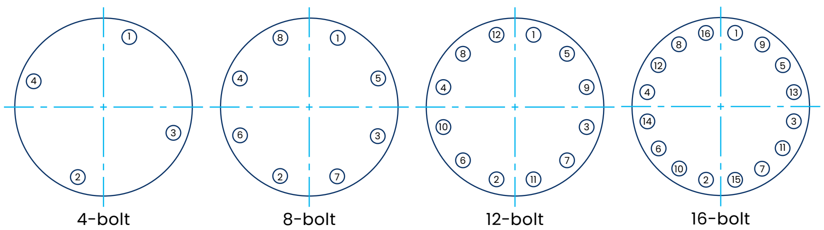


Figure 5 – Bolt tightening sequence

RE-TENSIONING BOLTS

The polyethylene flange and the gasket will undergo some stress relaxation that decreases the bolt tension and therefore gasket sealing stress. This means that the initial bolt pre-load will slowly decline to a residual level of about 35% of the initial bolt tension. This long-term level of engineered tension is sufficient to seal the joint assembly, with reserve included for surge pressure and other variables.

However, it is recommended to re-torque the flange assembly 12 -24 hours after installation (ref: PPI TN-384) i.e., repeat the 'Final Check' step of the previously described bolt tightening sequence.

3. TECHNICAL REFERENCES

[1] A.L. Headford, Stewarts and Lloyds Plastics, *High Intensity Polyethylene Stub Flange Connections*, Plastics Pipes IX Edinburgh Scotland, 1995

[2] SKF, Bolt Tightening Handbook, France, April 2001

[3] Water Services Association of Australia (WSSA), WSA109 Industry Standard for Flange Gaskets and O-Rings, Version 3.1, June 2021

[4] Plastics Pipe Institute (PPI) Technical Note TN-38 Polyethylene Flanged Joints, 2021

4. STANDARD REFERENCES

AS 2129	Flanges for pipes, valves and fittings
AS/NZS 2280	Ductile iron pipes and fittings
AS/NZS 2566.1	Buried flexible pipelines, Part 1: Design
AS/NZS 2566.2	Buried flexible pipelines, Part 2: Installation
AS/NZS 4087	Metallic flanges for waterworks purposes
AS/NZS 4020	Testing of products for use in contact with drinking water
AS/NZS 4129	Fittings for polyethylene (PE) pipes for pressure applications
AS/NZS 4130	Polyethylene pipes for pressure applications
AS/NZS 4158	Thermal-bonded polymeric coatings on valves and fittings for water industry purposes
AS/NZS 4331.1	Metallic flanges Part 1: Steel flanges (identical to ISO 7005-1)
AS/NZS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
ANSI/ASTM B16.5	Pipe Flanges and Flanged Fittings
ASME B31.1	Power Piping
ASME B31.3	Process Piping Design
ISO 724	ISO general-purpose metric screw threads – Basic dimensions
ISO 9624	Thermoplastics piping systems for fluids under pressure – flange adaptors and loose backing flanges - Mating dimensions

APPENDIX A

Table 1

Steel Backing Flanges AS2129: Table D (Max. 700kPa and 50°C, ≤DN1200)

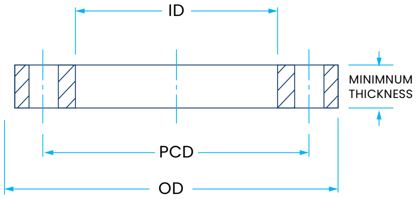


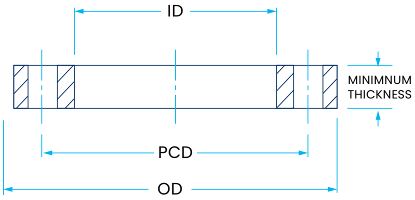
Figure 6

Flange minimum thickness is for forged or plate steel. Where steel refers to carbon steel, carbon-manganese steel, low alloy steel and stainless steel.

