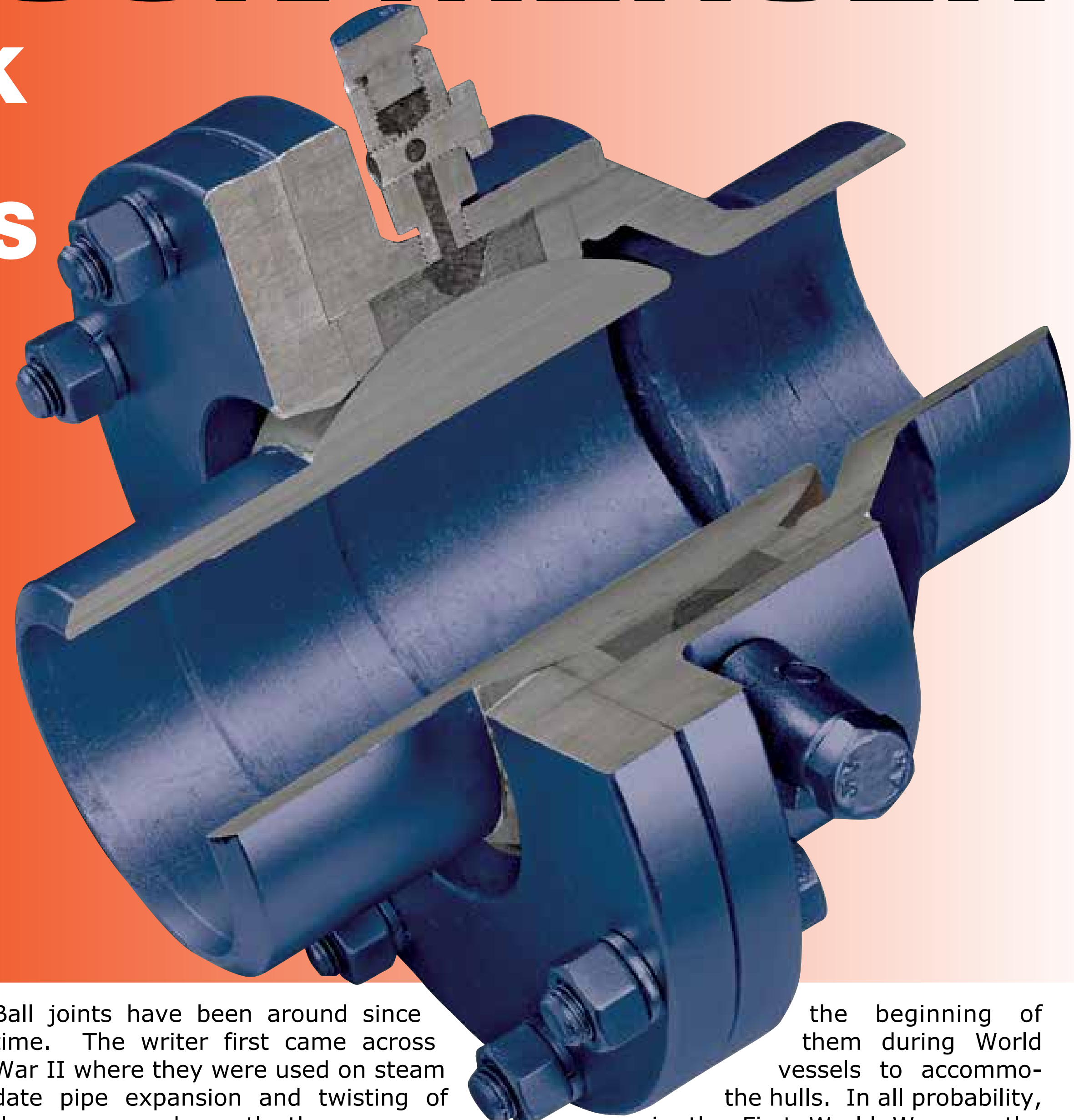
MASON-MERCER

STOCK BALL JOINTS



Ball joints have been around since the beginning of time. The writer first came across them during World War II where they were used on steam vessels to accommodate pipe expansion and twisting of the hulls. In all probability, they were used exactly the same way in the First World War, as the Liberty Ships of World War II were copies of the same vessels.

