

## 1. SCOPE

This joint assembly procedure is based on proposed guidelines from various sources including AAR M-1002, the Materials Technology Institute (MTI), ASME PCC-1 and the gasket installation procedure in the *Durlon Technical Handbook for Railroad Tank Cars* of Gasket Resources Inc.

- 1.1 The objective of this procedure is the elimination of bolted joint related NAR's on railroad tank cars by using the correct materials, equipment, installation procedures, and bolt tightening methods.

## 2. LOADER, JOINT ASSEMBLER QUALIFICATION

- 2.1 Prior to performing work on bolted flanges on railroad tank cars, the loaders or joint assemblers should become familiar with the methods to tighten the bolts and the use of selected tools in this procedure.

## 3. CLEANING AND VISUAL EXAMINATION OF "WORKING SURFACES"

Before assembly is started, all working surfaces shall be cleaned and visually examined.

### 3.1 Gasket-contact surface areas of both joint faces

- 3.1.1 Remove all traces of dirt, rust and old gasket material. One exception to this rule is when flexible graphite is the remaining material in the surface finish grooves and a flexible graphite flat gasket or filled SWG replacement gasket is to be used as flexible graphite bonds to itself in a seamless fashion, and thereby becomes an integral part of the newly-applied flexible graphite gasket.
- 3.1.2 Visually examine the gasket contact surfaces on flat flanges or tongue and groove flanges for scratches, nicks, gouges, and burrs. Scratches running radially across the face of the gasket-contact surface are of concern, particularly if they are deeper than the surface finish grooves and extend beyond the centerline of the gasket contact surface.
- 3.1.3 When the surface finish is either a serrated concentric or serrated spiral lay, the surface finish shall be in the range of 125-250  $\mu$  in. Surface finish comparator gauges can be used by the joint assemblers to determine flange finish.
- 3.1.4 Visually examine gasket contact surfaces for out-of-flatness. When checked for flatness using dial indicators, these surfaces should be within 0.15 mm (0.006 in) from the high-to-low spots (total indicator reading). The readings should be taken both radially and circumferentially to ensure uniform flatness.
- 3.1.3 Nut/washer bearing surfaces on flanges – Paint must be removed. Visually examine for scores and burrs, evidence of out-of-squareness, evidence of "Brinelling" (indentation of nuts into flange or washer contact surface) etc. Remove protrusions by filing or grinding. Use through-hardened flat steel washers (ASTM F436 or similar), or some combination of these if appropriate to provide smooth and square nut-bearing surfaces.

### 3.2 Existing Bolts, Washers and Nuts

- 3.2.1 Careful handling is required to avoid damaging the threads.
- 3.2.2 All previously used bolts/nuts shall be cleaned (such as wire brushing). Cleanliness of threaded components and like-new contact surface conditions are extremely important.
  - 3.2.2.1 Check for bolt and nut identification markings.
  - 3.2.2.2 On nuts, the side with identification markings shall face away from the flange surface. The side with no identification markings is the nut bearing surface that contacts the flange.

- 3.2.3 Bolt and nut threads – Visually examine the bolt and nut threads for damage, rust, corrosion and burrs. Replace any damaged components including bolt/nut combinations for which the nut will not turn easily. Replace any damaged components including bolt/nut combinations for which the nut will not turn easily by hand over the full length. Also replace bolt/nut combinations for which the looseness of the fit between the bolt/nut as judged by the Maintenance Engineer is unacceptable. Replace all visibly stretched, cracked or corroded bolts. Replace bolting if it has been coated with material which might prevent accurate assessment of torque being applied, for example, heavy paint.
- 3.2.4 Nut/washer bearing surfaces of flanges – Paint must be removed. Visually examine for scores and burrs, evidence of out-of-squareness, evidence of “Brinelling” (indentation of nuts into flange contact surface) etc. Remove protrusions by filing or grinding. Spot facing, the addition of through-hardened steel washers, or some combination of these, may be appropriate to provide smooth and square nut-bearing surfaces.
- 3.2.5 Flat Washers (where applicable) – Visually examine washers for scoring and cupping and replace any damaged components (only through hardened steel washers, ASTM F436 or similar, shall be used). Surface-hardened washers will crush under the applied load resulting in loss of preload and should not be used.
  - 3.2.5.1 Use of through-hardened steel washers is recommended for oversized holes, slotted holes, and when a high strength steel nut is used with low strength austenitic stainless steel flanges.

### 3.3 New Bolt/Washer/Nut Components

Fastener Selection - Refer to Section 8 for specific information on recommended fastener grades for nonpressure and pressure tank cars. Nonpressure tank cars using “hard” gaskets require fasteners of sufficient strength in order to seal.

- 3.3.1 Careful handling is required to avoid damaging the threads.
- 3.3.2 Verify that the materials of the new bolt/washer/nut components are as specified for the applicable flange, or company specifications; and that bolt and nut identification markings are visible.
  - 3.3.2.1 Verify that the nominal nut thickness is equal to the nominal bolt diameter; replace with Heavy Hex nut if measured thickness is less.