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
20	**15**	95	28	5	67	4X14	M12
25	**20**	100	34	5	73	4X14	M12
32	**25**	115	42	6	83	4X14	M12
40	**32**	120	51	6	87	4X14	M12
50	**40**	135	62	8	98	4X14	M12
63	**50**	150	78	8	114	4X18	M16
75	**65**	165	92	8	127	4X18	M16
90	**80**	185	108	10	146	4X18	M16
110	**100**	215	128	10	178	4X18	M16
125	**100**	215	135	10	178	4X18	M16
125	**125**	255	135	13	210	8X18	M16
140	**125**	255	158	13	210	8X18	M16
160	**150**	280	178	13	235	8X18	M16
180	**150**	280	188	13	235	8X18	M16
200	**200**	335	235	13	292	8X18	M16
225	**200**	335	238	13	292	8X18	M16
250	**250**	405	288	16	356	8X22	M20
280	**250**	405	294	16	356	8X22	M20
315	**300**	455	338	22	406	12X22	M20
355	**350**	525	376	22	470	12x26	M24
400	**400**	580	430	22	521	12X26	M24
450	**450**	640	517	25	584	12X26	M24
500	**500**	705	533	29	641	16X26	M24
560	**550**	760	618	29	699	16X30	M27
630	**600**	825	645	32	756	16X30	M27
710	**700**	910	740	35	845	20X30	M27
800	**800**	1060	843	41	984	20X36	M33
900	**900**	1175	947	48	1092	24X36	M33
1000	**1000**	1255	1050	51	1175	24X39	M36
1200	**1200**	1490	1260	60	1410	32x36	M33

Table 2

Steel Backing Flanges AS 2129: Table E (Max. 1400kPa and 50°C, ≤1200)



Flange minimum thickness is for forged or plate steel. Where steel refers to carbon steel, carbon-manganese steel, low alloy steel and stainless steel.

Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
20	**15**	95	28	6	67	4X14	M12
25	**20**	100	34	6	73	4X14	M12
32	**25**	115	42	7	83	4X14	M12
40	**32**	120	51	8	87	4X14	M12
50	**40**	135	62	9	98	4X14	M12
63	**50**	150	78	10	114	4X18	M16
75	**65**	165	92	10	127	4X18	M16
90	**80**	185	108	11	146	4X18	M16
110	**100**	215	128	13	178	8x18	M16
125	**100**	215	135	13	178	8X18	M16
125	**125**	255	140	14	210	8X18	M16
140	**125**	255	158	14	210	8X18	M16
160	**150**	280	178	17	235	8x22	M20
180	**150**	280	188	17	235	8x22	M20
200	**200**	335	235	19	292	8x22	M20
225	**200**	335	238	19	292	8x22	M20
250	**250**	405	288	22	356	12x22	M20
280	**250**	405	294	22	356	12x22	M20
315	**300**	455	338	25	406	12x26	M24
355	**350**	525	376	29	470	12x26	M24
400	**400**	580	430	32	521	12X26	M24
450	**450**	640	517	35	584	16x26	M24
500	**500**	705	533	38	641	16x26	M24
560	**550**	760	618	44	699	16X30	M27
630	**600**	825	645	48	756	16x33	M30
710	**700**	910	740	51	845	20x33	M30
800	**800**	1060	843	54	984	20X36	M33
900	**900**	1175	947	64	1092	24X36	M33
1000	**1000**	1255	1050	67	1175	24X39	M36
1200	**1200**	1490	1260	79	1410	32X39	M36

Table 3

Steel Backing Flanges A.N.S.I. 150

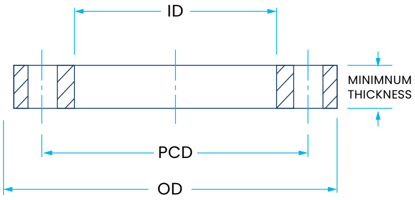


Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
20	**½"**	90	28	11.2	60.5	4x16	M14
25	**¾'**	100	34	6	73	4X14	M12
32	**1"**	108	42	14.2	79.5	4X16	M14
40	**1 ¼"**	117	51	15.7	89	4X16	M14
50	**1 ½"**	127	62	17.5	98.5	4X16	M14
63	**2"**	152	78	19.0	120.5	4X20	M18
75	**2 ½"**	178	92	22.3	139.5	4X20	M18
90	**3"**	191	108	23.9	152	4X20	M18
110	**4"**	229	128	23.9	190.5	8X20	M18
125	**5"**	254	135	23.9	216	8X22	M20
140	**5"**	254	158	23.9	216	8X22	M20
160	**6"**	279	178	25.4	241	8X22	M20
180	**6"**	279	188	25.4	241	8X22	M20
200	**8"**	343	235	28.4	298.5	8X22	M20
225	**8"**	343	238	28.4	298.5	8X22	M20
250	**10"**	406	288	30.2	362	12X26	M24
280	**10"**	406	294	30.2	362	12X26	M24
315	**12"**	482	338	31.8	432	12X26	M24
355	**14"**	533	376	35.0	476	12X30	M27
400	**16"**	600	430	36.6	540	16X30	M27
450	**18"**	635	470	39.6	578	16X33	M30
500	**20"**	700	533	43.0	635	20X33	M30
630	**24"**	815	645	47.8	750	20X36	M33

