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Mechanic
Job Performance Test

STATION 1

Identify Symbols

Instructions:

Identify the components and other information given by the symbol.

Test Schematic

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Mobile Hydraulic Mechanic Job Performance Test

STATION 2

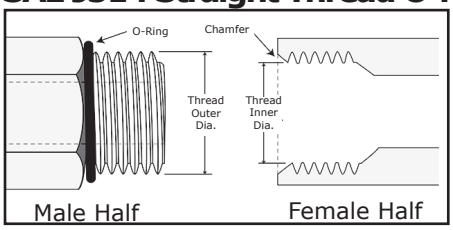
Identify Fasteners & Fittings

Instructions:
Choose the most correct answer for each fastener from the choices provided.

Identify the fittings provided. Look at each fitting and then select the correct answer on the multiple choice test.

American Connections

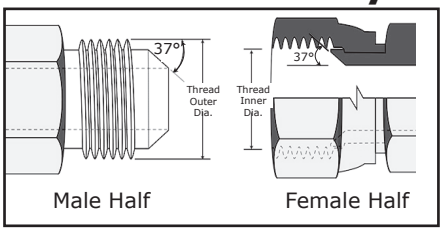
SAE J514 Straight Thread O-ring Boss (ORB)



This port connection is recommended by the NFPA for optimum leakage control in medium and high-pressure hydraulic systems. The male connector has a straight thread and an O-ring. The female port has a straight thread, a machined surface (minimum spotface) and a chamfer to accept the O-ring. The seal takes place by compressing the O-ring into the chamfer. The threads hold the connection mechanically.

Inch Size	Dash Size	Nominal Thread Size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
1/8	02	5/16 - 24	5/16	0.31	9/32	0.27
3/16	03	3/8 - 24	3/8	0.38	11/32	0.34
1/4	04	7/16 - 20	7/16	0.44	13/32	0.39
5/16	05	1/2 - 20	1/2	0.50	15/32	0.45
3/8	06	9/16 - 18	9/16	0.56	17/32	0.51
1/2	08	3/4 - 16	3/4	0.75	11/16	0.69
5/8	10	7/8 - 14	7/8	0.88	13/16	0.81
3/4	12	1 1/16 - 12	1 1/16	1.06	1	0.98
1	16	1 5/16 - 12	1 5/16	1.31	1 1/4	1.23
1 1/4	20	1 5/8 - 12	1 5/8	1.63	1 9/16	1.54
1 1/2	24	1 7/8 - 12	1 7/8	1.88	1 13/16	1.79
2	32	2 1/2 - 12	2 1/2	2.50	2 7/16	2.42

SAE J514 37°* Hydraulic

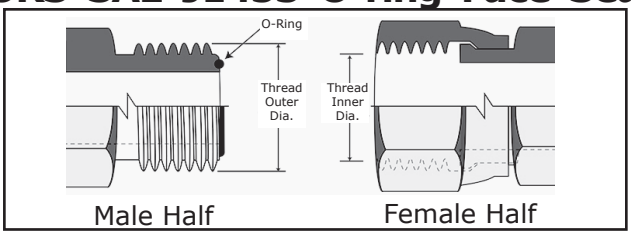


This connection is very common in fluid power systems. Both the male and female halves of the connections have 37° seats. The seal takes place by establishing a line contact between the male flare and the female cone seat. The threads hold the connection mechanically. **Caution**: In the –02, -03, -04, -05, -08 and –10 sizes, the threads of the SAE 45° flare and the SAE 37° flare are the same. However, the sealing surface angles are not the same.

Inch Size	Dash Size	Nominal Thread Size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
1/8	02	5/16 - 24	5/16	0.31	9/32	0.27
3/16	03	3/8 - 24	3/8	0.38	11/32	0.34
1/4	04	7/16 - 20	7/16	0.44	13/32	0.39
5/16	05	1/2 - 20	1/2	0.50	15/32	0.45
3/8	06	9/16 - 18	9/16	0.56	17/32	0.51
1/2	08	3/4 - 16	3/4-	0.75	11/16	0.69
5/8	10	7/8 - 14	7/8	0.88	13/16	0.81
3/4	12	1 1/16 - 12	1 1/16	1.06	1	0.98
1	16	1 5/16 - 12	1 5/16	1.31	1 1/4	1.23
1 1/4	20	1 5/8 - 12	1 5/8	1.63	1 9/16	1.54
1 1/2	24	1 7/8 - 12	1 7/8	1.88	1 13/16	1.79
2	32	2 1/2 - 12	2 1/2	2.50	2 7/16	2.42

*This connection was formerly known as JIC.

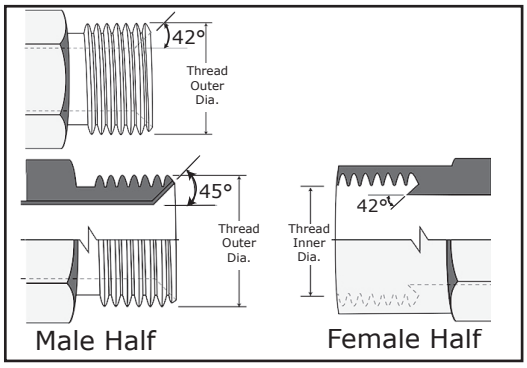
ORS SAE J1453 O-ring Face Seal



This connection offers the very best leakage control available today. The male connector has a straight thread and an O-ring in the face. The female has a straight thread and a machined flat face. The seal takes place by compressing the O-ring onto the flat face of the female, similar to the split flange type fitting. The threads hold the connection mechanically.

Inch size	Dash size	Nominal Thread size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
1/4	04	9/16 - 18	9/16	0.56	17/32	0.51
3/8	06	11/16 - 16	11/16	0.69	5/8	0.63
1/2	08	13/16 - 16	13/16	0.82	3/4	0.75
5/8	10	1 - 14	1	1.00	1 5/16	0.93
3/4	12	1 3/16 - 12	1 13/16	1.19	1 1/8	1.11
1	16	1 7/16 - 12	1 7/16	1.44	1 3/8	1.36
1 1/4	20	1 11/16 - 12	1 11/16	1.69	1 5/8	1.61
1 1/2	24	2 - 12	2	2.00	1 15/16	1.92

SAE J512 Inverted



This connection is frequently used in automotive systems. The male connector can either be a 45° flare in the tube fitting form or a 42° seat in the machined adapter form. The female has a straight thread with a 42° inverted flare. The seal takes place on the flared surfaces. The threads hold the connection mechanically.