## 4. INSTALL NEW GASKET

- 4.1 **Do not** reuse old gasket; **do not** use multiple gaskets.
- 4.2 Support the gasket when handling so that a buckling crease will not be created.
- 4.3 Confirm that gasket complies with gasket size (OD, ID, thickness), configuration and material specification shown in the specifications, as appropriate.
- 4.4 Carefully examine the new gaskets for manufacturing defects or shipping damage.
- 4.5 For all gasket types, make certain that the gasket lines up evenly all the way around (is concentric with either flange ID or OD of flange facing). No portion of the gasket should project into the flow path.
- 4.6 Do not apply either bolt lubricant or gasket release agents to either the gasket or gasket-contact surfaces; these surfaces must be dry.
- 4.7 If the flange has a flat surface, the gasket will be either a ring gasket that is centered inside of the bolt circle or a full face gasket with bolt holes that covers the entire flange. If the flange is grooved with a corresponding tongue on the mating valve or flange (T/G flange), the gasket will be a narrow ring that fits into the groove. Be sure that the gasket is fully seated at the bottom of the groove.

## 5. FLANGE ALIGNMENT AND ACCESSIBILITY

- 5.1 Position the flanges carefully to avoid damage to either the gasket or the flanges during initial contact.
- 5.2 If the flanges are tongue and groove, position tongue and groove of the flanges carefully to avoid damage to corners of tongue or groove facing during initial contact.
- 5.3 Flange faces shall be aligned within 1 mm in 200 mm (1/16" per foot) measured across any diameter. Flange bolt holes shall be aligned within 3 mm (1/8") maximum offset.

## 6. LUBRICATE BOLTS AND NUTS AND WASHERS

- 6.1 DO NOT LUBRICATE NEW FLUOROPOLYMER COATED BOLTS THE FIRST TIME THEY ARE USED. However, for the second and subsequent use, the lubrication practice outlined in 6.3 shall be followed.
- 6.2 DO NOT APPLY EITHER BOLT LUBRICANT OR GASKET RELEASE AGENTS TO EITHER THE GASKET OR GASKET-CONTACT SURFACES; THESE SURFACES MUST BE DRY.
- 6.3 Liberally coat all bolt and nut thread engagement surfaces, the washer face of the nuts, and the flange/washer/nut contact surfaces with a lubricant approved for the service conditions, which includes the commodity.
  - 6.3.1 Refer to Section 3.2.2.2 regarding the nut bearing / flange contact surface of the nut.

## 7. SELECTION OF TIGHTENING METHOD/TOOLS

**Every gasket applied to a railcar flange must be tightened using torque control. At a minimum a calibrated torque wrench (5% tolerance) can be used with a written torque specification and tightening sequence.**

While use of hand wrenches or impact wrenches is common on tank cars, it is highly recommended that torque control be used when installing gaskets and tightening bolted joints on tank cars. At the very least, a manual torque wrench should be used to tighten bolted joints. The loader or joint assembler should become familiar with the use of a torque control device such as a torque wrench.

## 8. TIGHTEN JOINT

- 8.1 Check alignment as described in Section 5.3.
- 8.2 Number the flange bolt holes in the appropriate cross-pattern sequence for the correct number of bolts in the bolt number drawing in Appendix B, starting at the location adjacent to the 12 o'clock position.
- 8.3 Select the correct Target Torque according to the bolt diameter and bolt grade and for the equipment being installed according to company guidelines or specifications.
- 8.4 Nonpressure (General Purpose) tank cars require a higher compressive load for "hard" gaskets versus elastomer gaskets. This makes fastener selection very important for nonpressure cars.
- 8.4 Install bolts and nuts, and if applicable, hardened washers.
- 8.5 Round 1 - PRE-TIGHTENING – THIS STEP IS VERY IMPORTANT. THIS STEP HELPS STABILIZE THE FLANGES AND KEEPS THEM PARALLEL. Hand tighten the nuts in a cross-pattern sequence, then snug up nuts in a cross-pattern sequence by tightening 1/4 turn with a hand wrench.
- 8.6 Start the bolt tightening process using the appropriate cross-pattern tightening sequence for the correct number of bolts in the bolt number drawing in Appendix B.
  - 8.6.1 Use only calibrated torque wrenches. Note: torque wrenches must be calibrated once per year or time frame according to company procedures.