Table 4

Steel Backing Flanges AS/NZS 4331.1 (ISO 7005-1) – Table 10 PN10

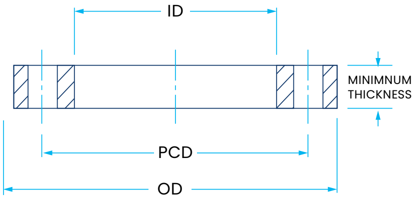


Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
20	**15**	**Refer to Table 5**					
25	**20**						
32	**25**						
40	**32**						
50	**40**						
63	**50**						
75	**65**						
90	**80**						
110	**100**						
125	**100**						
140	**125**						
160	**150**						
180	**150**						
200	**200**	340	235	24	295	8X22	M20
225	**200**	340	238	24	295	8X22	M20
250	**250**	395	288	26	350	12X22	M20
280	**250**	395	294	26	350	12X22	M20
315	**300**	445	338	28	400	12X22	M20
355	**350**	505	376	30	460	16X22	M20
400	**400**	565	430	32	515	16X26	M24
450	**450**	615	470	35	565	20X26	M24
450	**500**	670	517	38	620	20X26	M24
500	**500**	670	533	38	620	20X26	M24
560	**600**	780	618	42	725	20X29.5	M27
630	**600**	780	645	42	725	20X29.5	M27
710	**700**	895	740	-	840	24X29.5	M27
800	**800**	1015	843	-	950	24X32.5	M30
900	**900**	1115	947	-	1050	28X32.5	M30
1000	**1000**	1230	1050	-	1160	28X35.5	M33

Table 5

Steel Backing Flanges AS/NZS 4331.1 (ISO 7005-1) – Table 11 PN16

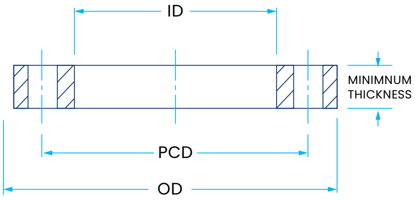


Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
20	**15**	95	28	14	65	4X14	M12
25	**20**	105	34	16	75	4X14	M12
32	**25**	115	42	16	85	4X14	M12
40	**32**	140	51	18	100	4X18	M16
50	**40**	150	62	18	110	4X18	M16
63	**50**	165	78	20	125	4X18	M16
75	**65**	185	92	20	145	8X18	M16
90	**80**	200	108	20	160	8X18	M16
110	**100**	220	128	22	180	8X18	M16
125	**100**	220	135	22	180	8X18	M16
140	**125**	250	158	22	210	8X18	M16
160	**150**	285	178	24	240	8X22	M20
180	**150**	285	188	24	240	8X22	M20
200	**200**	340	235	26	295	12X22	M20
225	**200**	340	238	26	295	12X22	M20
250	**250**	405	288	28	355	12X26	M24
280	**250**	405	294	28	355	12X26	M24
315	**300**	460	338	32	410	12X26	M24
355	**350**	520	376	35	470	16X26	M24
400	**400**	580	430	38	525	16X29.5	M27
450	**450**	640	470	42	585	20X29.5	M27
500	**500**	715	533	46	650	20X32.5	M30
560	**600**	840	618	52	770	20X35.5	M33
630	**600**	840	645	52	770	20X35.5	M33
710	**700**	910	740	-	840	24X35.5	M33
800	**800**	1025	843	-	950	24X39	M36
900	**900**	1125	947	-	1050	28X39	M36
1000	**1000**	1255	1050	-	1170	28X42	M39

Table 6

Steel Backing Flanges AS/NZS 4087 – Figure B7 PN16 (Max. 80°C)