Inch Size	Dash Size	Nominal Thread Size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
1/8	02	5/16 - 28	5/16	0.32	9/32	0.28
3/16	03	3/8 - 24	3/8	0.38	11/32	0.34
1/4	04	7/16 - 24	7/16	0.44	13/32	0.40
5/16	05	1/2 - 20	1/2	0.50	15/32	0.45
3/8	06	5/8 - 18	5/8	0.63	9/16	0.57
7/16	07	1 1/16 - 18	11/16	0.69	5/8	0.63
1/2	08	3/4 - 18	3/4	0.75	23/32	0.70
5/8	10	7/8 - 18	7/8	0.88	13/16	0.82
3/4	12	1 1/16 - 16	1 1/16	1.06	1	1.00

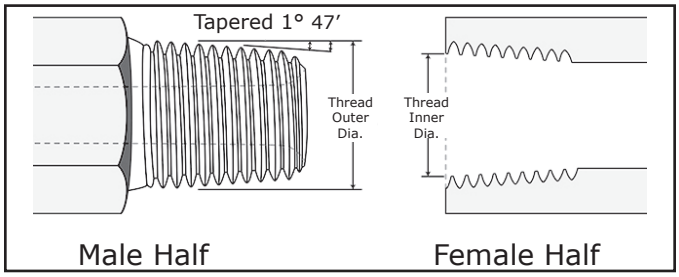
How to Measure Non-threaded Connections

Four Bolt Flange — First measure the port hole diameter using the caliper. Next, measure the longest bolt hole spacing from center-to-center or measure the flange head diameter.

Staplok® — Measure the male diameter with the OD portion of the caliper. Measure the female half by inserting the ID portion of the caliper into the through hole.

American Connections

NPTF (National Pipe Tapered Fuel)

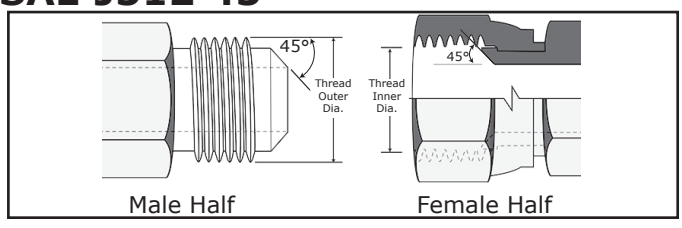


This connection is still widely used in fluid power systems, even though it is not recommended by the National Fluid Power Association (N.F.P.A.) for use in hydraulic applications. The thread is tapered and the seal takes place by deformation of the threads.

NPTF Threads Measure the thread diameter and subtract 1/4-inch to find the nominal pipe size.

Inch Size	Dash Size	Nominal Thread Size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
⅛	02	1/8 - 27	13/32	0.41	3/8	0.38
¼	04	¼ - 18	17/32	0.54	½	0.49
⅜	06	⅜ - 18	11/16	0.68	5/8	0.63
½	08	½ - 14	27/32	0.84	25/32	0.77
¾	12	¾ - 14	1 1/16	1.05	1	0.98
1	16	1 - 11½	1 5/16	1.32	1 1/4	1.24
1¼	20	1¼ - 11½	1 21/32	1.66	1 19/32	1.58
1½	24	1½ - 11½	1 29/32	1.90	1 13/16	1.82
2	32	2 - 11½	2 3/8	2.38	2 5/16	2.30

SAE J512 45°



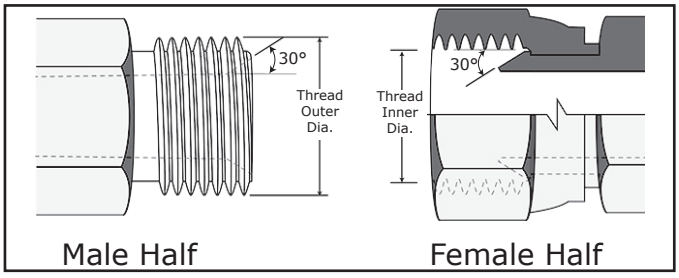
This connection is commonly used in refrigeration, automotive and truck piping systems. The connector is frequently made of brass. Both the male and female connectors have 45° seats. The seal takes place between the male flare and the female cone seat. The threads hold the connection mechanically.

Inch Size	Dash Size	Nominal Thread Size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
⅛	02	5/16 - 24	5/16	0.31	9/32	0.27
3/16	03	⅜ - 24	⅜	0.38	11/32	0.34
¼	04	7/16 - 20	7/16	0.44	13/32	0.39
5/16	05	½ - 20	½	0.50	15/32	0.45
⅜	06	5/8 - 18	5/8	0.63	9/16	0.57
½	08	¾ - 16	¾	0.75	11/16	0.69
5/8	10	7/8 - 14	7/8	0.88	13/16	0.81
¾	12	1 1/16 - 14	1 1/16	1.06	1	0.99
7/8	14	1¼- 12	1¼	1.25	1 5/32	1.16
1	16	1⅜ - 12	1⅜	1.38	1 9/32	1.29

Dash Numbers

Most fluid piping system sizes in the United States are measured by dash numbers. These are universally used abbreviations for the size of the component expressed as the numerator of the fraction with the denominator always being 16. For example, a –04 port is 4/16 or 1/4-inch. Dash numbers are usually nominal (in name only) and are abbreviations that make ordering of components easier.

NPSM (National Pipe Straight Mechanical)



This connection is sometimes used in fluid power systems. The female half has a straight thread and an inverted 30° seat. The male half of the connection has a straight thread and a 30° internal chamfer. The seal takes place by compression of the 30° seat on the chamfer. The threads hold the connection mechanically.

