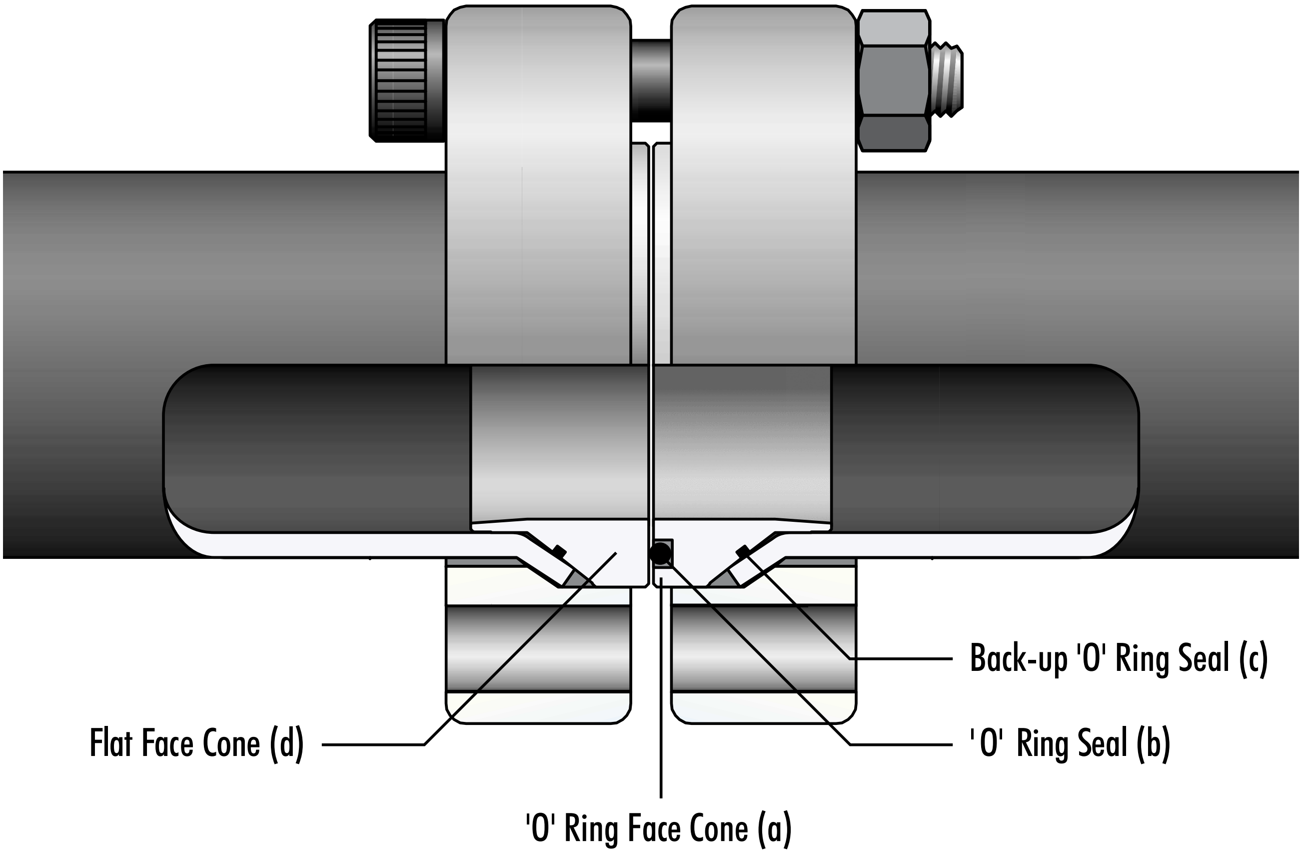
Flared System



The flared configuration is based on flaring the pipe ends to 37° and utilizing flanges and internal cones. ‘O’ring face cone (a) with ‘o’ring seal (b) mating to flat face cone (d). Both internal cones have back-up ‘o’rings (c).

Standard flare flanges and NPS pipe sizes are available from:

- 1/2” schedule 40 up to 10” schedule 40
- 1/2” schedule 80 up to 4” schedule 80
- 1-1/2” schedule 160 up to 3” schedule 160

Standard flare flanges and Metric pipe sizes are available from:

- 20mm up to 273mm various thin wall
- 20mm up to 90mm various wall thickness
- 56mm up to 97mm heavy wall

PREPARATION:

The flange is slipped onto the pipe before flaring. After flaring, the cone is located into the pipe. Bolting the flanges together draws the flared pipes and cones in contact with each other providing a leakfree connection.

The standard connection styles offered conform to SAE and ISO 4-bolt flanges. Other flange patterns may also be available.

3D step models available upon request

Flared System

TMI® 37° Flaring and Connection Procedure

The Flare Flange connection consists of pipe suitable for cold forming, flare flanges, flare cones with elastomer seals and bolting hardware.

Step 1: Cut pipe end square, deburr and clean. Slip flange onto the pipe before flaring. Place pipe into the flaring machine with the correct dies and flaring cone to suit the pipe size.

Step 2: Pipe is to protrude to the stop on the die. Lubricate the flaring cone, start the machine, flare the pipe end until fully formed against the die. Stop the machine, remove the pipe from the die.

Step 3: Clean and visually inspect the flare. The surface of the flare should be smooth and free of any defects.

Step 4: Select the correct pipe cone style (ref. pgs. B3-B4). Insert pipe cone into the flared end of the pipe (use rubber hammer if required).

Step 5: Select the required bolting hardware.

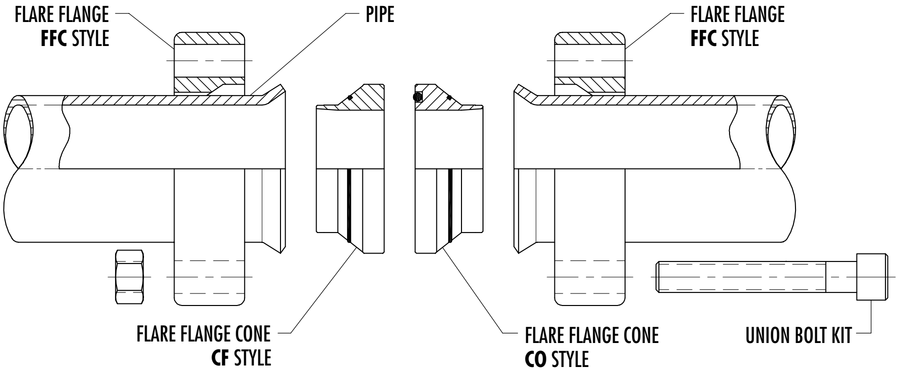
Step 6: Tighten bolts to the torque values specified. Always tighten bolts in a cross-over sequence and ensure that the flanges are parallel.