All in all, that is about a 100 year history with little difference in design except for the use of better grade materials and improved seals. While thin walled material like Stainless Steel hoses or the many variations of Stainless Steel expansion joints have very high safety factors, there is comfort in knowing you are using a zero thrust product where no component has a thickness less than the piping itself. One of our overseas reps, in a country where sabotage was common, commented "They are quite resistant to rifle fire as well."

We were first exposed to the need for ball joints where thermal expansion design centered around the use of high pressure steam for heating. There is one huge steam generating station in lower New York that continues to supply steam for heating in New York City. Any building owner that purchases this high pressure supply steam must engineer all their high pressure inlet piping to Con Edison's (the steam supplier's) satisfaction. The use of ball joints to handle thermal movement is a necessity as space is tight and leaves no room for pipe loops or offsets.

We not only sell our ball joints, but we engineer the systems as well, should there be no specifications or if specifications call for design by vendor.

We look forward to working with you.

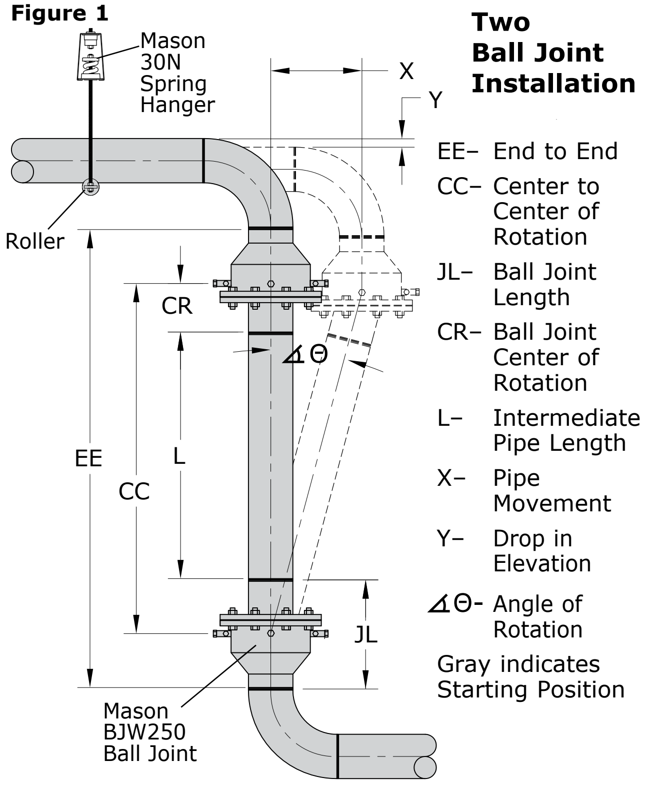
N. Mason

Bulletin BJ-35

TWO BALL JOINTS

When ball joints are installed at each end of a pipe offset (Fig. 1), the system can accommodate much larger movements with much lower anchorage requirements than solid pipe in the same configuration.