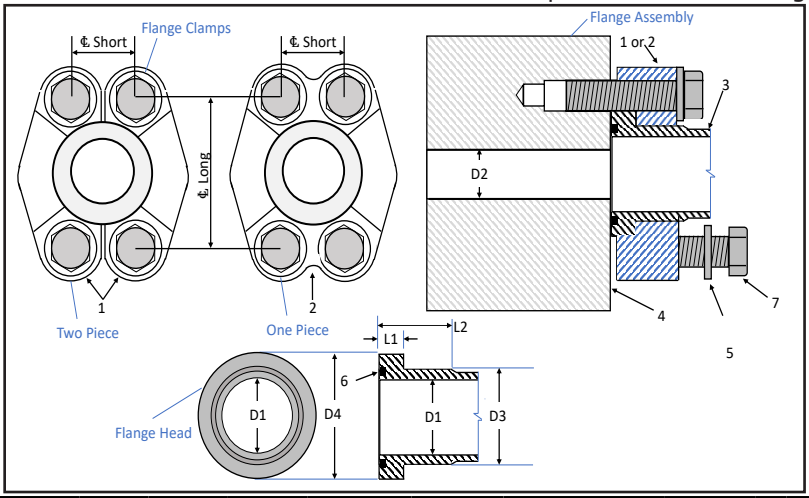
Note: A properly chamfered NPTF male will also seal with the NPSM female.

Inch Size	Dash Size	Nominal Thread Size	Male Thread OD (inch)		Female Thread ID (inch)	
			Fraction	Decimal	Fraction	Decimal
⅛	02	1/8 - 27	13/32	0.41	3/8	0.38
¼	04	¼ - 18	17/32	0.54	½	0.49
⅜	06	⅜ - 18	11/16	0.68	5/8	0.63
½	08	½ - 14	27/32	0.84	25/32	0.77
¾	12	¾ - 14	1 1/16	1.05	1	0.98
1	16	1 - 11½	1 5/16	1.32	1 1/4	1.24
1¼	20	1¼ - 11½	1 21/32	1.66	1 19/32	1.58
1½	24	1½ - 11½	1 29/32	1.90	1 13/16	1.82
2	32	2 - 11½	2 3/8	2.38	2 5/16	2.30

Caution: In the –02, –03, –04, –05, –08 and –10 sizes, the threads of the SAE 45° flare and SAE 37° flare are the same. However, the sealing surface angles are not the same.

SAE J518 4-Bolt Flange*

This connection is commonly used in fluid power systems. There are two pressure ratings. Code 61 is referred to as the "standard" series and Code 62 is the "6000 psi" series. The design concept for both series is the same, but the bolt hole spacing and flanged head diameters are larger for the higher pressure, Code 62 connection.



The female (port) is an unthreaded hole with four bolt holes in a rectangular pattern around the port. The male consists of a flanged head, grooved for an O-ring, and either a captive flange or split flange halves with bolt holes to match the port. The seal takes place on the O-ring, which is compressed between the flange head and the flat surface surrounding the port. The threaded bolts hold the connection together.

*SAE J518, JIS B 8363, ISO/DIS 6162 and DIN 20066 are interchangeable, except for bolt sizes.

How to Measure - Four Bolt Flange – First measure the port hole diameter using the caliper. Next, measure the longest bolt hole spacing from center-to-center or measure the flanged head diameter.

Table 1 — ISO and SAE Code 61 Flange Data

Nominal Size		1	2	3	4	5	D2		Maximum Working Pressure		Minimum Burst pressure	
						Flat Washer	D2 must not be greater than D1					
mm	in						mm	in	Mpa	psi	Mpa	psi
13	0.50	Two-piece flange clamp	One-piece flange clamp	Flanged head	Mounting face	M8	11.5 to 13.0	0.44 to 0.50	35	5,075	140	20,300
19	0.75					M10	17.7 to 19.2	0.69 to 0.75	35	5,075	140	20,300
25	1.00					M10	24.1 to 25.6	0.94 to 1.00	32	4,640	128	18,560
32	1.25					M10	30.5 to 32.0	1.19 to 1.25	28	4,060	112	16,240
38	1.50					M12	36.7 to 38.2	1.44 to 1.50	21	3,045	84	12,180
51	2.00					M12	49.5 to 51.0	1.94 to 2.00	21	3,045	84	12,180
64	2.50					M12	62.0 to 63.5	2.44 to 2.50	17.5	2,538	70	10,150
76	3.00					M16	74.7 to 76.2	2.94 to 3.00	16	2,320	64	9,280
89	3.50					M16	87.5 to 89.0	3.44 to 3.50	3.5	508	14	2,030
102	4.00					M16	100.1 to 101.6	3.94 to 4.00	3.5	508	14	2,030
127	5.00					M16	125.5 to 127.0	4.94 to 5.00	3.5	508	14	2,030

Table 2 — ISO and SAE Flange Head For Code 61

Nominal Size		O-ring code (6)	D1		D3		D4		L1		L2	
mm	in		mm	in	mm	in	mm	in	mm	in	mm	in
13	0.50	210	13.0	0.50	23.9	0.941	30.2	1.189	6.8	0.268	13	0.512
19	0.75	214	19.2	0.75	31.8	1.252	38.1	1.500	6.8	0.268	14	0.551
25	1.00	219	25.6	1.00	38.1	1.500	44.45	1.750	8.0	0.315	14	0.551
32	1.25	222	32.0	1.25	43.2	1.701	50.8	2.000	8.0	0.315	14	0.551
38	1.50	225	38.2	1.50	50.3	1.980	60.35	2.376	8.0	0.315	16	0.630
51	2.00	228	51.0	2.00	62.2	2.449	71.4	2.811	9.6	0.378	16	0.630
64	2.50	232	63.5	2.50	74.2	2.921	84.1	3.311	9.6	0.378	18	0.709
76	3.00	237	76.2	3.00	90.2	3.551	101.6	4.000	9.6	0.378	19	0.748
89	3.50	241	89.0	3.50	101.6	4.000	114.3	4.500	11.3	0.445	22	0.866
102	4.00	245	101.6	4.00	114.3	4.500	127	5.000	11.3	0.445	25	0.984
127	5.00	253	127.0	5.00	139.7	5.500	152.4	6.000	11.3	0.445	28	1.102