3D step models available upon request

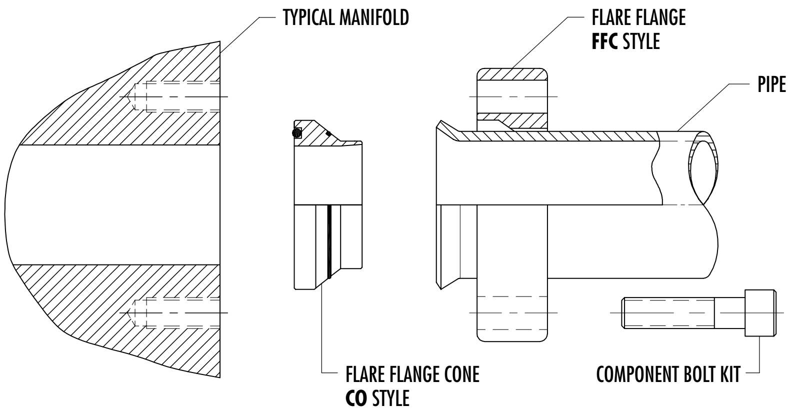
Flared System

Flare Flange Connections - Schedule 40/80/160

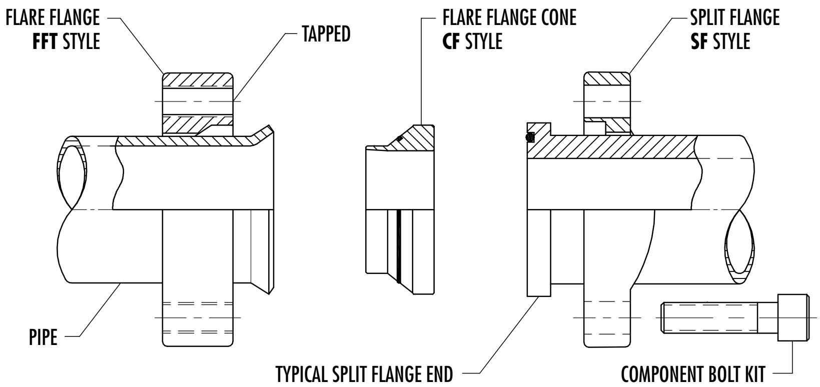
Typical Flare Union Connection



Typical Flare ('O' Ring Face) to Flat Face Component Connection



Typical Flare (Flat Face) to Split Flange Connection

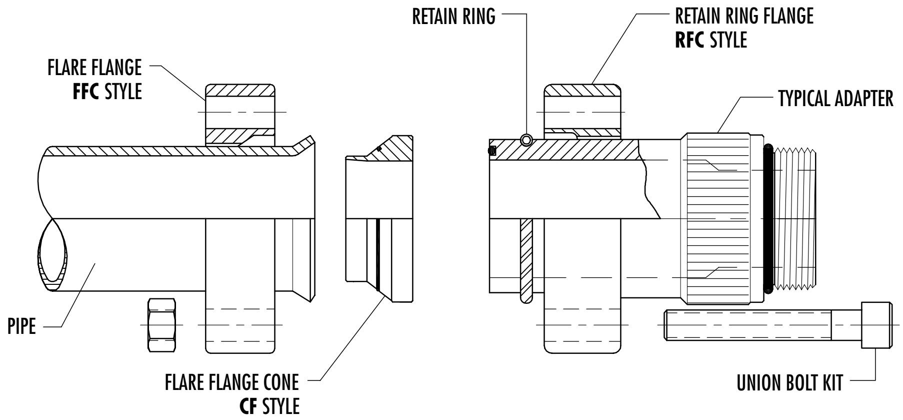


3D step models available upon request

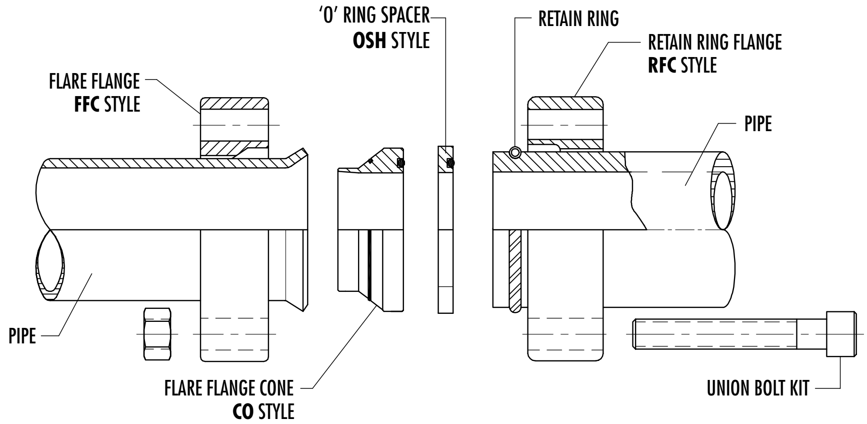
Flared System

Flare Flange Connections - Schedule 40/80/160

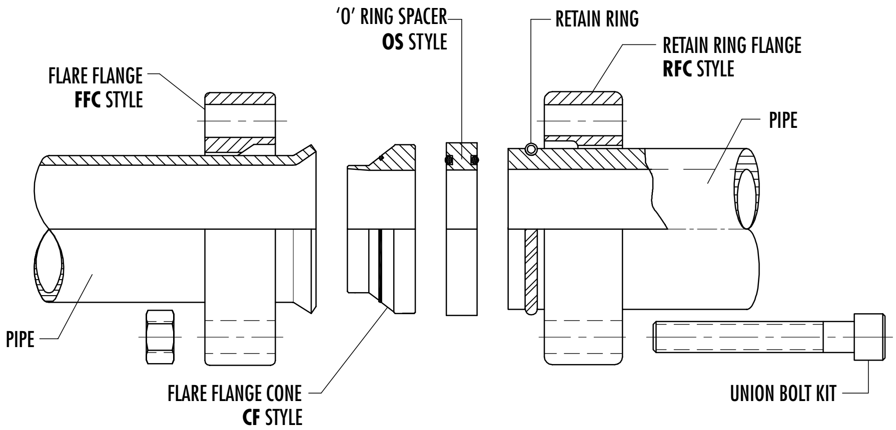
Typical Flare (Flat Face) to 'O' Ring Face Component Connection



Typical Flare ('O' Ring Face) to Retain Ring Pipe Connection

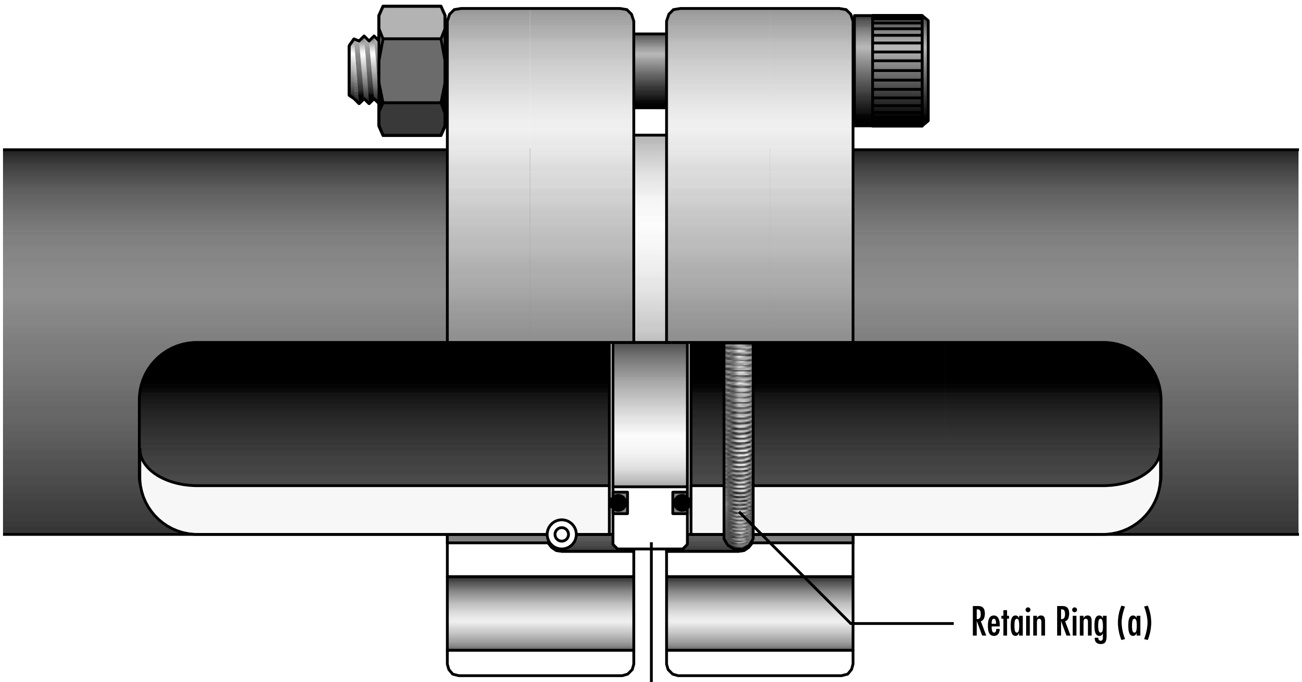


Typical Flare (Flat Face) to Retain Rin g Pipe Connection



3D step models available upon request

Retain Ring System



The retain ring configuration uses heavy wall pipe and has a machined butt end face, along with an annular groove on the outside diameter.

