

FLANGES AND FLANGE ADAPTERS FOR POLYPROPYLENE (PP-R & PP-RCT) PIPING SYSTEMS

PPI TN-71

2024



Foreword

This technical note was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and by developing design aids and reports to help engineers, code officials, specifying groups, contractors, and users.

The purpose of this technical note is to provide information regarding flanges and flange adapters for polypropylene (PP) piping systems.

The PPI has prepared this technical note as a service to the industry. The information in this note is offered in good faith and believed to be accurate at the time of its preparation but is offered “as is” without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regards to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. A list of member manufacturers is available on the PPI website. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this technical note within 5 years or sooner if required, from the date of its publication, in response to comments and suggestions from users of the document. Please send suggestions for improvements by contacting PPI. Information on other publications can be obtained by contacting PPI directly or visiting our website.

For further information, contact: The Plastics Pipe Institute
105 Decker Court
Suite 825
Irving, Texas, 75062
469.499.1044
www.plasticpipe.org

This Technical Note, TN-71, was first issued in October 2024.

Table of Contents

Foreword...	2
Table of Contents	3
Table of Figures	4
List of Tables	4
PREFACE	5
1.0 INTRODUCTION	5
2.0 ACRONYMS AND TERMINOLOGY	6
3.0 PRINCIPLES OF POLYPROPYLENE FLANGED CONNECTIONS	6
4.0 INSTALLATION INSTRUCTIONS – FLANGE TO FLANGE	7
4.1. Alignment of Flanged Joints.....	7
4.2. Inspect the flange adapter sealing surfaces.....	7
4.3. Examine the gasket	7
4.4. Inspect and clean the bolts, nuts, and washers	7
4.5. Lubrication of Threads and Nut contact surfaces.....	8
4.6. Installation of Bolts.....	8
4.7. Tightening of Bolts	8
4.8. Tightening Sequence of Bolts	9
4.9. Relaxation and re-tightening	9
4.10. Increasing bolt torque	9
5.0 INSTALLATION INSTRUCTIONS – FLANGE TO BUTTERFLY VALVE (BFV)	10
5.1. Preassembly	10
5.2. Installation Steps for Flange to BFV	10
6.0 PRESSURE-TESTING & LEAK CLOSURE GUIDELINE	11
7.0 FLANGE DISASSEMBLY	11
8.0 FLANGED JOINT PRESSURE RATINGS	12
9.0 FLANGED JOINT COMPONENTS	15
9.1. Flange Adapters	15
9.2. Backing Rings (Lap Joint Flange)	19
9.3. Spacer Rings / Butterfly Flange Adapters	21
9.4. Low Pressure Plastic & FRP Flanges	21
9.5. Bolts or Studs and Nuts	21
10.0 GASKETS	23

11.0	BOLT LOAD/TORQUE CALCULATION METHODOLOGY	25
11.1.	Rationale for this Methodology	25
11.2.	Nut Factors	27
11.3.	Calculation of Target Bolt Torque	27
12.0	EXAMPLE BOLT TORQUE CALCULATIONS	28
13.0	REFERENCES	29

Table of Figures

Figure 1: PP Flange Adapter to PP Flange Adapter joined using gasket and bolts.....	13
Figure 2: PP Flange Adapter to ASME WNRF Steel Flange	14
Figure 3: Polypropylene Flange Adapter Geometry	15
Figure 4: Flange adapter modified to accommodate butterfly valve disc.....	16
Figure 5: Geometry of a butt fusion flange adapter with backing ring	17
Figure 6: Geometry of a socket fitting flange adapter with backing ring	18
Figure 7a (top): Ductile Iron Convuluted LJF/BR Figure 7b (bottom): Steel Plate BR ...	20

List of Tables

Table 1: PCC-1 Legacy Cross-Pattern Tightening Sequence	9
Table 2: Specifications for Example	28
Table 3: Target Torque values for Nut Factor 0.16, Interfacial pressure 1,200 psi, Pipe DR 11	29

FLANGES AND FLANGE ADAPTERS FOR POLYPROPYLENE (PP-R & PP-RCT) PIPING SYSTEMS

PREFACE

Polypropylene pressure pipes and fittings are often joined to each other by heat fusion methods known as butt fusion, socket fusion, or electrofusion. Flanged connections are used as transitions to pipes of other materials (e.g., steel), connections to flanged fittings and valves, or as end connections on fabricated pipe spools and assemblies.

Flanged joints prevent leakage by compressing a deformable gasket material into irregularities in a less deformable material to seal possible leak paths. The mating faces of flanged joints are the surface areas that need to be sealed. The deformation characteristics of the deformable material, including gasket hardness, compressive strength, and compression set, are the primary determinant of the amount of compression, expressed as force per unit area, or pressure, required to properly seal a flanged joint.