Table 3 — ISO and SAE Code 61 Screw Data

7											
Nominal Size		Screw Thread		Screw Length		Screw Torque		℄ Long		℄ Short	
mm	in	Metric	U.S.	mm	in	Nm	ft-lb	mm	in	mm	in
13	0.50	M8	5/16 -18	25	1.25	32	24	38.1	1.500	17.5	0.688
19	0.75	M10	3/8 - 16	30	1.25	70	52	47.6	1.875	22.2	0.875
25	1.00	M10	3/8 - 16	30	1.25	70	52	52.4	2.062	26.2	1.031
32	1.25	M10	7/16 - 14	30	1.50	70	52	58.7	2.312	30.2	1.188
38	1.50	M12	1/2 - 13	35	1.50	130	96	69.9	2.750	35.7	1.406
51	2.00	M12	1/2 - 13	35	1.50	130	96	77.8	3.062	42.9	1.688
64	2.50	M12	1/2 - 13	40	1.75	130	96	88.9	3.500	50.8	2.000
76	3.00	M16	5/8 - 11	50	1.75	295	218	106.4	4.188	61.9	2.438
89	3.50	M16	5/8 - 11	50	2.00	295	218	120.7	4.750	69.9	2.750
102	4.00	M16	5/8 - 11	50	2.00	295	218	130.2	5.125	77.8	3.062
127	5.00	M16	5/8 - 11	55	2.25	295	218	152.4	6.000	92.1	3.625

*English Bolt Lengths May Vary By Manufacturer. Standard Covers Metric Bolt Configurations

For more detailed information, refer to ISO 6162-1

Updated 1/31/24

Code 62 (Split and One Piece Clamps)

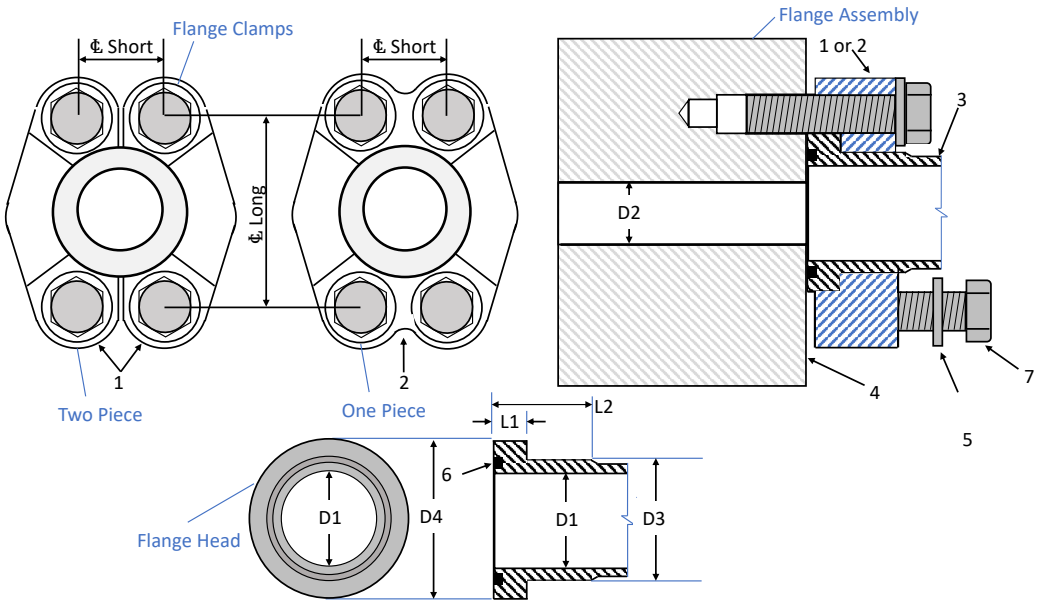
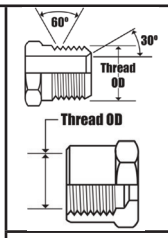
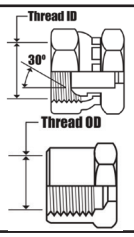
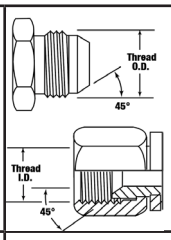
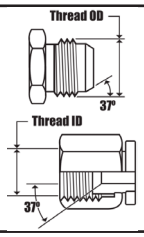
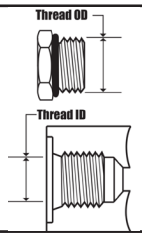
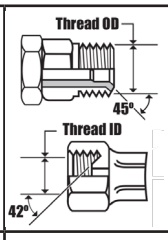
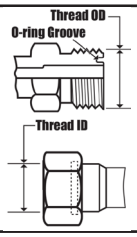


Table 4	ISO and SAE Code 62 Flange data										
Nominal Size		1	2	3	4	5	D2 D2 must not be greater than D1		Maximum Working Pressure		Minimum Burst Pressure	
mm	in					Flat Washer	mm	in	Mpa	psi	Mpa	psi
13	0.50	Two-piece flange clamp	One-piece flange clamp	Flanged head	Mounting face	M8	11.5 to 13.0	0.44 to 0.50	42	6,090	168	24,360
19	0.75					M10	17.7 to 19.2	0.69 to 0.75	42	6,090	168	24,360
25	1.00					M10	24.1 to 25.6	0.94 to 1.00	42	6,090	168	24,360
32	1.25					M10	30.5 to 32.0	1.19 to 1.25	42	6,090	168	24,360
38	1.50					M12	36.7 to 38.2	1.44 to 1.50	42	6,090	168	24,360
51	2.00					M12	49.5 to 51.0	1.94 to 2.00	42	6,090	168	24,360
64	2.50					M12	62.0 to 63.5	2.44 to 2.50	42	6,090	168	24,360
76	3.00					M16	74.7 to 76.2	2.94 to 3.00	42	6,090	168	24,360

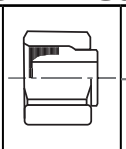
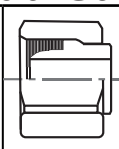
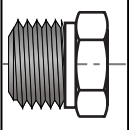
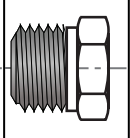
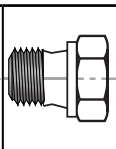
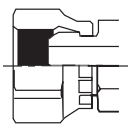
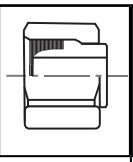
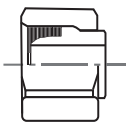
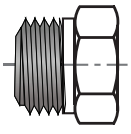
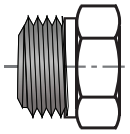
Table 5		ISO and SAE Flange Head For Code 62										
Nominal Size		O-ring code (6)	D1		D3		D4		L1		L2	
mm	in		mm	in	mm	in	mm	in	mm	in	mm	in
13	0.50	210	13.0	0.50	23.9	0.941	31.75	1.250	7.8	0.307	14	0.551
19	0.75	214	19.2	0.75	31.8	1.252	41.30	1.626	8.8	0.346	18	0.709
25	1.00	219	25.6	1.00	38.1	1.500	47.65	1.876	9.5	0.374	21	0.827
32	1.25	222	32.0	1.25	43.7	1.720	54.00	2.126	10.3	0.406	25	0.984
38	1.50	225	38.2	1.50	50.8	2.000	63.50	2.500	12.6	0.496	30	1.181
51	2.00	228	51.0	2.00	66.5	2.618	79.40	3.126	12.6	0.496	38	1.496
64	2.50	232	63.5	2.50	89.0	3.504	107.70	4.240	20.5	0.807	50	1.969
76	3.00	237	76.2	3.00	113.5	4.469	131.70	5.185	26.0	1.024	65	2.559