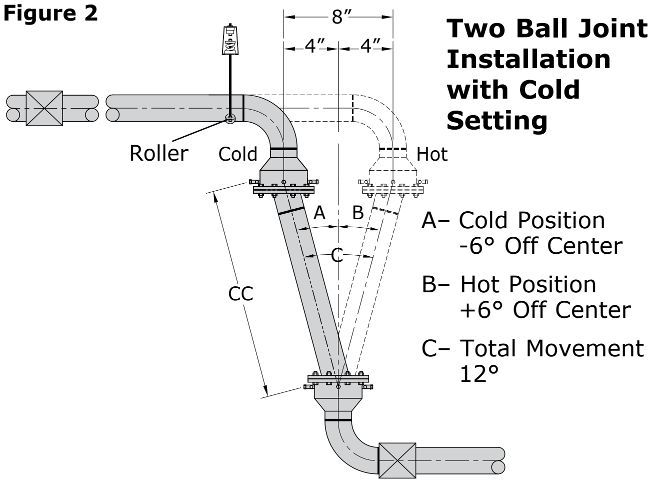
Figure 1



COLD SETTING

One way to increase allowable motion is to start out with the assembly pre-set all the way to the position when the pipe is cold (Fig. 2). Assuming the total expansion from Cold (Ambient Temperature) to Hot is 8 inches, you could set the pipe line 4 inches off center and design for a 4″ rather than an 8″ movement leg. The piping is preset 6° off center to 6° past center. Maximum rated movement is 7.5° off center, so 6° provides a safety factor.

Figure 2

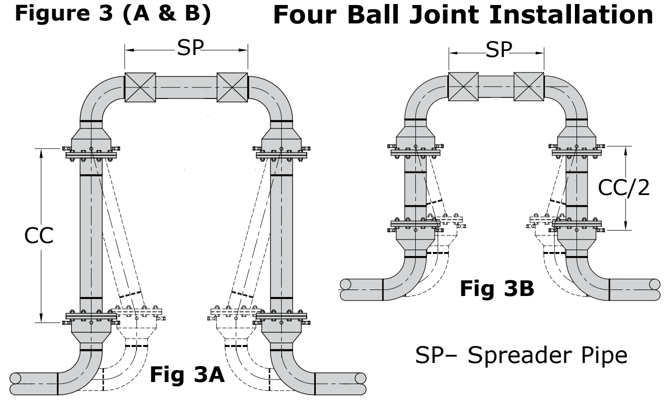


While the method is perfectly valid, steamfitters are accustomed to working "Plumb" and the "Cold Set" instruction can be missed. The method is excellent but supervision becomes essential and the designer must decide whether to take the risk.

FOUR BALL JOINTS

In many cases any offset is undesirable, so four ball joints are used in a loop (Fig. 3A). Using the same dimension "CC" in both legs, you can accommodate twice the motion. Reducing the centers 50% would accommodate the same two joint motion (Fig. 1) with smaller offset and conserve space as well (Fig. 3B).

Figure 3 (A & B)



DROP IN ELEVATION "Y"

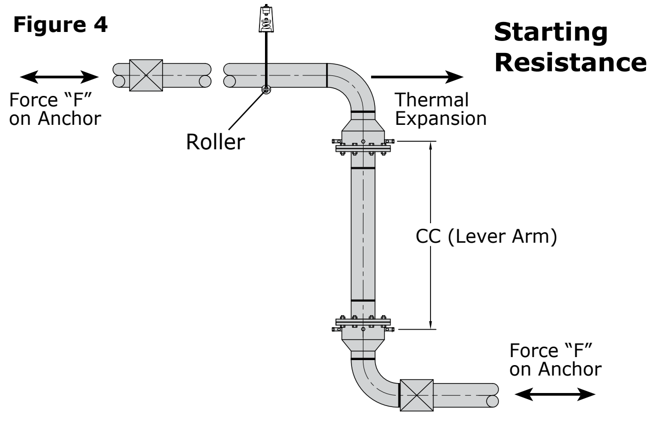
Ball joint movement reduces distance between parallel piping as shown by "Y" (Figure 1). This dimension is significant because if the offset is vertical, the adjacent pipe support could pull out. Therefore a Mason 30N spring hanger with a minimum deflection of 4 times "Y" should be installed at the first support and the second and third locations studied.

STARTING RESISTANCE

Ball joints do not generate any pressure thrust. However, there is an initial force required to start motion that controls anchorage.

The force "F" applied to the pipe anchors is directly related to the distance between Ball Joint Centers "CC". (Figure 4). Force "F" diminishes with longer lever arms needed for larger movements. Four joint loops have shorter levers for the same movement, so forces increase (Table 4).

Figure 4



USING SELECTION TABLES

The following tables provide rounded values for easy selection. For the sake of simplicity, Ball Joint Centers "CC" are in 6″ increments in Table 1 and 3″ in Table 2. If space is tight, interpolate between columns. Calculations based on Table 5 may save even more space.