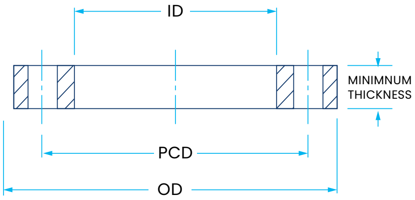


Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
63	**50**	150	78	11	114	4X18	M16
75	**65**	165	92	11	127	4X18	M16
90	**80**	185	108	11	146	4X18	M16
110	**100**	215	128	13	178	4X18	M16
160	**150**	280	178	13	235	8X18	M16
200	**200**	335	235	19	292	8X18	M16
225	**225**	370	238	19	324	8X18	M16
250	**250**	405	288	19	356	8X22	M20
315	**300**	455	338	23	406	12X22	M20
355	**350**	525	376	30	470	12X26	M24
n/a	**375**	550	n/a	30	495	12X26	M24
400	**400**	580	430	30	521	12X26	M24
450	**450**	640	470	30	584	12X26	M24
500	**500**	705	533	38	641	16X26	M24
630	**600**	825	645	48	756	16X30	M27
710	**700**	910	740	56	845	20X30	M27
n/a	**750**	995	n/a	56	927	20X33	M30
800	**800**	1060	843	56	984	20X36	M33
900	**900**	1175	947	66	1092	24X36	M33
1000	**1000**	1255	1050	66	1175	24X36	M33
1200	**1200**	1490	-	76	1410	32X36	M33

Note: This table has bolting compatibility with AS 2129 Table D flanges.

Table 7

Steel Backing Flanges AS/NZS 4087 – Figure B8 PN21 (Max. 80°C)

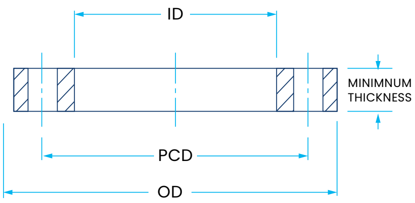


Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
63	**50**	165	78	15	127	4X18	M16
75	**65**	185	92	15	146	8X18	M16
90	**80**	205	108	15	165	8X18	M16
110	**100**	230	128	19	191	8X18	M16
160	**150**	305	178	24	260	12X22	M20
200	**200**	370	235	24	324	12X22	M20
225	**225**	405	238	30	356	12X26	M24
250	**250**	430	288	30	381	12X26	M24
315	**300**	490	338	30	438	16X26	M24
355	**350**	550	376	30	495	16X30	M27
n/a	**375**	580	n/a	38	521	16X30	M27
400	**400**	610	430	38	552	20X30	M27
450	**450**	675	470	38	610	20X33	M30
500	**500**	735	533	48	673	24X33	M30
630	**600**	850	645	58	781	24X36	M33
710	**700**	935	740	58	857	24X36	M33
n/a	**750**	1015	n/a	58	940	28X36	M33
800	**800**	1060	843	68	984	28X36	M33
900	**900**	1185	947	68	1105	32X39	M36
1000	**1000**	1275	1050	78	1194	36X39	M36
1200	**1200**	1530	-	88	1441	40X42	M39

Note: This table has bolting compatibility with AS 2129 Table F & H flanges.

Table 8

Steel Backing Flanges AS/NZS 4087 – Figure B9 PN35 (Max. 80°C)

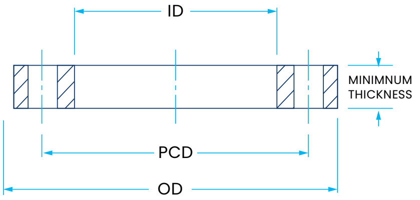


Figure 6

NOMINAL PIPE OD	FLANGE SIZE	OD	ID	MINIMUM THICKNESS	PCD	BOLT HOLE NO. X DIA.	BOLT SIZE
63	**50**	165	78	19	127	4X18	M16
75	**65**	185	92	19	146	8X18	M16
90	**80**	205	108	24	165	8X18	M16
110	**100**	230	128	24	191	8X18	M16
160	**150**	305	178	31	260	12X22	M20
200	**200**	370	235	31	324	12X22	M20
225	**225**	405	238	38	356	12X26	M24
250	**250**	430	288	38	381	12X26	M24
315	**300**	490	338	38	438	16X26	M24
355	**350**	550	376	48	495	16X30	M27
n/a	**375**	580	n/a	48	521	16X30	M27
400	**400**	610	430	48	552	20X30	M27
450	**450**	675	470	58	610	20X33	M30
500	**500**	735	533	58	673	24X33	M30
630	**600**	850	645	68	781	24X36	M33
710	**700**	935	740	78	857	24X36	M33
n/a	**750**	1015	n/a	78	940	28X36	M33
800	**800**	1060	843	84	984	28X36	M33
900	**900**	1185	947	94	1105	32X39	M36
1000	**1000**	1275	1050	98	1194	36X39	M36
1200	**1200**	1530	-	108	1441	40X42	M39