After machining, the flange is slipped onto the pipe and a retain ring (a) which consists of a segmented stainless steel ring bound by a spiral wound stainless steel spring is sprung over the pipe's outside diameter nesting in the annular groove. Bolting the flanges together draws them against the retain rings with the 'o'ring spacer (b) captive within the connection.

Pipe sizes 1 1/2" through 10" are available for use with retain ring flanges.

The standard connection styles offered conform to SAE and ISO 4-bolt flanges along with Tube-Mac® Industries 8-bolt/12-bolt proprietary flanges. Other flange patterns may also be available. Pipe sizes 1 1/2" through 10" are available for use with retain ring flanges.

The standard connection styles offered conform to SAE and ISO 4-bolt flanges along with Tube-Mac® Industries 8-bolt/12-bolt proprietary flanges. Other flange patterns may also be available.

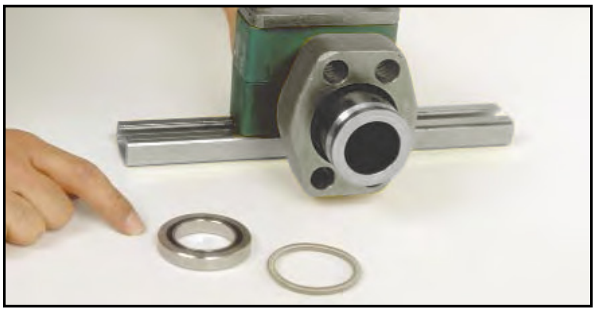
3D step models available upon request

Retain Ring System

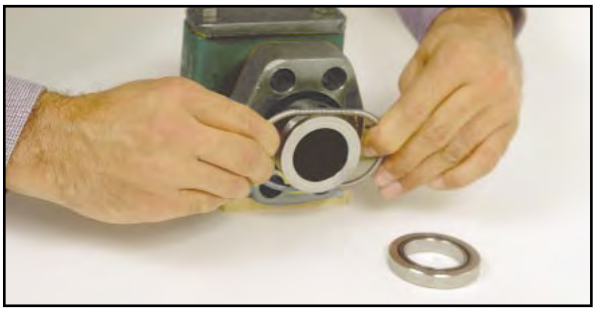
TMI® Retain Ring Flange Connection Procedure

The retain ring flange connection consists of machined pipe, retain ring flanges, retain rings, ‘o’ ring spacer and bolting hardware.

Step 1: Pipe supplied with butt end machined along with an annular groove on the outside diameter.

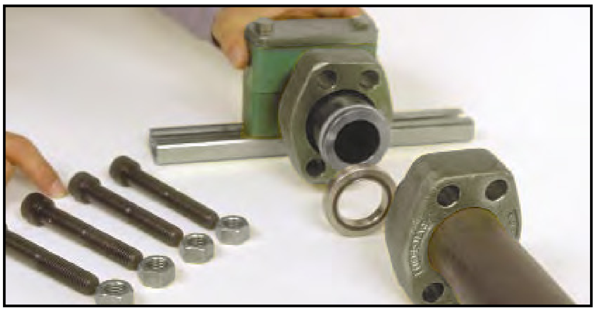


Step 2: Slip flange onto the pipe.

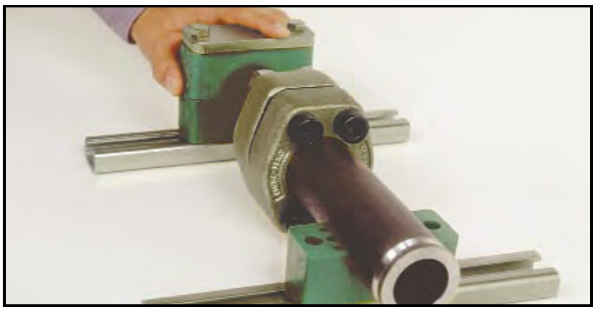


Step 3: Retain ring is sprung over the pipe’s outside diameter nesting in the annular groove.

Step 4: Select the correct ‘o’ ring spacer style. The ‘o’ ring provides a seal against the butt end of the pipe.



Step 5: Select the required bolting hardware from Section R of this catalogue. Carefully place the ‘o’ ring spacer in between the pipe ends. Slide the flanges forward and the ‘o’ ring seal retainer becomes captive within the flanges.



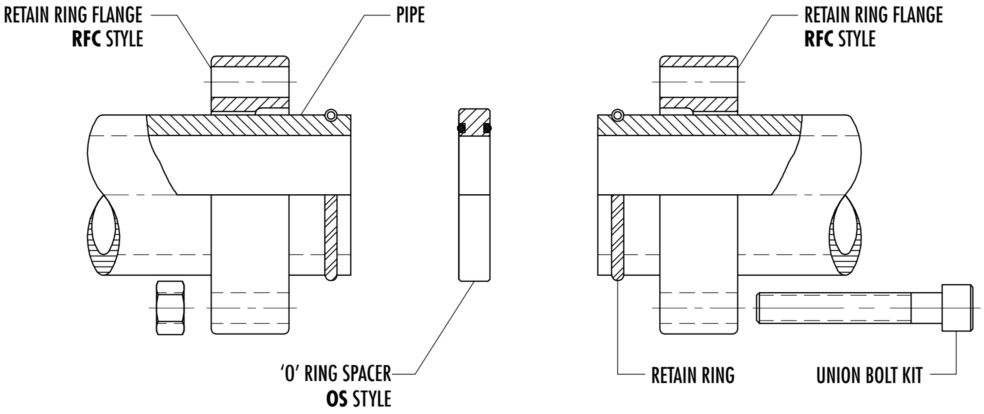
Step 6: Tighten bolts to the torque values specified. Always tighten bolts in a cross-over sequence and ensure that the flanges are parallel.