It is desirable to utilize common bolting patterns to facilitate connections to readily available flanged fittings and valves. Flanges used in North America for plumbing and heating/cooling systems generally conform to ASME B16.5 bolting patterns. These are sometimes referred to as "ANSI bolt patterns"¹.

1.0 INTRODUCTION

Bolted flanges are a common method for joining metal pipes to metal pipes, fittings, and valves. Flanges can also be used to transition from plastic piping materials, such as polypropylene (PP), to other plastic materials (e.g., CPVC, HDPE) and metal.

The design and selection of components for flanged joints connecting polypropylene pressure pipe-to-pipe (i.e., PP-to-PP), including the material types classified as PP-R & PP-RCT, or PP pipe-to-metal pipe (e.g., steel) are based on lower interfacial pressures than those used for metal-to-metal flanged joints. The initial interfacial pressure is limited by the allowable short duration stress of the gasket material and the PP flange adapter.

This PPI Technical Note focuses on the design and installation practices for transitioning from polypropylene pipe conforming to industry standards ASTM F2389² or CSA B137.11³, to pipes, fittings, or valves of other materials using flange adapters and connections.

¹ ASME B16.5 *Pipe Flanges and Flange Fittings: NPS ½ through NPS 24, Metric/Inch Standard* previously published as ANSI B16.5 and ASA B16.5

² *Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems*

³ *Polypropylene (PP-R & PP-RCT) pipe and fittings for pressure applications*

2.0 ACRONYMS AND TERMINOLOGY

- ASME American Society of Mechanical Engineers
- BCD bolt circle diameter
- BFV butterfly valve
- BR backing ring (also known as “back-up ring”)
- CFG compressed fiber gaskets
- DVS Deutscher Verband für Schweißen und verwandte Verfahren e. V. (“German Welding Society”)
- FA flange adapter
- FRP fiberglass reinforced pipe (Glass-Fiber-Reinforced Thermosetting-Resin Pipe)
- GF glass fiber
- LJF lap joint flange
- ID inside diameter
- MSF minimum seating force
- OD outside diameter
- WNRF weld neck raised face
- MOBL maximum operating bolt load
- MSF minimum seating force
- PP polypropylene
- PP-R polypropylene random copolymer
- PP-RCT polypropylene random copolymer with modified crystallinity and temperature resistance
- PP flange adapter PP fitting which provides a flange connection on one end by use of adapter a backing ring or lap-joint flange (Van Stone type flange) and straight pipe stub or socket fusion connection on the other end
- PTFE polytetrafluoroethylene
- EPDM ethylene propylene diene terpolymer
- CSM chlorosulfonated polyethylene (also CSPE)
- FPM fluoropolymer (also FKM)

3.0 PRINCIPLES OF POLYPROPYLENE FLANGED CONNECTIONS

The mating interfacial surface area of a metal-to-PP flange adapter may be significantly less than that between PP-to-PP flange adapters, since the bore (i.e., inside diameter) of the metal flange and pipe is typically larger than the bore of the PP flange adapter. Because of this, the required bolt and nut force of a PP-to-PP flanged joint may be greater than for PP-to-metal flanged joints due to the larger interfacial surface area. See [Section 11.1](#) for additional discussion about this topic.

To establish higher long-term interfacial stress, retorquing is suggested to compensate for the stress relaxation in the PP flange adapters and gaskets.

While retightening of the bolts is recommended for all flanged joints, the creep relaxation of the PP flange adapter can significantly reduce the stress between the mating faces and loosen the bolts. Consequently, retightening is more important with PP flanged joints than with metal flanged joints.

Most PP flange adapters are provided with an internal taper/bevel to allow for rotation of the butterfly valve (BFV) disc when connecting to a BFV. In some cases, it may be necessary to provide a spacer ring with a tapered bore to provide clearance for the disc. The flange adapter manufacturer may also require the use of a gasket in addition to the integral seal of the butterfly valve. Consult the BFV manufacturer's instructions to confirm proper sealing materials and bolt torque. Where discrepancies exist between BFV and flange instructions, consult with the manufacturers of both products to confirm correct installation procedures.

4.0 INSTALLATION INSTRUCTIONS – FLANGE TO FLANGE

4.1. Alignment of Flanged Joints

- a. Proper alignment of all joint members is an essential element of proper flange joint assembly.
- b. When achieving proper alignment requires more force that can be exerted by hand or common hand and hammer alignment tools, consult the PP piping manufacturer for guidance.

4.2. Inspect the flange adapter sealing surfaces

- a. Check the adapter for tool marks, dents, or scratches.
- b. Radial tool marks on the sealing surface are difficult to seal against, regardless of the style of gasket.
- c. Ensure that the finish is adequate for the style of gasket being used.

4.3. Examine the gasket

- a. Verify that the gasket material is compatible with the fluid being used in the pipeline and consistent with the sealing stress used for bolt torque values.
- b. Check for tool marks, shipping, and storage damage. Discard any damaged gaskets.