Note: This table has bolting compatibility with AS 2129 Table F & H flanges.

APPENDIX B

STEPS TO ESTIMATE BOLT TORQUE

Step 1. Determine the Joint Specification and Geometry Variables.

a. Dimensional size of all flange components (Incl. backing rings, gaskets, stub adaptors, raised flange faces, bolt hole diameter and number, pipe, and fitting inside diameters etc).

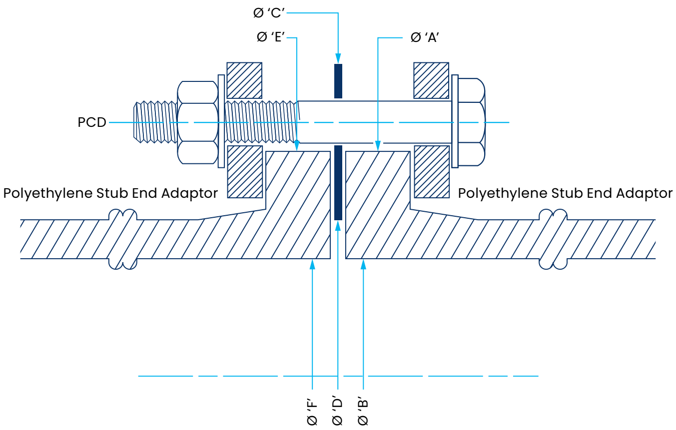


Figure A1

b. Operating and test pressures (Where appropriate, apply a transient surge pressure factor of 1.2 to test pressure).

c. Gasket material and required sealing stress.

d. Bolt number, size, material, lubrication, proof stress, stress area and nut factor (K-factor).

Step 2. Calculate the Waterway Area (this is defined by the maximum internal diameter of the assembled flanges and gasket):

$$A_{WWAY} = \frac{\pi\,(ID_{waterway})^2}{4} \quad \text{units} = mm^2$$

Step 3. Calculate the Net Gasket Interfacial Contact Area.

$$A_{interfacial} = \frac{\pi\,(OD_{sealing\ surface}{}^2 - ID_{sealing\ surface}{}^2)}{4}$$

Where: $OD_{sealing\ surface}$ = minimum of dimensions A, C and E
$ID_{sealing\ surface}$ = maximum of dimensions B, D and F

Step 4. Calculate the Backing Ring to PE Flange Head Contact Area.

$$A_{Backing\ ring\text{-}PE\ flange} = \frac{\pi\,(OD_{PE\ flange\ adaptor\ head}{}^2 - ID_{backing\ ring}{}^2)}{4}$$

Note: in the case of a full-face PE flange adaptor the total bolt hole area must be subtracted from the calculated area shown above.

Step 5. Calculate the Bolt Load

$$\text{Bolt Stress} = \frac{P_{test} \times TSF \times A_{WWAY} + (\sigma_{gasket} \times A_{interfacial})}{\text{Number of bolts}}$$

Where: P_{test} = hydrostatic test pressure (N/mm^2)
TSF = transient surge factor
σ_{gasket}=gasket sealing stress (N/mm^2)

Note: Subject to a transient surge engineering analysis, the Surge Factor may be disregarded at the designer's discretion.

Step 6. Check Bolt is Within 30% to <80% Proof Stress Range

$$\text{Bolt Stress} = \frac{\text{Bolt Load}}{\text{Bolt Cross Sectional Area}}$$

Step 7. Check PE Flange Head Compressive Strain (ε_{comp}) <3%

$$\varepsilon_{comp} = \frac{(\text{Bolt Load} \times \text{No: of Bolts} / A_{\text{Backing ring-PE flange}})}{E} \quad \text{X } 100$$

Where: E = short term modulus for PE, typically 950 N/mm^2

Step 8. Estimate the Bolt Torque

Torque = Nut Factor x Bolt Load x Bolt Diameter units=Nm

Nut Factor represents the efficiency in which torque is converted to axial bolt load.