3D step models available upon request

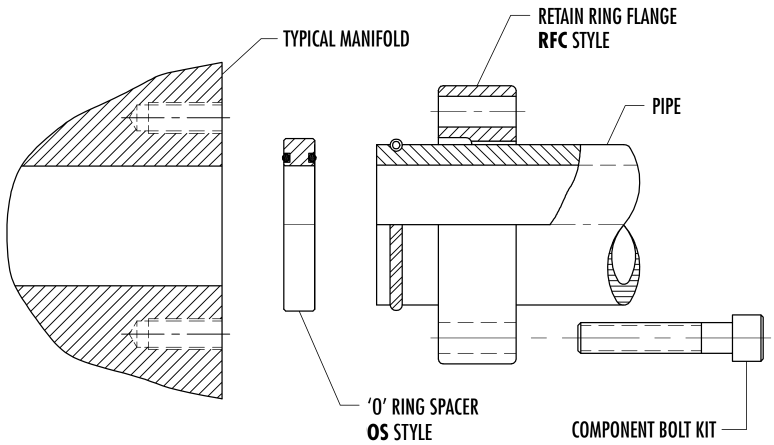
Retain Ring System

Retain Ring Flange Connections - Heavy Wall Pipe

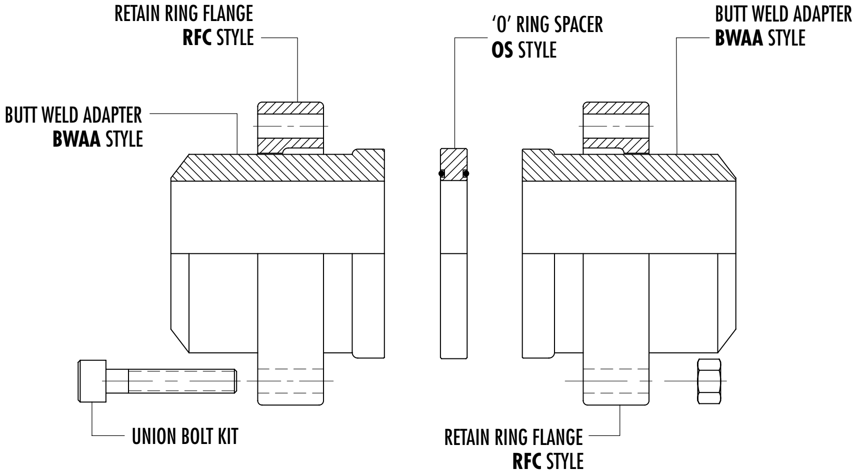
Typical Pipe Union Connection



Typical Pipe to Flat Face Connection



Typical Butt Weld Adapter Union Connection

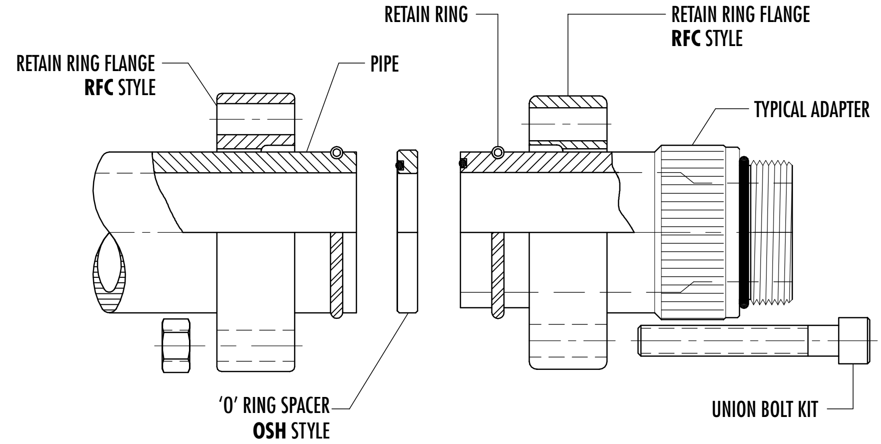


3D step models available upon request

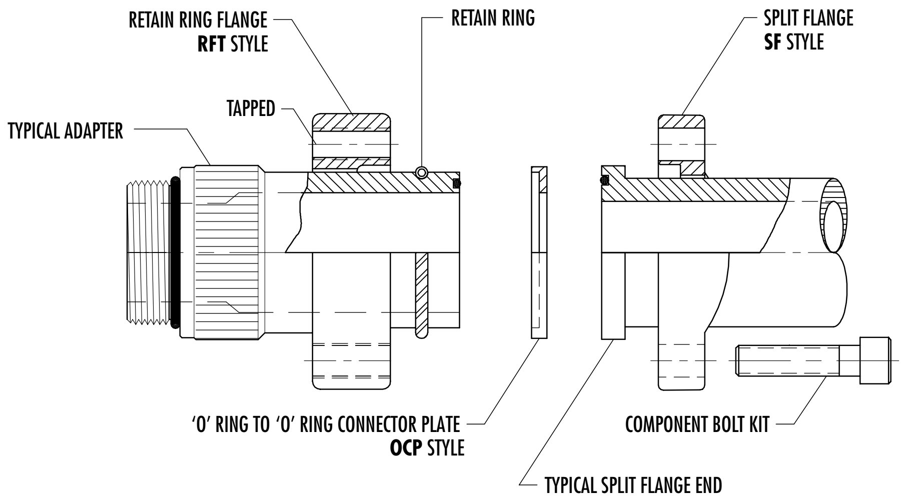
Retain Ring System

Retain Ring Flange Connections - Heavy Wall Pipe

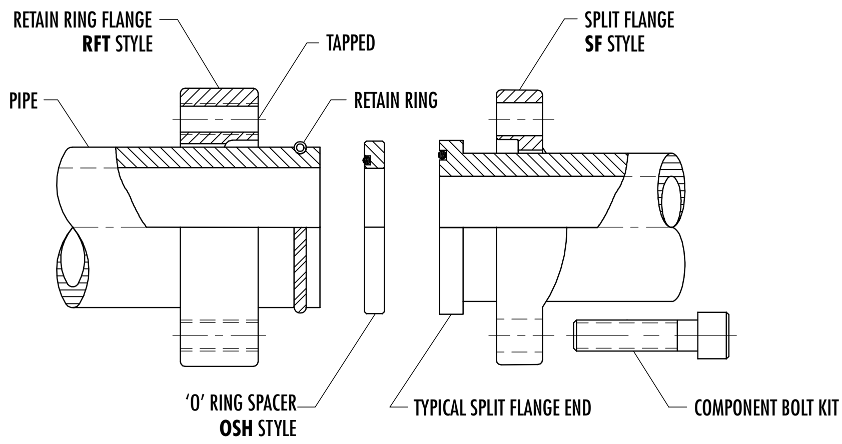
Typical Pipe to 'O' Ring Face Retain Ring Component Connection



Typical 'O' Ring Face Retain Ring Component to SAE Split Flange Connection

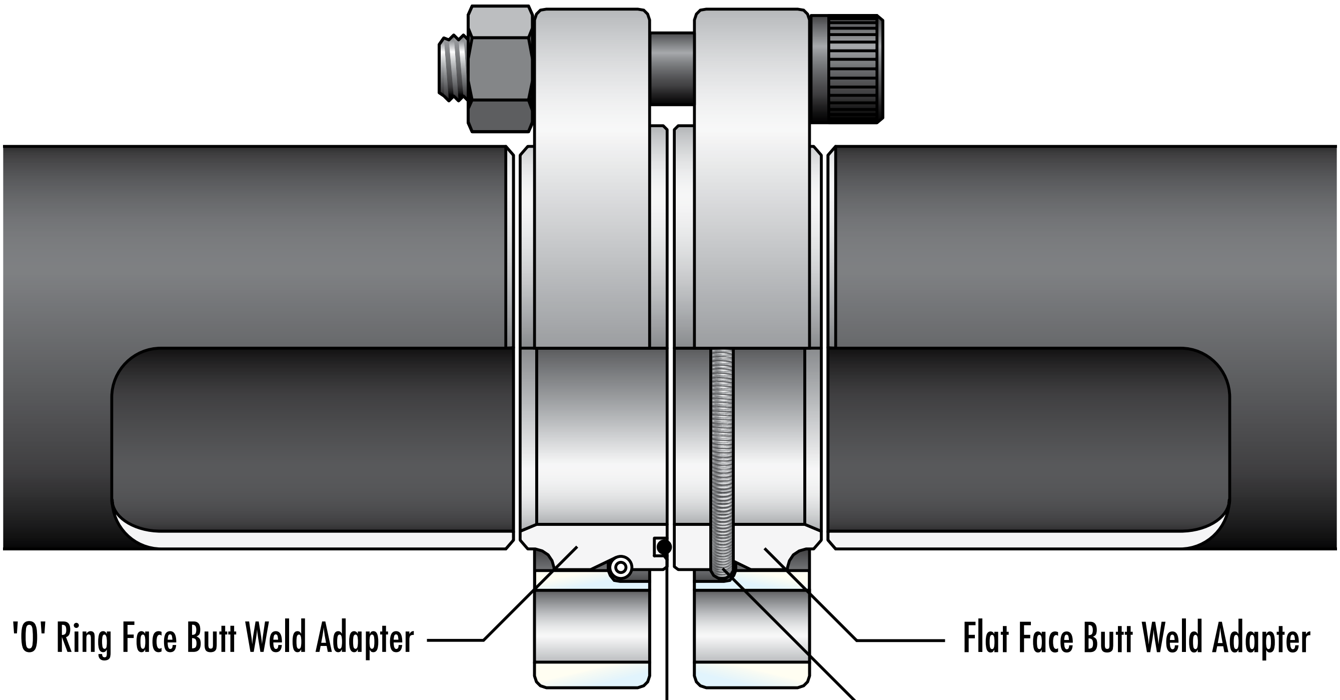


Typical Pipe to SAE Split Flange Connection



3D step models available upon request

Low Pressure Retain Ring System



The low pressure retain ring configuration uses butt weld adapters, (1) 'o'ring face and (1) flat face, with an groove on the outside diameter.

After pipe preparation, the adapter is welded onto the pipe. The flange is slipped onto the pipe and a low pressure retain ring (a) which consists of a segmented stainless steel ring bound by a spiral wound stainless steel spring is sprung over the adapter's outside diameter nesting in the groove.