The next page provides examples of how to use the tables with the installations previously discussed.

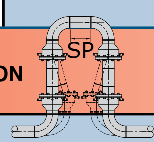
TABLE 1 "CC", "L", and "Y" DIMENSIONS for TWO JOINT INSTALLATION WITHOUT COLD SETTING See Figure 1

Pipe Size (inches)	Up to 4"	5"	6"	7"	8"	9"	10"	11"	12"	CR Ball Joint Center of Rotation (inches)	JL Ball Joint Length (inches)
	Pipe Movement "X"										
	Ball Joint Centers "CC" (inches)										
2	24	30	36	42	48	54	60	66	72		
2 1/2-14	48	60	72	84	96	108	120	132	144		
Size	Intermittent Pipe Length "L" (inches)										
2	16	22	28	34	40	46	52	58	64	4	7
2 1/2	40	52	64	76	88	100	112	124	136	4 1/8	7 7/8
3	39	51	63	75	87	99	111	123	135	4 3/8	8 1/2
4	38	50	62	74	86	98	110	122	134	5	10 1/2
5	38	50	62	74	86	98	110	122	134	5 1/8	10 5/8
6	37	49	61	73	85	97	109	121	133	5 5/8	11 7/8
8	34	46	58	70	82	94	106	118	130	7	14 3/8
10	33	45	57	69	81	93	105	117	129	7 5/8	16
12	29	41	53	65	77	89	101	113	125	9 1/2	18 1/8
14	27	39	51	63	75	87	99	111	123	10 1/2	19 1/4
Size	Drop in Elevation "Y" (inches)										
2	.34	.42	.50	.59	.67	.76	.84	.92	1.01		
2 1/2-14	.17	.21	.25	.29	.33	.38	.42	.46	.50		

TABLE 2 "CC", "L", and "Y" DIMENSIONS for TWO JOINT INSTALLATION WITH COLD SETTING See Figure 2

Pipe Size (inches)	Up to 4"	5"	6"	7"	8"	9"	10"	11"	12"	CR Ball Joint Center of Rotation (inches)	JL Ball Joint Length (inches)
	Pipe Movement "X"										
	Ball Joint Centers "CC" (inches)										
2	12	15	18	21	24	27	30	33	36		
2 1/2-14	24	30	36	42	48	54	60	66	72		
Size	Intermittent Pipe Length "L" (inches)										
2	4	7	10	13	16	19	22	25	28	4	7
2 1/2	16	22	28	34	40	46	52	58	64	4 1/8	7 7/8
3	15	21	27	33	39	45	51	57	63	4 3/8	8 1/2
4	14	20	26	32	38	44	50	56	62	5	10 1/2
5	14	20	26	32	38	44	50	56	62	5 1/8	10 5/8
6	13	19	25	31	37	43	49	55	61	5 5/8	11 7/8
8	10	16	22	28	34	40	46	52	58	7	14 3/8
10	9	15	21	27	33	39	45	51	57	7 5/8	16
12	5	11	17	23	29	35	41	47	53	9 1/2	18 1/8
14	3	9	15	21	27	33	39	45	51	10 1/2	19 1/4
Size	Drop in Elevation "Y" (inches)										
2	.17	.21	.25	.29	.34	.38	.42	.46	.50		
2 1/2-14	.08	.10	.13	.15	.17	.19	.21	.23	.25		

TABLE 3 MINIMUM SPREADER PIPE "SP" BETWEEN ELBOWS for FOUR JOINT INSTALLATION TO AVOID JOINT CLASHING See Figure 3



Pipe Size (inches)	Up to 4"	5"	6"	7"	8"	9"	10"	11"	12"
	Pipe Movement "X"								
	Spreader Pipe "SP" between Elbows (inches)								
2	18	21	24	27	30	30	30	33	36
2 1/2	18	21	24	27	30	30	30	33	36
3	18	21	24	27	30	30	30	33	36
4	24	24	24	27	30	30	30	33	36
5	24	24	24	27	30	30	30	33	36
6	18	21	24	27	30	30	30	33	36
8	18	21	24	27	30	30	30	33	36
10	18	21	24	27	24	27	30	33	36
12	18	21	24	27	24	27	30	33	36
14	12	15	18	21	24	24	24	27	30