Table 6		ISO and SAE Code 62 Screw Data									
		7									
Nominal Size		Screw Thread		Screw Length		Screw Torque		℄ Long		℄ Short	
mm	in	Metric	U.S.	mm	in	Nm	ft-lb	mm	in	mm	in
13	0.50	M8	5/16-18	30	1.25	32	24	40.5	1.594	18.2	0.718
19	0.75	M10	3/8-16	35	1.50	70	52	50.8	2.000	23.8	0.937
25	1.00	M12	7/16-14	45	1.75	130	96	57.2	2.252	27.8	1.093
32	1.25	M12	1/2-13	45	1.75	130	96	66.7	2.625	31.8	1.250
38	1.50	M16	5/8-11	55	2.25	295	218	79.4	3.125	36.5	1.437
51	2.00	M20	3/4-10	70	2.75	550	407	96.8	3.812	44.5	1.750
64	2.50	M24	7/8-9	80	3.50	550	407	123.8	4.875	58.7	2.312
76	3.00	M30	1 1/8-7	90	4.50	650	481	152.4	6.000	71.4	2.812
*English Bolt Lengths May Vary By Manufacturer. Standard Covers Metric Bolt Configurations											
For more detailed information, refer to ISO 6162-2											

SAE Thread Guide

Dash Size	 NPTF	 NPSM	 SAE 45° Auto Refrig.	 SAE 37° (JIC) Hydraulic	 SAE O-Ring Boss	 SAE Invert Flare	 ORS
-02	⅛ - 27	⅛ - 27	5⁄16 -24	5⁄16 - 24	5⁄16-24	5⁄16 - 24	
-03			⅜ - 24	⅜ - 24	⅜ -24	⅜ - 24	
-04	¼-18	¼ -18	7⁄16 - 20	7⁄16 - 20	7⁄16 - 20	7⁄16 - 24	9⁄16 -18
-05			½ - 20	½ - 20	½ -20	½ - 20	
-06	⅜-18	⅜ -18	⅝ - 18	9⁄16 - 18	9⁄16 -18	⅝ -18	11⁄16 - l6
-07			11⁄16 - 24			11⁄16 - 18	
-08	½-14	½ - 14	¾ -16	¾ - 16	¾-16	¾ -18	13⁄16 - l6
-10			⅞ - 14	⅞ - 14	7 ⅛-1 4	⅞ -18	1 -14
-12	¾-14	¾ - 14	1 1⁄16 -14	l 1⁄16 - 12	l 1⁄16 -12	l 1⁄16 - l6	l 3⁄16 - 12
-14			1 ¼ - 12	l 3⁄16 -12	l 3⁄16 - 12		
-16	1-11 ½	1 -11 ½	1 ⅜ - 12	1 5⁄16-12	l 5⁄16 -12		l 7⁄16 - 12
-20	1 ¼ - 11 ½	l ¼-11 ½	1 ⅝ - 12	l ⅝ - 12	l ⅝ -12		1 11⁄16 - 12
-24	1½ -11 ½	l ½-11 ½		1 ⅞ - 12	l ⅞-12		2 - 12
-32	2 - 11 ½	2 -11 ½		2 ½ - 12	2 ½ -12		
-40	2 ½ - 8	2 ½ - 8		3 -12	3 - 12		
-48	3 - 8	3 - 8		3 ½ -12	3 ½ -12		

Metric Thread Guide

Fitting Size	 DIN "L" Swivel Female Thread Size	 DIN "S" Swivel Female Thread Size	 DIN "L" Male Stud Thread Size	 DIN "S" Male Stud Thread Size	 Male BSPP Thread Size	 BSP Swivel Female Thread Size	 French Swivel Female Gaz Series	 French Swivel Female Metric Series	 French Male Stud Metric Series	 French Male Stud Gaz Series
4	-	-	-	-	¼ - 19	¼ - 19	-	-	-	-
6	M12 x 1.5	M14 x 1.5	M12 x 1.5	M14 x 1.5	⅜ - 19	⅜ - 19	-	M12 x 1	M12 x 1	-
8	M14 x 1.5	M16 x 1.5	M14 x 1.5	M16 x 1.5	½ - 14	½ - 14	-	M14 x 1.5	M14 x 1.5	-
10	M16 x 1.5	M18 x 1.5	M16 x 1.5	M18 x 1.5	⅝ - 14	⅝ - 14	-	M16 x 1.5	M16 x 1.5	-
12	M18 x 1.5	M20 x 1.5	M18 x 1.5	M20 x 1.5	¾ - 14	¾ - 14	-	M18 x 1.5	M18 x 1.5	-
13	-	-	-	-	-	-	M20 x 1.5	-	-	M20 x 1.5
14	-	M22 x 1.5	-	M22 x 1.5	-	-	-	M20 x 1.5	M20 x 1.5	-
15	M22 x 1.5	-	M22 x 1.5	-	-	-	-	M22 x 1.5	M22 x 1.5	-
16	-	M24 x 1.5	-	M24 x 1.5	1 - 11	1 - 11	-	M24 x 1.5	M24 x 1.5	-
17	-	-	-	-	-	-	M24 x 1.5	-	-	M24 x 1.5
18	M26 x 1.5	-	M26 x 1.5	-	-	-	-	M27 x 1.5	M27 x 1.5	-
20	-	M30 x 2	-	M30 x 2	1¼ - 11	1¼ - 11	-	M27 x 1.5	M27 x 1.5	-
21	-	-	-	-	-	-	M30 x 1.5	-	-	M30 x 1.5
22	M30 x 2	-	M30 x 2	-	-	-	-	M30 x 1.5	M30 x 1.5	-
25	-	M36 x 2	-	M36 x 2	1½ - 11	1½ - 11	-	M33 x 1.5	M33 x 1.5	-
27	-	-	-	-	-	-	M36 x 1.5	-	-	M36 x 1.5
28	M36 x 2	-	M36 x 2	-	-	-	-	M36 x 1.5	M36 x 1.5	-
30	-	M42 x 2	-	M42 x 2	2 - 11	2 - 11	-	M39 x 1.5	M39 x 1.5	-
33	-	-	-	-	-	-	M45 x 1.5	-	-	M45 x 1.5