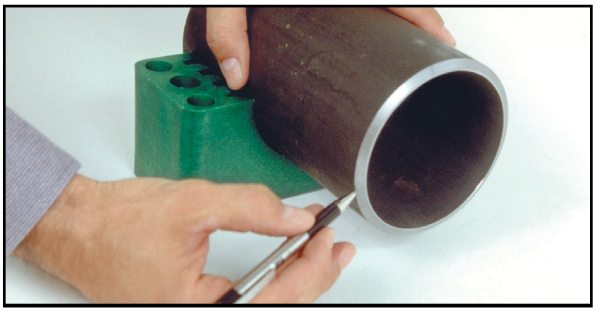
Bolting the connection together draws the flanges against the retain rings with the o-ring seal (b) captive within the connection. Adapter sizes 2 1/2" through 8" are available for use with low pressure retain ring flanges.

The standard connection styles are SAE J518 Code 61 (ISO 6162-1) and Tube-Mac® proprietary 6-Bolt and 8-Bolt flanges.

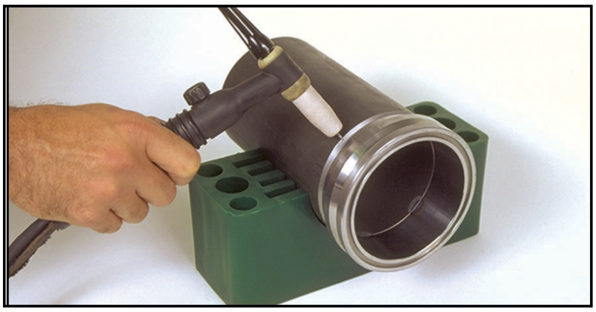
3D step models available upon request

TMI® Low Pressure Retain Ring Flange Connection Procedure

The low pressure retain ring flange connection consists of pipe, butt weld adapters with elastomer seal, retain ring flanges, retain rings, and bolting hardware.

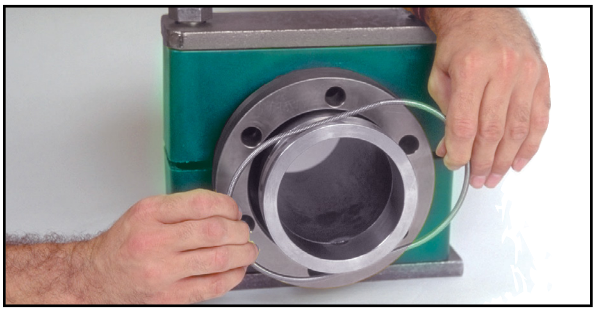


Step 1: Cut pipe end square, and bevel for butt weld.

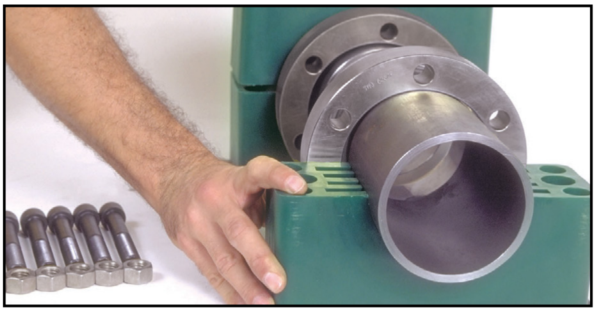


Step 2: Select the correct low pressure retain ring butt weld adapter to suit the pipe size. Weld the root pass with tig, then use #7018 welding stick for the filler and weld cap.

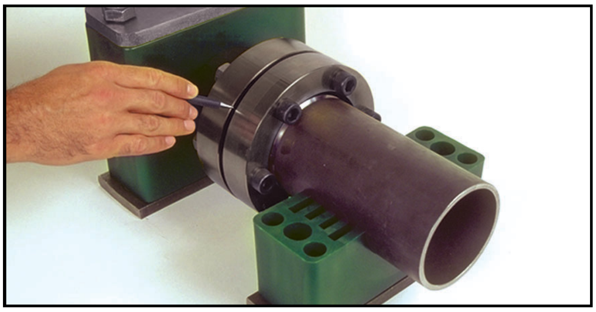
Step 3: Grind the weld on the inside of the pipe using a pencil type grinder. Clean the inside of the pipe after grinding.



Step 4: Slip flange onto the pipe. Retain ring is sprung over the pipe adapter's outside diameter nesting in the groove.



Step 5: Select the required bolting hardware.



Step 6: Tighten bolts to the torque values specified. Always tighten bolts in a cross-over sequence and ensure the flanges are parallel.

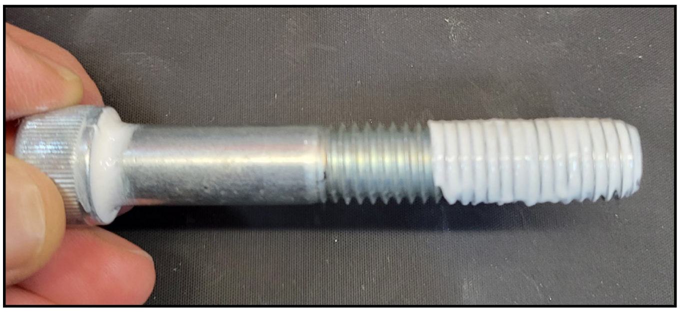
3D step models available upon request

TMI® Flange Systems

Procedure for Tightening of the bolts

Most carbon steel socket head cap screw bolts are oiled from the factory.

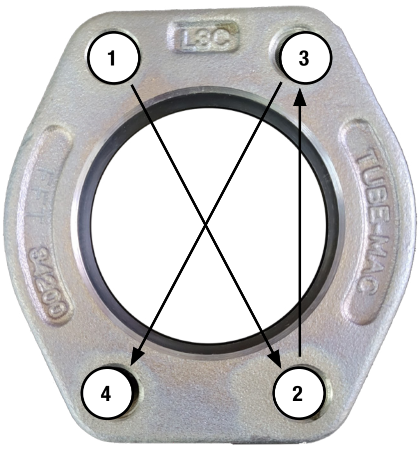
For stainless steel bolts and hot dipped galvanized bolts lubricate the threads with Never Seez Regular Grade White Lubricant or equivalent as shown.



1. Bolting to a component apply lubricant to the threads and bolt head shoulder. (Shown in the photo)
2. Bolting a union, lubricate the threads and hex nut face on the flange side. (Hex nut is not shown in the photo)

Tighten bolts in diagonal sequence 1 thru 4 in small increments to appropriate torque level.

See illustrated example below:



Tightening of the bolts should start immediately after greasing the threads and hex nuts.

Step 1: Tighten lightly with an Allen key and/or wrench.

Step 2: Tighten crosswise as shown with 30% of the recommended torque.

Step 3: Tighten crosswise as shown with 70% of the recommended torque.

Step 4: Tighten crosswise as shown with 100% of the recommended torque.

Note:
The distance between the flanges of a union or the flange and the component's mating surface must be equal around the flange. Never torque one bolt fully at a time. Torquing of the bolts must be done equally in the sequence shown.

3D step models available upon request

TMI® Flange Systems

Torque Values for Lubricated Bolts

1000 PSI (70 bar) TMI® Low Pressure						
Size	**Flange (NPS)**	**Bolt Size (UNC)**	**Torque (ft-lbs)**	**Flange (Metric)**	**Bolt Size (Metric)**	**Torque (Nm)**
1-1/2"	14-150	1/2"	80-90	M14-150	M12	22-27
2"	14-200	1/2"	80-90	14-200	M12	25-30
2-1/2"	14-250	1/2"	80-90	M14-250	M12	30-35
3"	14-300	5/8"	110-120	M14-300	M16	40-45
3-1/2"	14-350	5/8"	110-120	M14-350	M16	50-55
4"	14 and 34-400	5/8"	110-120	14 and 34-400	M16	55-60
5"	14 and 34-500	5/8"	110-120	14 and M34-500	M16	65-70
6"	16-600	5/8"	110-120	M16-600	M16	175-180
8"	18-800	3/4"	120-130	M18-80	M20	175-180
10"	18-1000	3/4"	120-130	18-1000	M20	175-180