4.4. Inspect and clean the bolts, nuts, and washers

- a. Provide washers for each side of the bolt and nut assembly.
- b. Lack of washers will affect the bolt torque required to achieve proper compression of the sealing surfaces.
- c. Inspect all bolts, nuts, and washers to ensure they are free from damage. Discard any damaged components.

4.5. Lubrication of Threads and Nut contact surfaces

- a. For coated bolts and nuts being used for the first time, the factory-installed coating of polytetrafluoroethylene (PTFE) or polyamide/amide is sufficient surface lubrication. Additional lubrication is not necessary, unless the bolts or nuts are being re-used.
- b. For non-coated bolts and nuts, or if bolts or nuts are being reused, lubricate the bolt threads and the nut contact surfaces. Do not install bolts and nuts without lubrication.
- c. The nut factor **0.16** is appropriate for coated bolts and a nut factor of **0.20** is appropriate for non-coated bolts.
- d. Torque values found in **Table 3** only apply for the initial tightening of lubricated or new coated bolts.

4.6. Installation of Bolts

- a. Bolts, washers, and nuts should be installed so that they are hand-tight with the marked end of the bolts and nuts located on the same side of the joint and facing outward to facilitate inspection.

4.7. Tightening of Bolts

- a. Bolts should be tightened by securing the bolt in place and tightening/turning each nut by hand to prevent cross threads.
- b. Multiple rounds of tightening should be used to ensure uniform bolt tightness.
- c. After hand-tightening, a minimum of three (3) rounds of incremental tightening with a suitable torque wrench is recommended, tightening to approximately 30% of the target torque value on the first round.
- d. Tighten to 50% to 70% of the target torque value on the second round, and to tighten to 100% of specified torque value on the third round.
- e. After the third round, it is recommended that each bolt should be retorqued to 100% in a circular pattern to ensure that no bolts were inadvertently missed during the tightening sequence.
- f. If a bolt or nut still turns at the target torque value, continue tightening until an increase in torque is observed.
- g. In addition to performing the final torque tightening pass at 100% or torque value, measurements of the gaps between the flanges should be taken to verify that the flanges are being brought together evenly (i.e., parallel). Measurements of this gap at eight (8) equally spaced locations are recommended.

NOTE 1: When the target torque value is extremely high (e.g., above 300 ft-lbs.), additional tightening rounds should be considered to avoid deflecting or distorting the flange or backing ring and creating misalignment.

NOTE 2: Under no circumstances should bolt tightening be used to close the gap or "cinch up" the gap between flange faces or components.

4.8. Tightening Sequence of Bolts

- a. The tightening sequence for bolts and nuts is based on usage of a single tightening tool, tightening one bolt at a time.
- b. The “Legacy PCC-1” cross-pattern tightening sequence and bolt numbering system, when using a single tool, is shown in Table 4 of **ASME PCC-1**. It is included here as **Table 1** for convenience.
- c. Only the portion of ASME PCC-1 Table 4 indicating up to 28 bolts has been included, since that is the number of bolt holes associated with a nominal 28 in. (i.e., 710 mm) pipe diameter.

There have been successful implementations of joint assembly patterns and torque-increment combinations that require less effort than the “Legacy PCC-1” method. The reader is referred to Appendix F of PCC-1 *ASME Guidelines for Pressure Boundary Bolted Flange Joint Assembly* for these alternative patterns.

Table 1: PCC-1 Legacy Cross-Pattern Tightening Sequence and Bolt Numbering System When Using a Single Tool

No. of Bolts	Sequentially Clockwise Sequence					
4	1-3-2-4					
8	1-5-3-7	→	2-6-4-8			
12	1-7-4-10	→	2-8-5-11	→	3-9-6-12	
16	1-9-5-13	→	3-11-7-15	→	2-10-6-14	→ 4-12-8-16
20	1-11-6-16	→	3-13-8-18	→	5-15-10-20	→ 2-12-7-17 → 4-14-9-19
24	1-13-7-19	→	4-16-10-22	→	2-14-8-20	→ 5-17-11-23 → 3-15-9-21 → 6-18-12-24
28	1-15-8-22	→	4-18-11-25	→	6-20-13-27	→ 2-16-9-23 → 5-19-12-26 → 7-21-14-28 → 3-17-10-24

4.9. Relaxation and re-tightening

- a. All gaskets relax after tightening and seating.
- b. Retightening the flange bolts is recommended to compensate for the relaxation of gaskets.

4.10. Increasing bolt torque

- a. If leakage of any joint occurs after reaching the recommended flange bolt torque, bolt torque may be increased by 10% and the bolts retightened to the new higher torque in the same sequence as noted above.
- b. A maximum of 20% increase above the recommended torque may be used.
- c. If leakage of the joint still occurs, the connections should be disassembled, all parts examined for defects, replaced if necessary, and reassembled as noted above.