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Mobile Hydraulic Mechanic Job Performance Test

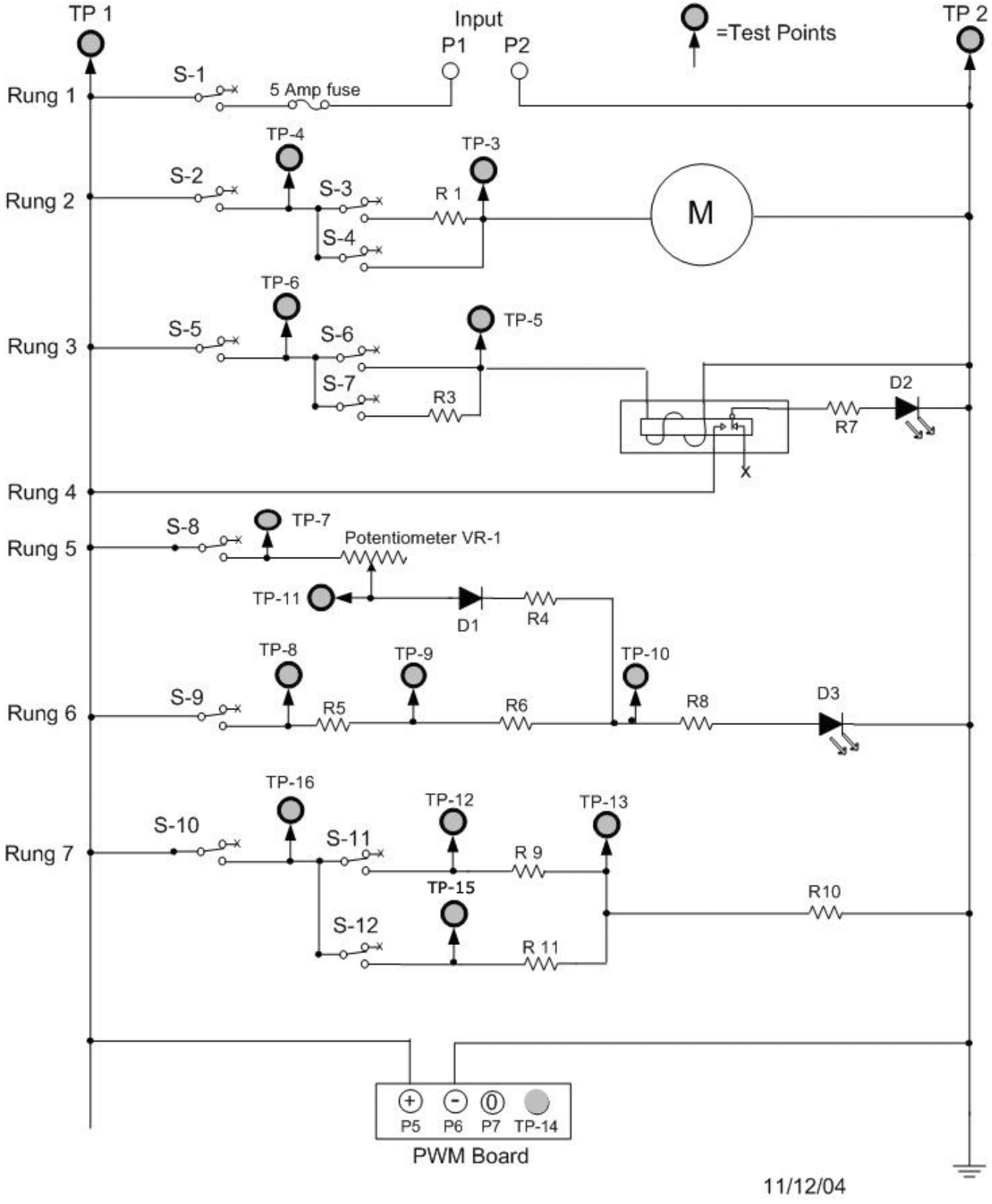
STATION 3

Electrical

Instructions:

Utilize multimeter to measure voltage, amperage, and resistance.

JP-3 - Test Schematic



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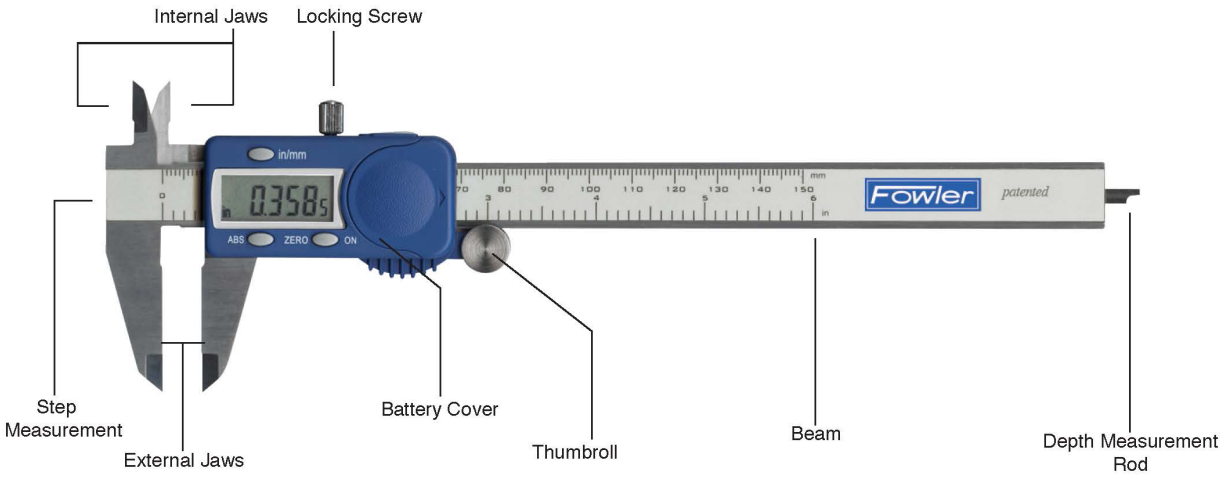
Mobile Hydraulic Mechanic Job Performance Test

STATION 4

Measure a Cylinder Piston

Instructions:

Measure the cylinder piston using a scale, caliper and micrometer. Write the measurements in the space provided on your handout sheet.