- 8.6.2 To ensure the flanges remain parallel after each tightening round, the gap between the flanges can be checked at four locations 90 degrees apart for up to 8 bolt flanges, and at every other bolt for flanges with more than 8 bolts. If the gap is not reasonably uniform around the circumference, make the appropriate adjustments by selective bolt loosening and tightening before proceeding.
- 8.7 Round 2: Beginning at the #1 bolt, torque bolts to 30% of Target (final) Torque value using the appropriate cross-pattern tightening sequence from the applicable bolt number drawing. If possible check gap (see 8.6.2).
- 8.8 Round 3: Beginning at the #1 bolt, torque bolts to 60% of Target (final) Torque, following appropriate bolting sequence from the applicable bolt number drawing. If possible check gap (see 8.6.2).
- 8.9 Round 4: Beginning at the #1 bolt, torque bolts to 100% of Target (final) Torque, following appropriate bolting sequence from the applicable bolt number drawing. If possible check gap (see 8.6.2).
- 8.10 Round 5: Beginning at the #1 bolt, tighten bolts in a rotational pattern at 100% of Target (final) Torque. Continue tightening with a rotational pattern until no further nut rotation occurs at the 100% Target Torque level for any nut.
- 8.11 Apply required leak test. If joint leaks at low pressure, carefully disassemble joint and identify problem; after remedying, reassemble by following the staged bolting sequence tightening procedures covered in 8.5 through 8.10 above. If joint shows minimal leakage at test pressure, retighten to 100% of final torque value using Round 4/Round 5 procedure. Reapply required leak test; if joint still leaks, consult the Maintenance Engineer.
- 8.12 Retorque. If possible, repeat Round 5 after a minimum of four hours. (Tests show that a large percentage of the short-term bolt preload loss occurs within four hours after initial tightening. Retorquing recovers this loss.)
9. NONPRESSURE (GENERAL PURPOSE) TANK CARS
- 9.1 VALVE FASTENERS FOR NONPRESSURE TANK CARS –MSRP C-III, Appendix M, Section 4.3 of the AAR allows fasteners with a minimum tensile strength of 60 ksi and stainless fasteners with a minimum yield of 30 ksi. However, for “hard” gaskets some fasteners may not have sufficient strength to seat gaskets such as compressed non-asbestos or filled PTFE gaskets.
- 9.1.2 Recommended fastener grades:  
Carbon/Alloy Steel Fasteners: ASTM A193 Grade B7, ASTM A-449, SAE Grade 5.  
Stainless Steel Fasteners: ASTM A193 Grades B8 Class 2, B8M Class 2.
- 9.2 BELLVILLE / CONICAL SPRING WASHERS – The use of Bellville spring washers on valve flanges has proven to reduce the effects of bolt and gasket relaxation. In situations of excess vibration or where valve flange fasteners become loose, conical spring washers should also be considered.
- A recommended source for Bellville washers is Solon Manufacturing (800) 825-1337, [www.solonmfg.com](http://www.solonmfg.com).
- 9.3 MANWAY EYEBOLTS – Recommended fastener grades.
- 9.3.1 Carbon/Alloy Steel Fasteners: ASTM A193 Grade B7, ASTM A-449, A-307 (not less than 1-in diameter).
- 9.3.2 Refer to Appendix C for bolted manway eyebolt tightening sequences.
- 9.4 MANWAY COVER GASKETS FOR NONPRESSURE TANK CARS - BOLTED AND HINGED MANWAY STYLE MARKING
- 9.4.1 A manway style decal/stencil shall be applied to an operating platform corner post, on top of the manway cover, or on any other unobstructed location near the manway on all cars equipped with bolted and hinged manways. (see AAR M-1002 Appendix C, Section 8).

9.4.2 The manway style decal/stencil shall state the following in letters and numerals at least 1/4 in. (6.35 mm) high:

MANWAY STYLE: XXXX-123

The X's indicate the manufacturer's identification and the numbers indicate the style number assigned by the manufacturer.

9.4.3 New cars ordered after July 1, 1996 are to be designed to retain, under normal operating conditions, the manway gaskets listed below and designated as standard manway style AAR-1 (see appropriate manway style chart in M-1002, Appendix D, Tables D6 through D11).

MANWAY STYLE AAR-1 GASKET

- Elastomeric gasket: 21-11/16 in. O.D. x 19-1/2 in. I.D. x 1/4 in. thick
- Hard gasket: 21-5/8 in. O.D. x 19-1/2 in. I.D. x 1/8 in. thick

Elastomeric refers to a solid "rubber" type material, such as EPDM, Viton®, Buna-N, or Neoprene, without any reinforcement or fibers. Hard gasket refers to industrial style gasket such as compressed fiber or filled PTFE gaskets.

9.4.4 Manway covers on cars built before July 1, 1996 – The manways on these cars could be one of many different styles and the gasket dimensions (OD, ID and thickness) can vary depending on the manway style.(see appropriate manway style chart in M-1002, Appendix D, Tables D6 through D11).

Also, refer to the manway style decal/stencil on the top of the tank car per 9.2.1 and Fig. C3 from AAR M-1002, Appendix C (below).

9.4.5 Elastomer and Hard gasket dimensions. The gasket dimensions (OD, ID and thickness) can vary even for the same AAR manway style depending whether the gasket material is an elastomer or defined as a "Hard" gasket.