TABLE 4 STARTING RESISTANCE AT 250psi See Figure 4

Pipe Size (in)	Torque "T" (ft-lbs)	Up to 4"	**Up to 4"**	6"	**6"**	8"	**8"**	10"	**10"**	12"	**12"**
		Pipe Movement "X"									
		Force "F"* (lbs) on Anchors Without & **With Cold Setting**									
2	200	200	**400**	133	**267**	100	**200**	80	**160**	67	**133**
2 1/2	230	115	**230**	77	**153**	58	**115**	46	**92**	38	**77**
3	320	160	**320**	107	**213**	80	**160**	64	**128**	53	**107**
4	600	300	**600**	200	**400**	150	**300**	120	**240**	100	**200**
5	1000	500	**1000**	333	**667**	250	**500**	200	**400**	167	**333**
6	2000	1000	**2000**	667	**1333**	500	**1000**	400	**800**	333	**667**
8	3300	1650	**3300**	1100	**2200**	825	**1650**	660	**1320**	550	**1100**
10	6000	3000	**6000**	2000	**4000**	1500	**3000**	1200	**2400**	1000	**2000**
12	7500	3750	**7500**	2500	**5000**	1875	**3750**	1500	**3000**	1250	**2500**
14	11000	5500	**11000**	3667	**7333**	2750	**5500**	2200	**4400**	1833	**3667**

TABLE 5 BALL JOINT ANGULAR MOVEMENT

Pipe Size (inches)	Maximum Angle	Θ Recommended Angle with 20% Safety Factor
2	30°	24°
21/2 - 14	15°	12°

In all engineered systems, a safety factor is important.

Two Ball Joint Installation without Cold Setting

To size an 8" two ball joint offset for 6" movement at 250 psi, use Table 1. The recommended Center to Center "CC" is 72", the Intermediate Pipe Length "L" is 58" and the Drop in Elevation "Y" is 0.25". Table 4 shows the Force "F" on Anchor as 1100 lbs. A stainless expansion joint thrust is 12,000 lbs., 11 times the required anchorage for the ball joints.

Two Ball Joint Installation with Cold Setting

To size an 8" two ball joint offset for 6" movement at 250 psi with cold set, use Table 2. The recommended Center to Center "CC" is 36", the Intermediate Pipe Length "L" is 22" and the Drop in Elevation "Y" is 0.13". Table 4 shows the Force "F" on Anchor as 2200 lbs. This force is still much lower than the stainless expansion joint thrust of 12,000 lbs., which is 5.5 times the required anchorage for the ball joints.

Four Ball Joint Installation without Cold Setting

To size an 8" four ball joint loop for 6" movement, divide the 6" movement by two, as there are two 3" movement legs. Using Table 1, 4" column, "CC" is 48", "L" is 34" and "Y" is 0.17". To size the spreader pipe "SP" so the two legs of the loop do not clash, use Table 3 for a Minimum Spreader Length "SP" of 24".

"Cold Set" designs are the same as above, using Table 2.

FRICTION FORCES

Pipe Friction is usually taken as 30% of the pipe weight between anchors. Add this force to Table 4 or calculated numbers as an additional force on anchors.

CALCULATIONS

For engineers who prefer to do their own calcs. Refer to Figure 1 for definitions of "CC", "L", "CR", "EE", "JL" and "Y"; Table 4 for "F" and "T"; and Table 5 for "Θ".

Two Ball Joint Installation without Cold Setting

Example: 10" steam line, thermal expansion 7".

CC = X / [Sin (Θ/2)] = 7" / [Sin (12°/2)] = 67"

L = CC - (2 x CR) = 67" - (2 x 7.625") = 51.75"

EE = L + (2 x JL) = 51.75" + (2 x 16") = 83.75"

$Y = CC - (CC^2 - X^2)^{1/2} = 67'' - (67^2 - 7^2)^{1/2} = 0.37''$

For 0.37" movement, we recommend a spring hanger with a deflection 4 times "Y" or 1.48", i.e. Mason 1.5" deflection 30N hanger.