Functions

On/Zero: Press <on> function button. Press button an additional time to zero. Caliper features auto-off function.
Zero Setting: Press <zero> function button.
Change Measuring Standard: Press <inch/mm> function button.
Absolute/Incremental: Press <abs> button, to return to zero function press button again.
RS232 data output: By connection cable (not included).The 54-100-004-1 does not have RS232 capabilities.

Battery Replacement

• Slide off the battery cover, then remove the battery by gently tapping the instrument in your hand. (Never try to force or pry the battery out). Insert the new battery with the positive pole "+" facing upwards and replace the cover.

• Please dispose of used batteries at a proper collection center.

Cleaning

Clean the caliper with a soft cloth and a few drops of clock oil. DO NOT use any type of solvent. DO NOT immerse the caliper in liquid.

Troubleshooting Chart

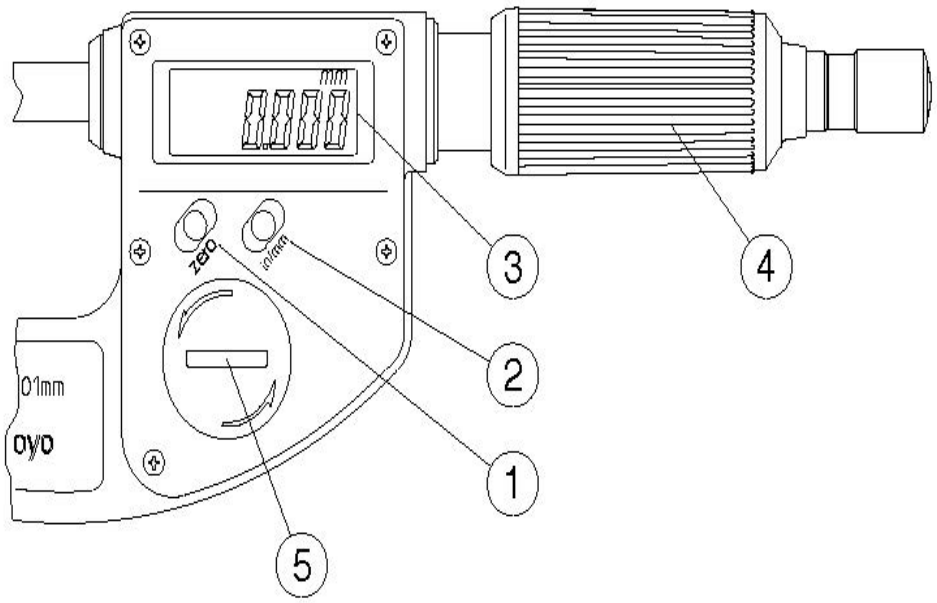
Symptom	Corrective Action
• Digits do not change or count correctly	• Remove the battery for 30 seconds then reinstall.
• No Display	• Check battery contacts or replace battery.

RESET: In order to RESET the instrument, remove the battery, wait 30 seconds, replace the battery and turn the instrument on.

Precautions: *Although a top quality product, certain precautions are required for any electronic instrument:*
• Avoid exposure to all liquids and excessive humidity.
• Avoid exposure to electromagnetic fields.
• Do not expose the instrument to direct sunlight.
• Do not attempt to disassemble the caliper for extended periods of time.

Technical Data

Measuring Range:	0-6"/150mm or 0-12"/300mm
Resolution:	.0005"/.01mm
Accuracy:	6"/150mm: ±.001"/.02mm; 12"/300mm: ±.0016"/.04mm
• Repeatability:	.0005"/.01mm
• Measuring system:	Capacitive
• Display:	LCD (7.0 mm high)
• Maximum Measuring Speed:	120" per second
• Battery:	3V, type CR2032 Lithium (Part #: 5U085)
• Battery life:	Approx. 1 year
• Operational Temperature Range:	0°C to +40°C
• Maximum Relative Humidity:	80%



1. ZERO button
2. Millimeter/Inch conversion
3. LCD Display
4. Thimble
5. Battery Cap (on back)

Button Function and Alarms

1. Button functions

ZERO button: If pressed, it zero-sets the display value.

2. Display indicators

B : Low battery voltage. Immediately replace the battery.

E-oS : Error due to electrical noise or overspeed. Set the origin again, as described in "[4] Setting The Origin". This micrometer is not provided with the ON/OFF switch. The display unit (LCD) is always turned on. Since the display unit (LCD) consumes only a little power, the battery life is available for 1.2 years under normal use.

Setting The Origin

IMPORTANT:

•Before measuring check the origin (datum-point) according to the steps below.

•Remove dust/oil from the measuring faces before origin setting.

1. Turn the thimble to gently bring the spindle into contact with the anvil. Apply the rated measuring force using the ratchet stop/friction thimble.
2. Press the ZERO button.
3. "0.000" appears, indicating the origin has been set

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Mobile Hydraulic Mechanic Job Performance Test

STATION 5

Measure Fluid Conductors and Determine Operating Pressure

Instructions:

Make the appropriate measurements of the six fluid conductor samples provided. Determine the burst pressure and working pressure (Safety Factor = 4:1). Write your answers in the spaces provided on the test sheet.

Steel Tubing Data

Steel tubing is called out by outside diameter and wall thickness. For hydraulic plumbing, use a low carbon seamless steel tubing which can be bent and flared without cracking. Order "hydraulic grade" tubing. Pressure ratings in this table are based on a tubing with tensile strength of 55,000 PSI, and were calculated by Barlow's formula: $P = (2t \bullet S) / O$, in which P = burst strength in PSI, t = wall thickness, S = tensile strength in PSI, and O = outside diameter. This formula may be used to calculate tubing sizes not listed. For pressure rating at other safety factors, take burst PSI and divide by desired design factor.