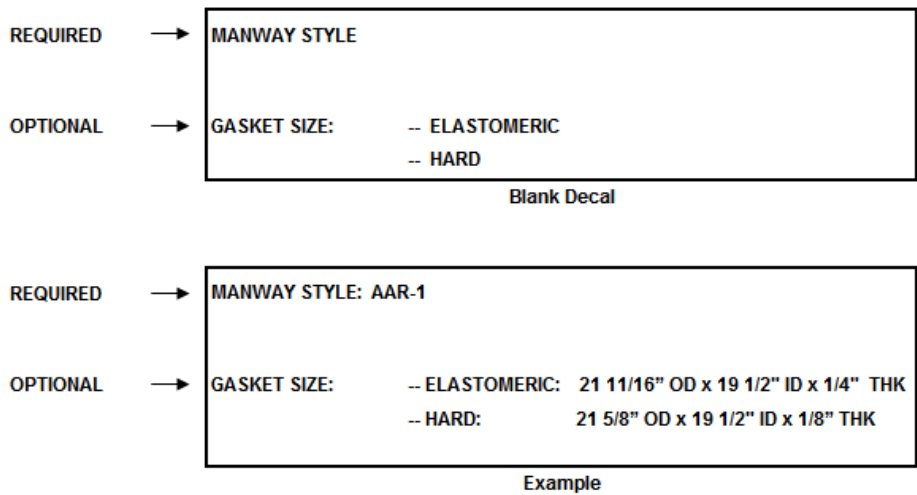


Fig. C3 Manway style decal stencil

10. PRESSURE TANK CARS

10.1 FLANGE CONNECTIONS ON PRESSURE CARS ARE TONGUE & GROOVE

10.2 VALVE FLANGE CONNECTIONS

10.2.1 The flanges on the valves have a tongue with two 1/16" witness grooves that mates to a corresponding groove in the manway plate.

10.2.2 The valve groove on manway plate has one 1/16" witness groove centered in the groove and a nominal 0.380" width. The groove OD and ID tolerances are  $\pm 0.003$ " and the groove variation can be between 0.377" to 0.383".

10.3 MANWAY (PRESSURE PLATE) FLANGE CONNECTIONS

10.3.1 The flanges on the manway plate have a tongue with two 1/16" witness grooves that mates to a corresponding groove in the nozzle flange that is welded to the tank.

10.3.2 The corresponding groove on manway nozzle has one 1/16" witness groove centered in the groove and a nominal 0.563" width. The groove OD and ID tolerances are  $\pm 0.010$ " and the groove variation can be between 0.552" to 0.573".

10.4 TONGUE & GROOVE GASKET TOLERANCES

10.4.1 Pressure car valve gaskets and gaskets for T/G flanges on nonpressure cars have a nominal 3/8" width with an OD tolerance of  $+0/-1/32$ , and an ID tolerance of  $-0/+1/32$ ".

10.4.2 Pressure car manway plate gaskets have a nominal 1/2" width with OD/ID tolerances of  $\pm 1/32$ ".

APPENDIX A  
TANK CAR BOLTED JOINT COMPONENTS

NONPRESSURE TANK CAR

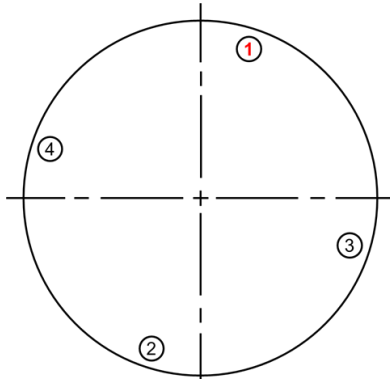
GP Tank Car Component Gaskets	Model # / And/or Size	# Bolts	Bolt Dia	Bolt Grade	Flange Type (T/G, FF, RF)	Gasket Material/Cut Dimensions				Torque (ft-lbs)
						Material	Thk.	OD	ID	
Multi-Housing Cover Plate Flange	--									
Air Valve										
Eduction or Siphon Valve										
Blind Flange/Mag. Gauging Device										
Vacuum Relief Valve										
Safety Valve										
AAR Manway Style										
BOV - Tank/Valve										
BOV - Valve/Nozzle										
Thd. Bottom Outlet Cap, 4" or 6"										

PRESSURE TANK CAR

Pressure Tank Car Component Gaskets	Valve Mfg / Model #	# Bolts	Bolt Dia	Bolt Grade	Flange Type (T/G)	Gasket Material/Cut Dimensions				Torque (ft-lbs)
						Material	Thk.	OD	ID	
Manway/Pressure Plate Flange	--									
Angle Valve, Air										
Angle Valve, Liquid										
Angle Valve, Liquid										
Gauging Device or Venting Valve										
PRD/Safety Valve										

APPENDIX B

VALVE, PRESSURE PLAT BOLT NUMBER TIGHTENING SEQUENCES

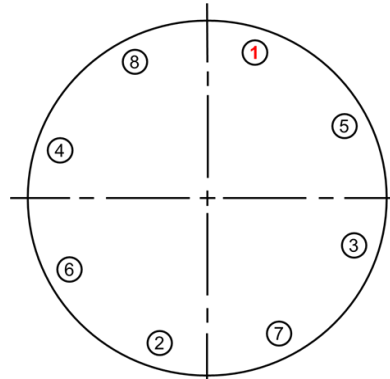


4-Bolt

© Gasket Resources, Inc.