3000 PSI (210 bar) SAE Code 61 (ISO 6162-1)						
Size	**Flange (NPS)**	**Bolt Size (UNC)**	**Torque (ft-lbs)**	**Flange (Metric)**	**Bolt Size (Metric)**	**Torque (Nm)**
1/2"	34-050	5/16"	15-18	M34-050	M8	22-27
3/4"	34-075	3/8"	20-30	M34-075	M10	25-30
1"	34-100	3/8"	20-30	M34-100	M10	30-35
1-1/4"	34-125	7/16"	40-50	M34-125	M10	40-45
1-1/2"	34-150	1/2"	55-60	M34-150	M12	50-55
2"	34-200	1/2"	80-90	M34-200	M12	55-60
2-1/2"	34-250	1/2"	80-90	M34-250	M12	65-70
3"	34-300	5/8"	110-120	M34-300	M16	175-180
3-1/2"	34-350	5/8"	110-120	M34-350	M16	175-180
4"	34-400	5/8"	110-120	M34-400	M16	175-180

6000 PSI (420 bar) SAE Code 62 (ISO 6162-2)						
Size	**Flange (NPS)**	**Bolt Size (UNC)**	**Torque (ft-lbs)**	**Flange (Metric)**	**Bolt Size (Metric)**	**Torque (Nm)**
1/2"	64-050	5/16"	16-18	M64-050	M8	22-27
3/4"	64-075	3/8"	20-30	M64-075	M10	30-35
1"	64-100	7/16"	40-50	M64-100	M12	45-50
1-1/4"	64-125	1/2"	55-60	M64-125	M12	60-65
1-1/4"(2)	-	-	-	M64-125-M14	M14	80-85
1-1/2"	64-150	5/8"	110-120	M64-150	M16	120-130
2"	64-200	3/4"	120-130	M64-200	M20	150-160

3D step models available upon request

TMI® Flange Systems

Torque Values for Lubricated Bolts

5800 PSI (400 bar) ISO 6164 and TMI® 8-Bolt						
Size	**Flange (NPS)**	**Bolt Size (UNC)**	**Torque (ft-lbs)**	**Flange (Metric)**	**Bolt Size (Metric)**	**Torque (Nm)**
1-1/2"	74-150	5/8"	110-120	M74-150	M16	120-130
2"	74-200	5/8"	110-120	M74-200	M16	120-130
2-1/2"	74-250	3/4"	120-130	M74-250	M20	155-160
3"	74-300	1"	350-400	M74-300	M24	325-330
4"	74-400	1-1/8"	500-550	M74-400	M30	520-530
4-1/2"	48-450	3/4"	190-200	48-450	M20	320-330
5"	48-500	1"	350-400	48-500	M24	370-380
6"	48-600	1-1/8"	500-550	48-600	M30	800-810
8"(1)	48-800-290BC	1-1/8"	500-550	48-800-290BC	M30	800-810
8"	48-800	1-1/2"	1100-1200	48-800	M36	1550-1620
10"	412-1000	1-1/2"	1100-1200	412-1000	M36	1550-1620

10000 PSI (690 bar) Pattern acc. to SAE Code 62 (ISO 6162-2)						
Size	**Flange (NPS)**	**Bolt Size (UNC)**	**Torque (ft-lbs)**	**Flange (Metric)**	**Bolt Size (Metric)**	**Torque (Nm)**
1/2"	104-050	5/16"	20	M104-050	M8	30
3/4"	104-075	3/8"	30	M104-075	M10	35
1"	104-100	7/16"	50	M104-100	M12	45
1-1/4"	104-125	1/2"	60	M104-125	M12	65
1-1/4"(2)	-	-	-	M104-125-M14	M14	85
1-1/2"	104-150	5/8"	120	M104-150	M16	135
2"	104-200	3/4"	130	M104-200	M20	165
2-1/2"	104-250	1"	350	M104-250	M24	330
3"	104-300	1-1/8"	500	M104-300	M30	520

Note:
Above 10000 PSI (690 bar) Flange is only available for SCHXXS NPS Duplex Pipe.
Flanges with Metric Threads available.

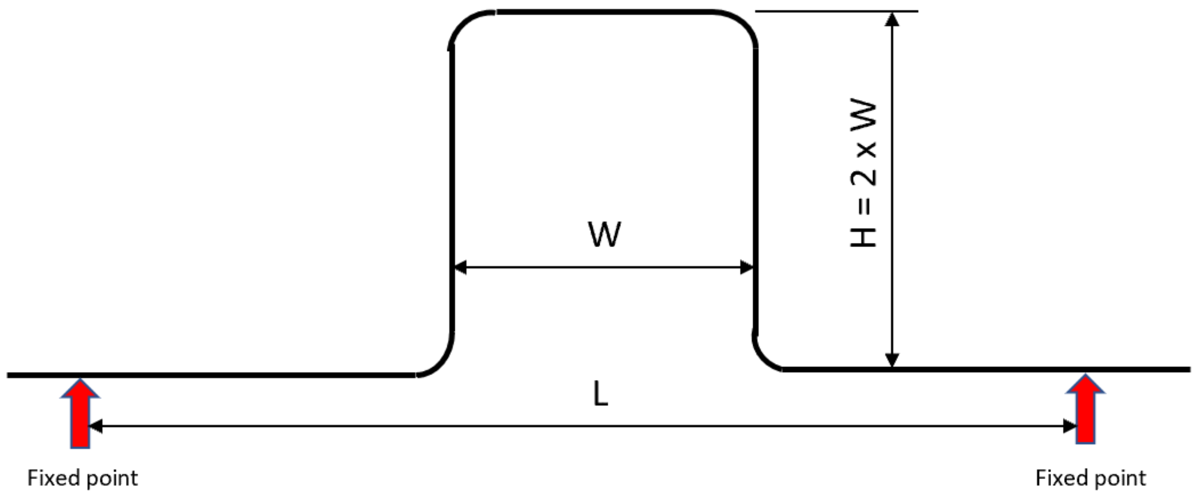
TMI® Flange Systems

Expansion Loop for High Pressure Pipes

Thermal expansion will occur between all fixed points in a piping system. The fixed points should be solid anchor points and not pipe clamps. The pipe is free to expand between the fixed points. The expansion loop, as a rule, should be located in the centre distance between the two fixed points.

The height of the expansion loop is normally twice the width. The exception happens when more than one line runs parallel in a bank of lines. Then the dimensions of the loops must be increased to allow nesting of the additional lines.

See illustration below:



Calculations

1. The formula for calculating thermal expansion:
$\Delta L = C \times L \times (T_f - T_g) \times 12$in./ ft.
Coefficient of thermal expansion (C):
Steel (C) = 6.5 x 10-6 in./ in.°F

Distance between fixed points (L) in feet.
Temperature of fluid (Tf)
Temperature of ground (Tg)

2. After calculating the expansion, find the expansion loop size from the charts for the applicable pipe or tube. Loop sizes are taken to the nearest half foot on the height and width.

Example

Find the loop size for a 4” diameter steel pipe hydraulic oil 120°F with 200 ft between fixed points and an average ground temperature of 70°F.

Given:
Steel (C) = 6.5 x 10-6 in./ in.°F
Distance (L) = 200 ft.
Temp. Diff. (ΔT)= (120°F - 70°F) = 50°F
Pipe Diam. (D) = 4”

Calculations:
$\Delta L = C \times L \times (T_f - T_g) \times 12$in./ ft.
$\Delta L = 6.5 \times 10\text{-}6 \times 200 \times (120 - 70) \times 12$
$\Delta L = 0.78$ in. (thermal expansion)

From the expansion loop chart for carbon steel on the following page B15
Nominal 4” Pipe Size
Thermal Expansion calculated at 0.78 in.
The Expansion Loop is 6 feet high x 3 feet wide.