F = 2T / CC = 2 x 6000 ft-lbs / 5.58 ft = 2151 lbs.

Two Ball Joint Installation with Cold Setting

Example: 10" steam line, thermal expansion 9".

CC = [X/2] / [Sin(Θ/2)] = [9"/2] / [Sin (12°/2)] = 43"

L = CC - (2 x CR) = 43" - (2 x 7.625") = 27.75"

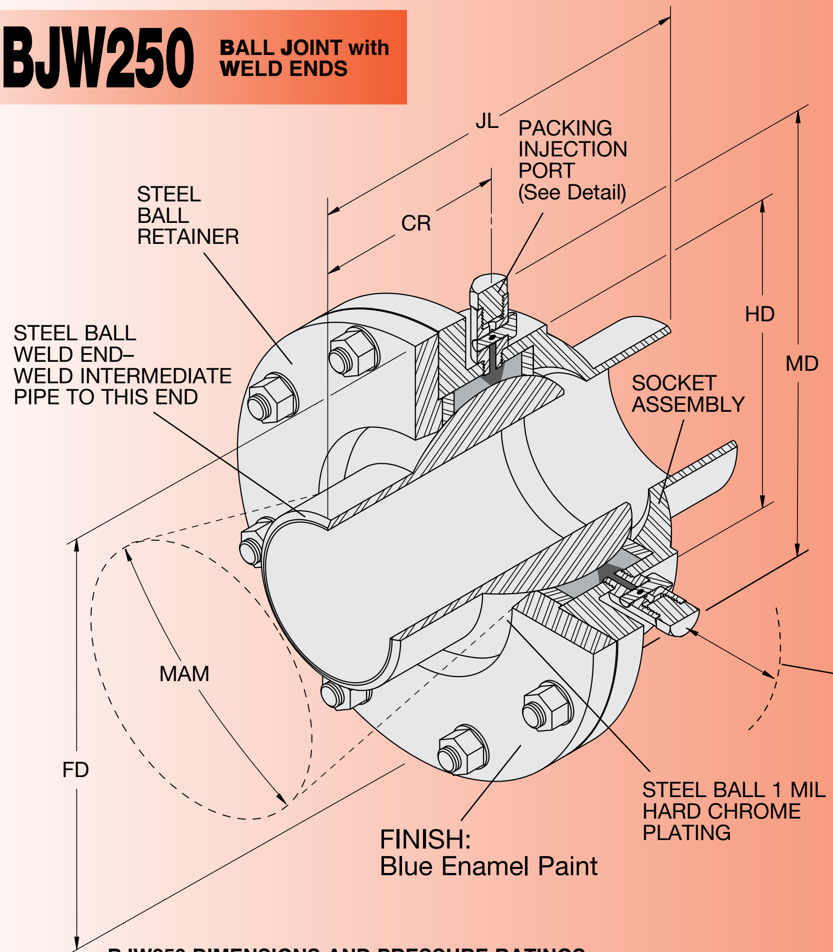
EE = L + (2 x JL) = 27.75" + (2 x 16") = 59.75"

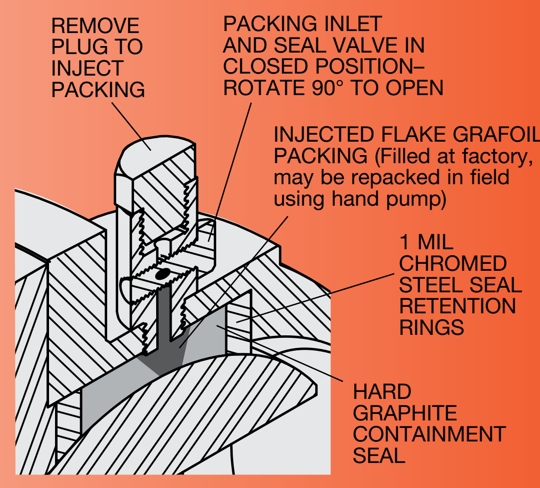
$Y = CC - (CC^2 - (X/2)^2)^{1/2} = 43'' - (43^2 - (9/2)^2)^{1/2} = 0.24''$

For 0.24" movement, we recommend a spring hanger with a deflection 4 times "Y" or 0.96", i.e. Mason 1" deflection 30N hanger.