SEQUENTIAL  
ORDER  
(Rounds 1,2,3 & 4)  
1-2  
3-4

ROTATIONAL  
ORDER  
(Round 5)  
1  
3  
2  
4

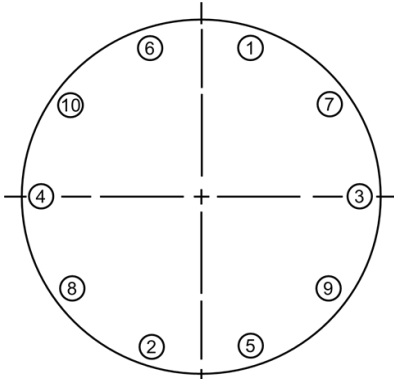


8-Bolt

© Gasket Resources, Inc.

SEQUENTIAL  
ORDER  
(Rounds 1,2,3 & 4)  
1-2  
3-4  
5-6  
7-8

ROTATIONAL  
ORDER  
(Round 5)  
1  
5  
3  
7  
3  
2  
6  
4  
8

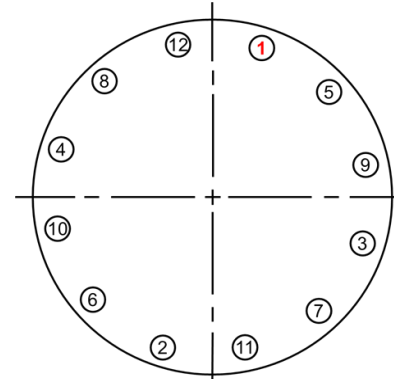


10-Bolt

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SEQUENTIAL  
ORDER  
(Rounds 1,2,3 & 4)  
1-2  
3-4  
5-6  
7-8  
9-10

ROTATIONAL  
ORDER  
(Round 5)  
1  
7  
3  
9  
5  
2  
8  
4  
10  
6

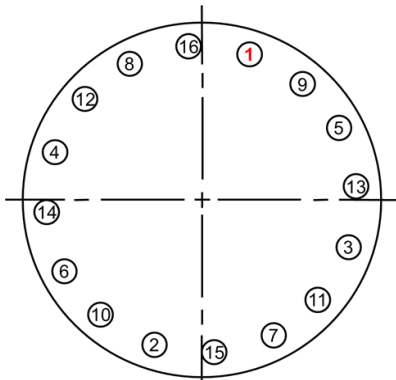


12-Bolt

© Gasket Resources, Inc.

SEQUENTIAL  
ORDER  
(Rounds 1,2,3 & 4)  
1-2  
3-4  
5-6  
7-8  
9-10  
11-12

ROTATIONAL  
ORDER  
(Round 5)  
1  
5  
9  
3  
7  
11  
2  
6  
10  
4  
8  
12

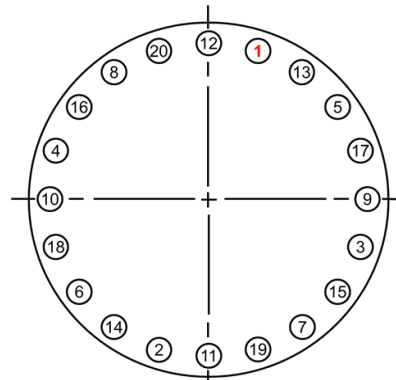


16-Bolt

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SEQUENTIAL  
ORDER  
(Rounds 1,2,3 & 4)  
1-2  
3-4  
5-6  
7-8  
9-10  
11-12  
13-14  
15-16

ROTATIONAL  
ORDER  
(Round 5)  
1  
9  
5  
13  
3  
11  
7  
15  
2  
10  
6  
14  
4  
12  
8  
16



20-Bolt

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SEQUENTIAL  
ORDER  
(Rounds 1,2,3 & 4)  
1-2  
3-4  
5-6  
7-8  
9-10  
11-12  
13-14  
15-16  
17-18  
19-20

ROTATIONAL  
ORDER  
(Round 5)  
1  
13  
5  
17  
9  
3  
15  
7  
19  
11  
2  
6  
14  
10  
4  
16  
8  
20  
12

**WARNING:** Bolts must be tightened in the cross-pattern tightening sequence, employing the incremental rounds of tightening as prescribed in this procedure. If this is not done, the flanges may become cocked relative to each other, an indicator of non-uniform gasket loading and potential joint leakage.