Note: The recommendation for using an expansion loop:

- Carbon steel pipes, every 100 feet (30 meters)
- Stainless steel pipes, every 65 feet (20 meters)

3D step models available upon request

TMI® Flange Systems

Expansion Loop Sizes for Carbon Steel Pipes

Based on (ΔL) Thermal Expansion

Pipe Size (in)	ΔL (in)	Loop Size (ft)	
		H	W
3/4"	0.00 - 1.50	4	2
	1.50 - 6.00	6	3
1"	0.00 - 1.00	4	2
	1.00 - 4.14	6	3
1-1/4"	0.00 - 0.93	4	2
	0.93 - 3.33	6	3
	3.33 - 5.56	8	4
1-1/2"	0.00 - 0.88	4	2
	0.88 - 2.75	6	3
	2.75 - 4.75	8	4
2"	0.00 - 0.85	4	2
	0.85 - 2.38	6	3
	2.38 - 4.00	8	4
2-1/2"	0.00 - 0.78	4	2
	0.78 - 2.14	6	3
	2.14 - 3.71	8	4
	3.71 - 5.31	10	5
3"	0.00 - 0.72	4	2
	0.72 - 1.78	6	3
	1.78 - 3.00	8	4
	3.00 - 4.35	10	5
3-1/2"	0.00 - 0.68	4	2
	0.68 - 1.35	6	3
	1.35 - 2.70	8	4
	2.70 - 3.84	10	5
	3.84 - 5.00	12	6
4"	0.00 - 0.63	4	2
	0.63 - 1.45	6	3
	1.45 - 2.41	8	4
	2.41 - 3.45	10	5
	3.45 - 4.52	12	6
5"	0.00 - 0.42	4	2
	0.42 - 1.27	6	3
	1.27 - 2.12	8	4
	2.12 - 3.00	10	5
	3.00 - 3.96	12	6
	3.96 - 4.13	14	7

Pipe Size (in)	ΔL (in)	Loop Size (ft)	
		H	W
6"	0.00 - 0.46	4	2
	0.46 - 1.16	6	3
	1.16 - 1.87	8	4
	1.87 - 2.35	10	5
	2.35 - 3.51	12	6
	3.51 - 4.26	14	7
8"	0.00 - 0.54	4	2
	0.54 - 1.00	6	3
	1.00 - 1.64	8	4
	1.64 - 2.30	10	5
	2.30 - 2.95	12	6
	2.95 - 3.64	14	7
	3.64 - 4.35	16	8
10"	0.00 - 0.42	4	2
	0.42 - 0.91	6	3
	0.92 - 1.44	8	4
	1.44 - 2.00	10	5
	2.00 - 2.57	12	6
	2.57 - 3.16	14	7
	3.16 - 3.80	16	8
	3.80 - 4.14	18	9
12" & 14"	0.00 - 0.39	4	2
	0.39 - 0.87	6	3
	0.87 - 1.34	8	4
	1.34 - 1.88	10	5
	1.88 - 2.43	12	6
	2.43 - 3.00	14	7
	3.00 - 3.57	16	8
	3.57 - 4.14	18	9
16"	0.00 - 0.41	4	2
	0.41 - 0.85	6	3
	0.85 - 1.32	8	4
	1.32 - 1.83	10	5
	1.83 - 2.34	12	6
	2.34 - 2.86	14	7
	2.86 - 3.43	16	8
	3.43 - 4.00	18	9

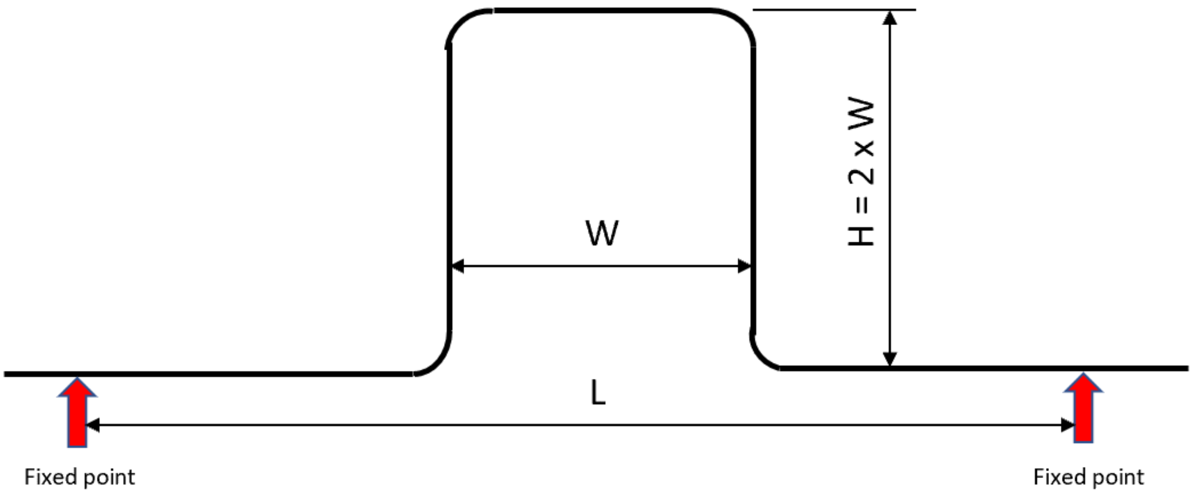
Courtesy of Thermacor 9.20.21

3D step models available upon request

TMI® Flange Systems

Guideline for Expansion Loop of High Pressure Pipes

Refer to illustration below.



The charts below are a guideline for carbon steel pipe sizes based on hydraulic oil systems with ΔT= (120°F - 70°F) = 50°F

NPS Pipe Size (Schedule)	L (ft)	H (ft)	W (ft)
2” SCH 160/XXS	100	4	2
2-1/2” SCH 80	100	4	2
2-1/2” SCH 160/XXS	100	4	2
3” SCH 80	100	4	2
3” SCH 160/XXS	100	4	2
4” SCH 80	200	6	3
4” SCH160/XXS	200	6	3
5” SCH160/XXS	200	6	3
6” SCH160/XXS	300	8	4
8” SCH160/XXS	300	8	4

Metric Pipe Size (OD x Wall)	L (m)	H (mm)	W (mm)
60 x 8.0mm	30	1200	610
66 x 8.5mm	30	1200	610
73 x 7.0mm	30	1200	610
80 x 10mm	30	1200	610
90 x 9.0mm	30	1200	610
97 x 12mm	60	1829	914
115 x 15mm	60	1829	914
130 x 15mm	60	1829	914
150 x 15mm	60	1829	914
190 x 20mm	90	2439	1219
250 x 25mm	90	2439	1219

Note: The recommendation for using an expansion loop:

- Carbon steel pipes, every 100 feet (30 meters)
- Stainless steel pipes, every 65 feet (20 meters)

Temperature and Pressure Conversion

Temperature Conversion Table

Celsius to Fahrenheit		Fahrenheit to Celsius	
°C	°F	°F	°C
150	302	340	171
145	293	330	166
140	284	320	160
135	275	310	154
130	266	300	149
125	257	290	143
120	248	280	138
115	239	270	132
110	230	260	127
105	221	250	121
100	212	240	116
95	203	230	110
90	194	220	104
85	185	210	99
80	176	200	93
75	167	190	88
70	158	180	82
65	149	170	77
60	140	160	71
55	131	150	66
50	122	140	60
45	113	130	54
40	104	120	49
35	95	110	43
30	86	100	38
25	77	90	32
20	68	80	27
15	59	70	21
10	50	60	16
5	41	50	10
0	32	40	4
-5	23	30	-1
-10	14	20	-7
-15	5	10	-12
-20	-4	0	-18
-25	-13	-10	-23
-30	-22	-20	-29
-35	-31	-30	-34
-40	-40	-40	-40
-45	-49	-50	-46
-50	-58	-60	-51

Pressure Conversion Table

bar to psi		psi to bar	
bar	psi	psi	bar
1000	14505	10000	689
800	11604	9000	620
600	8703	7000	483
500	7253	6000	414
400	5802	4000	276
250	3626	3000	207
160	2321	2500	172
100	1451	1000	69
60	870	900	62
40	580	600	41
35	508	500	34
25	363	400	28
16	232	250	17
10	145	150	10.3
6	87	100	6.9
4	58	90	6.2
2.5	36	60	4.1
1.6	23	40	2.8
1	15	25	1.7
		19	0.7

Temperature Conversion Factor

Degree Celsius (°C x 9/5) + 32 = Fahrenheit °F

Pressure Conversion Factor

bars x 14.5 = PSI

3D step models available upon request

TMI® Flange Systems

Fluid Conditioning and Cleanliness

The cleanliness of the hydraulic piping is a key factor in the overall success of any system. Approximately 75% of operational failures of a hydraulic system is related to contaminates in the system. Impurities introduced into the system by welding is the number one cause of system failures.