F = 2T / CC = 2 x 6000 ft-lbs/ 3.58 ft = 3352 lbs.

BJW250 BALL JOINT with WELD ENDS





SEAL AND PACKING DETAIL

Maintain 4" minimum clearance around MD to allow for repacking. Packing can be injected under full line pressure when required. Packing to be Flake Grafoil.

BJW250 DIMENSIONS AND PRESSURE RATINGS

Type & Size	Pipe Size (inches)	JL Joint Length (inches)	CR Center of Rotation (inches)	FD Flange Diameter (inches)	HD Hub Diameter (inches)	MD Max. Diameter (inches)	MAM Max. Angular Movement (degrees)	Maximum Pressure @480°F (psi)	Starting Resistance Torque (ft-lbs)	Number of Ports	Ship Weight (lbs)
BJW250-2	2	7	4	–	5 1/4	9 1/2	30	250	200	2	16
BJW250-2 1/2	2 1/2	7 7/8	4 1/8	–	6	10 1/4	15	250	230	2	23
BJW250-3	3	8 1/2	4 3/8	–	6 1/2	10 3/4	15	250	320	2	26
BJW250-4	4	10 1/2	5	10 7/8	7 7/8	12 1/8	15	250	600	4	72
BJW250-5	5	10 5/8	5 1/8	12	9	13 1/4	15	250	1000	4	80
BJW250-6	6	11 7/8	5 5/8	13 1/4	10 1/2	14 3/4	15	250	2000	5	113
BJW250-8	8	14 3/8	7	16	13	17 1/4	15	250	3300	6	189
BJW250-10	10	16	7 5/8	19 3/8	16	20 1/4	15	250	6000	7	280
BJW250-12	12	18 1/8	9 1/2	22	18 1/2	22 3/4	15	250	7500	8	361
BJW250-14	14	19 1/4	10 1/2	23 5/8	20	24 1/4	15	250	11000	9	443

BALL JOINT SPECIFICATION:

Steel Ball Joints shall have weld ends or fixed and floating flanges. The thrust free, ball and socket arrangement shall allow 360° of intermittent rotation and a minimum rocking motion of ± 7.5 degrees. Seals are guaranteed by the high pressure injection of graphite packing in a cavity between reinforced hard graphite and steel rings.

The ball and steel seal retention rings shall be plated with a minimum 1 mil thickness of crack free hard chrome. The socket must incorporate an adequate number of packing cylinders for uniform distribution of the graphite seal. All cylinders must incorporate a valve to prevent blowback should pumping additional sealing material become necessary while under full line pressure.

Minimum ratings are 250 psi (17 Bar) @ 480°F (250°C).

Certifications must include:

1. Either manufacturer's published information or calculations by a P.E. to verify length of spool pieces and the distance between centers of ball joints for the motion with a reasonable safety factor.

2. The friction force at the start of motion to be resisted by the anchors.

Should the consulting firm prefer to indicate location of anchors and ball joints as preliminary and leave final selections to job site conditions, the manufacturer must have a P.E. on staff with a minimum of 5 years piping design experience to submit final details to allow motion as well as the force on the anchors to overcome starting friction.

*Ball Joints shall be weld end **BJW** or Flanged **BJF** as manufactured by Mason Industries, Inc.*

MASON – MERCER
350 Rabro Drive, Hauppauge, NY 11788 • FAX 631/348-0279
MASON– 631/348-0282 • Email info@Mason-Ind.com • Website www.Mason-Ind.com
MERCER– 631/582-1524 • Email info@Mercer-Rubber.com • Website www.Mercer-Rubber.com

Wu1301
01/13