APPENDIX C  
NONPRESSURE CAR HINGED & BOLTED MANWAY  
EYEBOLT TIGHTENING PROCEDURE

CUSTOMER: \_\_\_\_\_

TANK CAR NO. \_\_\_\_\_

LOCATION: \_\_\_\_\_

PART NO. \_\_\_\_\_

AAR MANWAY STYLE: \_\_\_\_\_

GASKET DIMENSIONS: \_\_\_\_\_  
(Refer to GRI MW Gasket Style/Size Chart)

GASKET MATERIAL: DURLON 9000, DURLON 9600, DURLON 8500  
(Durlon materials are "Hard" manway gasket styles as noted in Appendix D of M-1002)

EYEBOLT GRADE: A307, A449, A193-B8/B8M Class 2  
(Circle one)

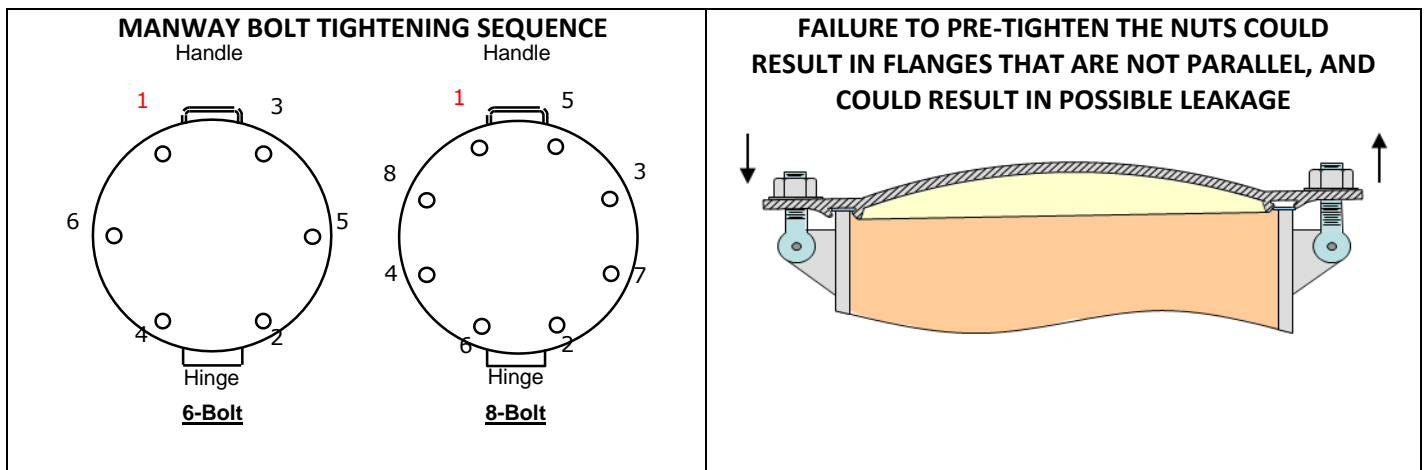
EYEBOLT DIAMETER: \_\_\_\_\_

LUBRICATION USED: \_\_\_\_\_

ASSEMBLY TORQUE: \_\_\_\_\_  
(From chart below)

ASSEMBLY SEQUENCE	6 Eyebolts		8 Eyebolts	
	Handtight then 1/4 turn		Handtight then 1/4 turn	
<b>ASSEMBLY SEQUENCE</b> Assembly requires a minimum of 5 steps: • <b>Pretightening.</b> Hand tighten lubricated eyebolts then 1/4 turn with a hand wrench. • Three star pattern tightening sequences in either a 6-bolt or 8-bolt pattern, increasing the torque in each sequence per the chart on the right. • A rotational pass at full torque to equalize the stress on each eyebolt. • Optional. Retorque after 4-24 hrs.	75 ft-lbs	1st Sequence	65 ft-lbs	1st Sequence
	145 ft-lbs	2nd Sequence	125 ft-lbs	2nd Sequence
	245 ft-lbs	3rd Sequence	210 ft-lbs	3rd Sequence
	245 ft-lbs	Rotational	210 ft-lbs	Rotational
Retorque after 4 to 24 hrs. A large percentage of the short-term bolt preload loss occurs within twenty-four hours after initial tightening with most occurring after four to five hours. This Round recovers this loss.				

**WARNING:** Bolts must be tightened in the cross-pattern tightening sequence, employing the incremental rounds of tightening as prescribed in this procedure. If this is not done, the flanges may become out of parallel relative to each other, an indicator of non-uniform gasket loading and potential joint leakage.