WORKED EXAMPLE 1

DN160 PN16 PE100 PE Stub Flange Adaptor to DN160 PN16 PE100 PE Stub Flange Adaptor

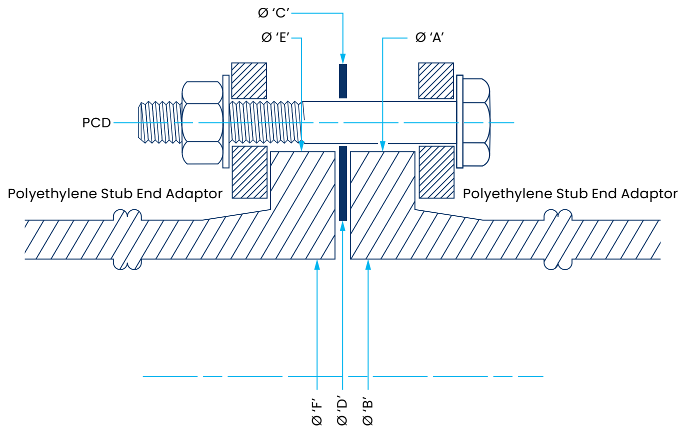


Figure A2

Step 1. Determine the Joint Specification and Geometry Variables.

Variable	Data	Reference
Backing Ring OD / ID	280mm/178mm	POP007 Appendix A – Table 6
PCD	235mm	POP007 Appendix A – Table 6
No. of Bolts/Diameter	8 off / M16 (0.016m)	AS/NZS 4087
Bolt Material / Grade	Stainless Steel / Class 50	WSA 109
Bolt Condition / Nut Factor (K-factor)	Lightly oiled / K = 0.2	WSA 109
Bolt Stress Area / Proof Stress	157mm^2 / 210N/mm^2	ISO 724
Gasket Material / Sealing Stress	EDPM / 4MPa (4N/mm^2)	WSA 109
Gasket OD / ID (ØC/ØD)	280mm / 161mm	WSA 109
Stub Flange Adaptor Head OD / ID (ØA/ØB) = (ØE/ØF)"	212mm / 130mm	ISO 9624, Supplier
Pipe Size / SDR	DN160 / SDR 11	AS/NZS 4130
Maximum Operating Pressure (@20°C)	1600kPa (1.6N/mm^2)	AS/NZS 4130
Pipeline Test Pressure	2000kPa (2.0N/mm^2)	AS/NZS 2566.2
Transient Surge Factor	1.2	Surge & Fatigue Analysis
Stub Flange Adaptor E-modulus	950MPa (950N/mm^2)	AS/NZS 2566.1
Maximum Flange Compression	3%	AS/NZS 4129

Step 2. Calculate the Waterway Area

$$A_{WWAY} = \frac{\pi\,(161)^2}{4} = 20{,}358\text{mm}^2$$

Step 3. Calculate the Net Gasket Interfacial Contact Area

$$A_{interfacial} = \frac{\pi\,(212^2 - 161^2)}{4} = 14{,}941\text{mm}^2$$

Step 4. Calculate the Backing Ring to PE Flange Head Contact Area

$$A_{Backing\ ring\text{-}PE\ flange} = \frac{\pi\,(212^2 - 178^2)}{4} = 10{,}414\text{mm}^2$$

Step 5. Calculate the Bolt Load

$$\text{Bolt Load} = \frac{2.0 \times 1.2 \times 20{,}358 + (4 \times 14{,}941)}{8} = 13.6\text{kN}$$

Step 6. Check Bolt is within 30% to<80% Proof Stress Range

Bolt Stress = 13,578N / 157mm^2 = 86.5N/mm^2

% Proof Stress = (86.5N/mm^2/210N/mm^2) x 100 = 41%, **OK within acceptable range**

Step 7. Check PE Flange Head Compressive Strain (ε_{comp}) <3%

$$\varepsilon_{comp} = \frac{(13{,}578 \times 8) / 10{,}414}{950} \times 100 = 11\%$$