The cleanliness of the hydraulic fluid (oil) directly affects the reliabiity and longevity of the hydraulic system and components. Contaminants in the oil accelerates component wear and fatigue. Performance is comprised and valves can malfunction. Components with small bores can become blocked if the fluid has particles of debris within it. Clearing a blockage can be difficult, time consuming and very expensive. Therefore it is common to specify that the hydraulic fluid used in the system is cleaned to a measurable degree of cleanliness.

Types of Contaminates

There are various types of contaminates, such as;

- Particulates (dirt, sand, rust, dust, fibres, elastomer pieces and paint chips)
- Water
- Sealants (Teflon tape and pastes)
- Wear metals from pumps and valves
- Sludge, oxidation, and other corrosion particulates
- Acids and other chemicals

Sources of Contamination

Contaminants can be introduced into the hydraulic system from various sources such as:

- Fabrication and Assembly of the hydraulic piping system
- New hydraulic fluid (oil)
- Induced during routine maintenance of the system
- Externally ingested from the surrounding environment
- Internally generated from wear and tear of components

Fabrication and Assembly: During the fabrication and assembly of the hydraulic piping contamination may be introduced into the system such as:

- Dust and dirt from storage and handling
- Burrs, chips and weld splatter –
- Fibres from rags
- Sandblasting residue
- Paint chips or overspray
- Pipe sealants and tape from assembly
- Other lubricants such as Never Seez used when torquing up the bolts during assembly

Welded pipe joints or flanges is not recommended by Tube-Mac. Only a non-welded piping solution should be used for hydraulic piping systems along with cold drawn, seamless, carbon steel pipe, phosphate and oiled inside and outside. Stainless Steel pipe is recommended for corrosive environments. Deburr all sharp edges of the cut pipe ends prior to flaring or grooving the pipe. To protect contaminates from entering the pipe, caps or plugs on the end of each pipe or heat shrink bags over the flanged ends of each pipe is recommended. These are to be removed just prior to installation. Tube-Mac's Installation and Hydraulic Oil Flushing Procedures will aid in the elimination of these contaminants.

TMI® Flange Systems

Fluid Conditioning and Cleanliness

New Hydraulic Fluid: new hydraulic fluid (referred herein as “oil”) supplied from a tote or drum may not be necessarily clean. Typically, new oils have a cleanliness level of approximately ISO 23/21/18.

Before the oil is extracted, an oil sample from each supplied tote or drum must be taken for analysis to establish the cleanliness of the supplied oil.

Flushing New Systems: Whenever a new hydraulic piping system is installed, or a repair/modification is performed, the system must be flushed with oil prior to start-up. Tube-Mac recommends the “system oil” be used for flushing a Tube-Mac non-welded piping system and upon completion the “system oil” remains in the piping for the operation of the equipment.

ISO 4406 Cleanliness Code

ISO Code Number	No. of Particles per ml	
	More Than	Up to and Including
24	80 000	160 000
23	40 000	80 000
22	20 000	40 000
21	10 000	20 000
20	5 000	10 000
19	2 500	5 000
18	1 300	2 500
17	640	1 300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64

The use of Tube-Mac’s **Pressure Testing and Oil Flushing Unit** along with a Tube-Mac fully trained Flushing Technician is highly recommended. Prior to filling the pipes, the hoses are disconnected at the major equipment such as hydraulic motors, cylinders, valve stands and power units. They are then temporarily looped together at each end. Then the oil can be transferred from the tote or drum to fill the reservoir and pipes using the Oil Flushing Unit with filtration. The system is then pressurized to 1.5 times normal operating pressure and checked for any leaks. Once confirmed, the oil is then circulated throughout the system for several hours taking oil samples at various intervals for analysis until the desire cleanliness level is reached.

Upon completion the hoses are reconnected to all major equipment and the system is ready for commissioning.

The cleanliness level is predetermined by the system designer or OEM to maximize component life. Many OEMs have established guidelines on the allowable contamination levels at start-up that range from 20 – 1000 particles/milliliter.

The two most common cleanliness measuring standards in the oil & gas, and process industries are The ISO 4406, and The NAS 1638 cleanliness standards. The ISO Cleanliness Code, ISO 4406:2021 is perhaps the most widely used international standard for representing the particle contamination level of industrial fluid power systems. The contamination code consists of three (3) numbers. The first number represents the number of particles per milliliter that are 4 micrometres or larger. The second number 6 micrometres or larger and the third number 14 micrometres or larger.

For example, 18/16/13. Using the ISO particle count table above, an oil with a cleanliness rating of 18/16/13 would mean that it contained:

1300 - 2500 particles greater than 4 micron in size

320 - 640 particles greater than 6 micron in size, and

40 - 80 particles greater than 14 microns in size.

3D step models available upon request

TMI® Flange Systems

Fluid Conditioning and Cleanliness

NAS 1638 Cleanliness Code

Class	Maximum No. of Particles / 100 ml				
	5 - 15	15 - 25	25 - 50	50 - 100	> 100
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1 000	178	32	6	1
3	2 000	356	63	11	2
4	4 000	712	126	22	4
5	8 000	1 425	253	45	8
6	16 000	2 850	506	90	16
7	32 000	5 700	1 012	180	32
8	64 000	11 400	2 025	360	64
9	128 000	22 800	4 050	720	128
10	256 000	45 600	8 100	1 440	256
11	512 000	91 200	16 200	2 880	512
12	102 400	182 400	32 400	5 760	1 024

The **NAS 1638 Cleanliness Standard** was originally developed for aerospace components in the US but is still widely used for industrial fluid power applications. NAS 1638 is comprised of fluid cleanliness classes, each class defined in terms of maximum allowed particle counts per 100ml for designated particle size ranges.

In **NAS 1638** classification the code number refers to a maximum quantity of particles within a specific size class. Most users use a single code number based on the highest particle count in any of the size ranges.

See the NAS 1638 Cleanliness Code chart for the various cleanliness levels.

Converting Oil Cleanliness Standards - ISO to NAS

In many situations, there is a requirement to be able to compare these cleanliness classification codes. The chart below provides a good comparison between the NAS and ISO cleanliness codes as related to particle count data.

Example: ISO 18/16/13 is equivalent to NAS 7.

Since 2001, however, the official Aerospace Standard used to measure the degree of fluid cleanliness is SAE AS4059. As such, the NAS 1638 standard is now considered obsolete; however, it is still widely used.

SAE AS4059, which supplied the old standard, is considered more accurate.

In fact, the quality of the new standard has made it widely accepted by companies in the sector, especially on the European continent. Additional information on understanding how SAE AS4059 works can be found at www.sae.org/standards/content/as4059/.

Cleanliness Code Comparisons

ISO Code	NAS Class
23/21/18	12
22/20/18	-
22/20/17	11
22/20/16	-
21/19/16	10
19/17/14	8
18/16/13	7
17/15/12	6
16/14/12	-
16/14/11	5
15/13/10	4
14/12/09	3
13/11/08	2
12/10/08	-
12/10/07	1
12/10/06	-

ISO Certification of Registration

CERTIFICATE
OF REGISTRATION

This is to certify that

Tube-Mac® Piping Technologies Ltd.

853 Arvin Avenue, Stoney Creek, Ontario L8E 5N8 Canada

operates a

Quality Management System

which complies with the requirements of

ISO 9001:2015

for the following scope of certification

Manufacturer and Supplier of Non-Welded Piping Systems and Components.

Tube-Mac® Piping Technologies Ltd. operates a Quality Management System compliant to ISO 9001:2015 and certified by SAI GLOBAL an ANAB* Accredited Management Certification Company.

*(ANAB) The ANSI National Accreditation Board

Offshore and Marine Type Approvals

IACS Members

ABS	American Bureau of Shipping
LR	Lloyds Register
DNV	Det Norske Veritas
CCS	China Classification Society
RMRS	Russian Maritime Register of Shipping

3D step models available upon request

Notes