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APPENDIX D

PRESSURE CAR BOLT TIGHTENING WORK SHEET  
STD. ANGLE VALVE – 4 BOLT FLANGE

Nominal Bolt Size: 3/4", Bolt Grade: \_\_\_\_\_

Approved Lubricant Used: \_\_\_\_\_

Tightening Fasteners – Refer to Sections 4 – 8

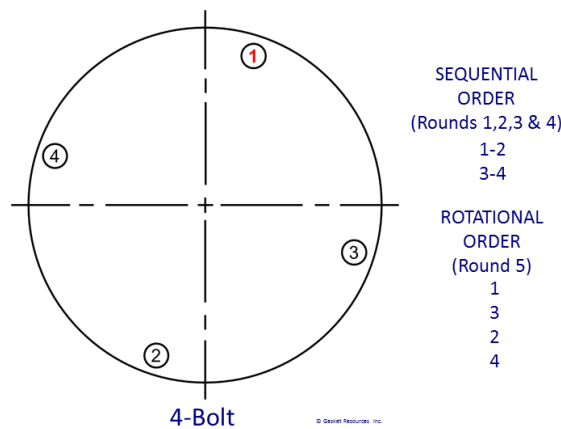
- Visually examine and clean flanges, bolts, nuts and washers. Replace components if necessary.
- Lubricate bolts, nuts and the flange-nut interface on the nuts.
- Install new gasket. Do not reuse old gasket or use multiple gaskets.
- Number bolt locations in cross-pattern sequence as shown on sketch below.
- **Round 1** - Hand tighten all nuts; then PRE-TIGHTEN bolts 1/4 turn in a cross-pattern sequence with a hand wrench. This helps to stabilize the flanges.
- If possible check gap for uniformity.
- Use the cross-pattern tightening sequence (illustrated below) for Rounds 2, 3, and 4. (This sequence constitutes a "Round".)

**Target Torque:** \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)  
S – socket, C – crow's foot (10% higher than socket torque. See GRI Torque Spreadsheet. Torque based on lubricated bolts.)  
\* If a valve requires a crow's foot, use on all fasteners for that valve.

- **Round 2** - \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)
- **Round 3** - \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)
- **Round 4** - \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)

\* Torque values are based on lubricated bolts, nuts and nut facings.

- If possible check gap around the circumference between each of these rounds, measured at each bolt. If the gap is not reasonably uniform around the circumference, make the appropriate adjustments by selective bolt tightening before proceeding.
- **Round 5** - 100% of Target Torque (same as Round 4). Use rotational clockwise tightening sequence, starting with Bolt No. 1, for one complete round and continue until no further nut rotation occurs at the 100% Target Torque value for any nut.
- **Retorque** - If possible, repeat Round 5 after a minimum of four to twenty-four hours. (Tests show that a large percentage of the short-term bolt preload loss occurs within four hours after initial tightening. Round 5 recovers this loss.)



**WARNING:** Bolts must be tightened in the cross-pattern tightening sequence, employing the incremental rounds of tightening as prescribed in this procedure. If this is not done, the flanges may become cocked relative to each other, an indicator of non-uniform gasket loading and potential joint leakage.

APPENDIX D

PRESSURE CAR BOLT TIGHTENING WORK SHEET  
SAFETY VALVE - 4 BOLT FLANGE

Nominal Bolt Size: 7/8", Bolt Grade: \_\_\_\_\_

Approved Lubricant Used: \_\_\_\_\_

Tightening Fasteners – Refer to Sections 4 – 8

- Visually examine and clean flanges, bolts, nuts and washers. Replace components if necessary.
- Lubricate bolts, nuts and the flange-nut interface on the nuts.
- Install new gasket. Do not reuse old gasket or use multiple gaskets.
- Number bolt locations in cross-pattern sequence as shown on sketch below.
- **Round 1** - Hand tighten all nuts; then PRE-TIGHTEN bolts 1/4 turn in a cross-pattern sequence with a hand wrench. This helps to stabilize the flanges.
- If possible check gap for uniformity.
- Use the cross-pattern tightening sequence (illustrated below) for Rounds 2, 3, and 4. (This sequence constitutes a "Round".)

**Target Torque:** \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)

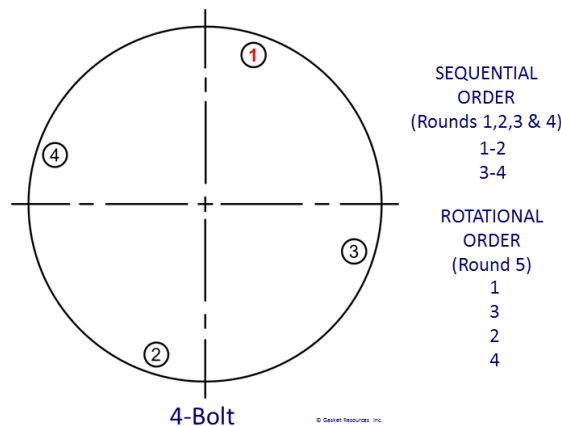
S – socket, C – crow's foot (10% higher than socket torque. See GRI Torque Spreadsheet. Torque based on lubricated bolts.)