OK, within acceptable range

Step 8. Calculate the Bolt Torque

0.2 x 13,578N x 0.016m = **43N.m**

WORKED EXAMPLE 2

DN630 PN16 PE100 PE Stub Flange Adaptor to DN600 PN16 DI Raised Face Flange

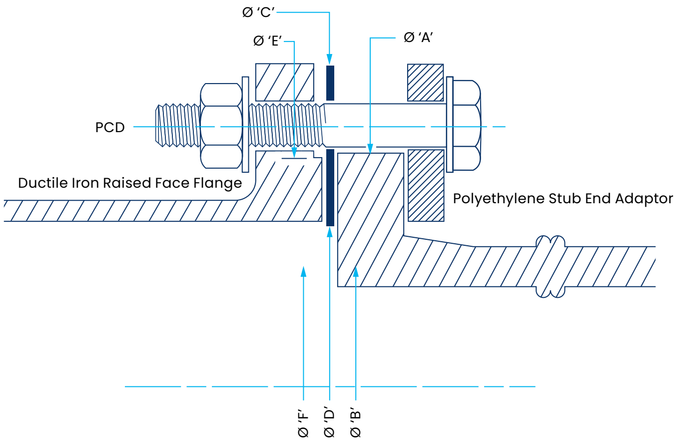


Figure A3

Step 1. Determine the Joint Specification and Geometry Variables.

Variable	Data	Reference
Backing Ring OD / ID	825mm/645mm	POP007 Appendix A – Table 6
PCD	756mm	POP007 Appendix A – Table 6
No. of Bolts/Diameter	16 off / M27 (0.027m)	AS/NZS 4087
Bolt Material / Grade	Carbon Steel / Gr. 4.6	WSA 109
Bolt Condition / Nut Factor (K-factor)	Well lubricated / K = 0.15	WSA 109
Bolt Stress Area / Proof Stress	459mm² / 240N/mm²	ISO 724
Gasket Material / Sealing Stress	EDPM / 4MPa (4N/mm²)	WSA 109
Gasket OD / ID (ØC/ØD)	825mm / 641mm	WSA 109
Stub Flange Adaptor Head OD / ID (ØA/ØB)	685 mm / 513mm	ISO 9624, Supplier
DI Flange Raised Face Diameter (ØE)	720mm	AS/NZS 4087
DI Flange Inside Diameter (ØF)	645mm	Supplier
Pipe Size / SDR	DN630 / SDR 11	AS/NZS 4130
Maximum Operating Pressure (@20°C)	1600kPa (1.6N/mm²)	AS/NZS 4130
Pipeline Test Pressure	2000kPa (2.0N/mm²)	AS/NZS 2566.2
Transient Surge Factor	None required	Surge & Fatigue Analysis
Stub Flange Adaptor E-modulus	950MPa (950N/mm²)	AS/NZS 2566.1
Maximum Flange Compression	3%	AS/NZS 4129

Step 2. Calculate the Waterway Area

$$A_{WWAY} = \frac{\pi\,(645)^2}{4} = 326{,}754mm^2$$

Step 3. Calculate the Net Gasket Interfacial Contact Area

$$A_{interfacial} = \frac{\pi\,(685^2 - 645^2)}{4} = 41{,}783mm^2$$

Step 4. Calculate the Backing Ring to PE Flange Head Contact Area

$$A_{Backing\ ring\text{-}PE\ flange} = \frac{\pi\,(682^2 - 645^2)}{4} = 41{,}783mm^2$$

Step 5. Calculate the Bolt Load

$$\text{Bolt Load} = \frac{2.0 \times 1.0 \times 326{,}754 + (4 \times 41{,}783)}{16} = 51.3kN$$

Step 6. Check Bolt is Within 30% to<80% Proof Stress Range

Bolt Stress = 51,289N / 459mm^2 = 111.7N/mm^2

% Proof Stress = (111.7N/mm^2/240N/mm^2) x 100 = 47%, **OK within acceptable range**

Step 7. Check PE Flange Head Compressive Strain (ε_{comp}) <3%

$$\varepsilon_{comp} = \frac{(51{,}298 \times 16)\ /\ 41{,}783}{950} \times 100 = 2.1\%$$

OK, within acceptable range

Step 8. Calculate the Bolt Torque

0.15 x 51,289N x 0.027m = **208N.m**

PIPA

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