\* If a valve requires a crow's foot, use on all fasteners for that valve.

- **Round 2** - \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)
- **Round 3** - \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)
- **Round 4** - \_\_\_\_\_ ft-lbs (S) \_\_\_\_\_ ft-lbs (C)

\* Torque values are based on lubricated bolts, nuts and nut facings.

- If possible check gap around the circumference between each of these rounds, measured at each bolt. If the gap is not reasonably uniform around the circumference, make the appropriate adjustments by selective bolt tightening before proceeding.
- **Round 5** - 100% of Target Torque (same as Round 4). Use rotational clockwise tightening sequence, starting with Bolt No. 1, for one complete round and continue until no further nut rotation occurs at the 100% Target Torque value for any nut.
- **Retorque** - If possible, repeat Round 5 after a minimum of four to twenty-four hours. (Tests show that a large percentage of the short-term bolt preload loss occurs within four hours after initial tightening. Round 5 recovers this loss.)



**WARNING:** Bolts must be tightened in the cross-pattern tightening sequence, employing the incremental rounds of tightening as prescribed in this procedure. If this is not done, the flanges may become cocked relative to each other, an indicator of non-uniform gasket loading and potential joint leakage.

APPENDIX D

PRESSURE CAR BOLT TIGHTENING WORK SHEET  
PRESSURE PLATE / MANWAY – 20 BOLT FLANGE

Nominal Bolt Size: 1-1/8", Bolt Grade: \_\_\_\_\_

Approved Lubricant Used: \_\_\_\_\_

Tightening Fasteners – Refer to Sections 4 – 8

- Visually examine and clean flanges, bolts, nuts and washers. Replace components if necessary.
- Lubricate bolts, nuts and the flange-nut interface on the nuts.
- Install new gasket. Do not reuse old gasket or use multiple gaskets.
- Number bolt locations in cross-pattern sequence as shown on sketch below.
- **Round 1** - Hand tighten all nuts; then PRE-TIGHTEN bolts 1/4 turn in a cross-pattern sequence with a hand wrench. This helps to stabilize the flanges.
- If possible check gap for uniformity.
- Use the cross-pattern tightening sequence (illustrated below) for Rounds 2, 3, and 4. (This sequence constitutes a "Round".)

**Target Torque:** \_\_\_\_\_ ft-lbs (S)

S – socket, C – crow's foot (10% higher than socket torque. See GRI Torque Spreadsheet. Torque based on lubricated bolts.)

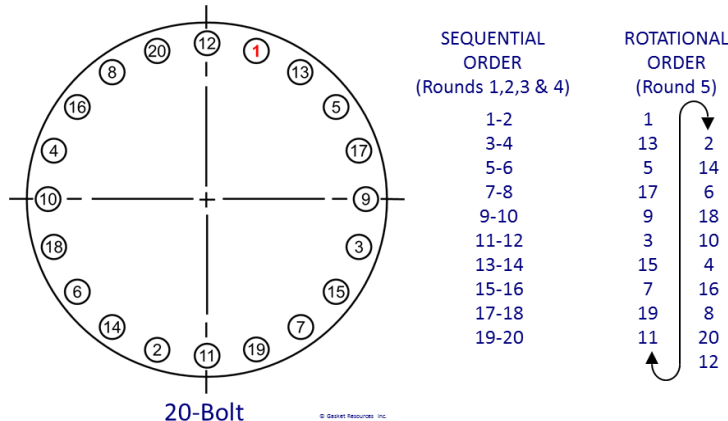
\* If a valve requires a crow's foot, use on all fasteners for that valve.

**CAUTION:** The weight of pressure plate cover can cause pressure plate flange to be misaligned, resulting in uneven gasket compression.

- **Round 2** - \_\_\_\_\_ ft-lbs
- **Round 3** - \_\_\_\_\_ ft-lbs
- **Round 4** - \_\_\_\_\_ ft-lbs

\* Torque values are based on lubricated bolts, nuts and nut facings.

- If possible check gap around the circumference between each of these rounds, measured at each bolt. If the gap is not reasonably uniform around the circumference, make the appropriate adjustments by selective bolt tightening before proceeding.
- **Round 5** - 100% of Target Torque (same as Round 4). Use rotational clockwise tightening sequence, starting with Bolt No. 1, for one complete round and continue until no further nut rotation occurs at the 100% Target Torque value for any nut.
- **R retorque** - If possible, repeat Round 5 after a minimum of four to twenty-four hours. (Tests show that a large percentage of the short-term bolt preload loss occurs within four hours after initial tightening. Round 5 recovers this loss.)



**WARNING:** Bolts must be tightened in the cross-pattern tightening sequence, employing the incremental rounds of tightening as prescribed in this procedure. If this is not done, the flanges may become cocked relative to each other, an indicator of non-uniform gasket loading and potential joint leakage.