Tube Dimensions (English)				Carbon Steel			Stainless Steel		
Tube OD	Wall Thickness	Tube ID	ID Area (sq-in)	CS Burst Pressure	WP - 6:1 (psig)	WP - 4:1 (psig)	SS Burst Pressure	WP - 6:1 (psig)	WP - 4:1 (psig)
1/4"	0.035	0.180	0.025	14000	2333	3500	21000	3500	5250
-4	0.042	0.166	0.022	16800	2800	4200	25200	4200	6300
	0.049	0.152	0.018	19600	3267	4900	29400	4900	7350
	0.058	0.134	0.014	23200	3867	5800	34800	5800	8700
	0.065	0.120	0.011	26000	4333	6500	39000	6500	9750
3/8"	0.035	0.305	0.073	9333	1556	2333	14000	2333	3500
-6	0.042	0.291	0.067	11200	1867	2800	16800	2800	4200
	0.049	0.277	0.060	13067	2178	3267	19600	3267	4900
	0.058	0.259	0.053	15467	2578	3867	23200	3867	5800
	0.065	0.245	0.047	17333	2889	4333	26000	4333	6500
1/2"	0.035	0.430	0.145	7000	1167	1750	10500	1750	2625
-8	0.042	0.416	0.136	8400	1400	2100	12600	2100	3150
	0.049	0.402	0.127	9800	1633	2450	14700	2450	3675
	0.058	0.384	0.116	11600	1933	2900	17400	2900	4350
	0.065	0.370	0.108	13000	2167	3250	19500	3250	4875
	0.072	0.356	0.010	14400	2400	3600	21600	3600	5400
	0.083	0.334	0.088	16600	2767	4150	24900	4150	6225
5/8"	0.035	0.555	0.242	5600	933	1400	8400	1400	2100
-10	0.042	0.541	0.230	6720	1120	1680	10080	1680	2520
	0.049	0.527	0.218	7840	1307	1960	11760	1960	2940
	0.058	0.509	0.203	9280	1547	2320	13920	2320	3480
	0.065	0.495	0.192	10400	1733	2600	15600	2600	3900
	0.072	0.481	0.182	11520	1920	2880	17280	2880	4320
	0.083	0.459	0.165	13280	2213	3320	19920	3320	4980
	0.095	0.435	0.149	15200	2533	3800	22800	3800	5700
3/4"	0.049	0.652	0.334	6533	1089	1633	9800	1633	2450
-12	0.058	0.634	0.316	7733	1289	1933	11600	1933	2900
	0.065	0.620	0.302	8667	1444	2167	13000	2167	3250
	0.072	0.606	0.288	9600	1600	2400	14400	2400	3600
	0.083	0.584	0.268	11067	1844	2767	16600	2767	4150
	0.095	0.560	0.246	12667	2111	3167	19000	3167	4750
	0.109	0.532	0.222	14533	2422	3633	21800	3633	5450
1"	0.049	0.902	0.639	4900	817	1225	7350	1225	1838
-16	0.058	0.884	0.614	5800	967	1450	8700	1450	2175
	0.065	0.870	0.594	6500	1083	1625	9750	1625	2438
	0.072	0.856	0.576	7200	1200	1800	10800	1800	2700
	0.083	0.834	0.546	8300	1383	2075	12450	2075	3113
	0.095	0.810	0.515	9500	1583	2375	14250	2375	3563
	0.109	0.782	0.480	10900	1817	2725	16350	2725	4088
	0.120	0.760	0.454	12000	2000	3000	18000	3000	4500
1-1/4"	0.049	1.152	1.042	3920	653	980	5880	980	1470
-20	0.058	1.134	1.010	4640	773	1160	6960	1160	1740
	0.065	1.120	0.985	5200	867	1300	7800	1300	1950
	0.072	1.106	0.961	5760	960	1440	8640	1440	2160
	0.083	1.084	0.923	6640	1107	1660	9960	1660	2490
	0.095	1.060	0.882	7600	1267	1900	11400	1900	2850
	0.109	1.032	0.836	8720	1453	2180	13080	2180	3270
	0.120	1.010	0.801	9600	1600	2400	14400	2400	3600
	0.156	0.938	0.691	12480	2080	3120	18720	3120	4680
	0.188	0.874	0.600	15040	2507	3760	22560	3760	5640

J517 100R-series hose showing maximum working pressure (MWP) with metric and SAE dash size

Pressures are shown as MPa / psi

The minimum burst pressure of 100R series hoses is at least four times the maximum working pressure.

The metric hose number is not a dimension; it is a label used to identify the product size.

Hose ID mm	Hose ID Inch	Dash Size	100R1	100R2	100R3	100R4	*100R5	100R6	100R7	100R8	100R12	100R13	*100R14	100R15	100R16	100R17	100R18	100R19
3	1/8	-2							21.0 3,045	42.0 6,090							21.0 3,045	
5	3/16	-3	25.0 3,625	41.5 6,018	10.5 1,523			3.5 508	21.0 3,045	35.0 5,075							21.0 3,045	28.0 4,060
6.3	1/4	-4	22.5 3,263	40.0 5,800	8.7 1,262			2.8 406	19.2 2,784	35.0 5,075					40.0 5,800	21.0 3,045	21.0 3,045	28.0 4,060
8	5/16	-5	21.5 3,118	35.0 5,075	8.4 1,218			2.8 406	17.5 2,538						35.0 5,075	21.0 3,045	21.0 3,045	28.0 4,060
10	3/8	-6	18.0 2,610	33.0 4,785	7.8 1,131			2.8 406	15.7 2,277	28.0 4,060	28.0 4,060			42.0 6,090	33.0 4,785	21.0 3,045	21.0 3,045	28.0 4,060
12.5	1/2	-8	16.0 2,320	27.5 3,988	7.0 1,015			2.8 406	14.0 2,030	24.5 3,553	28.0 4,060			42.0 6,090	27.5 3,988	21.0 3,045	21.0 3,045	28.0 4,060
16	5/8	-10	13.0 1,885	25.0 3,625	6.1 885			2.4 348	10.5 1,523	19.2 2,784	28.0 4,060				25.0 3,625	21.0 3,045	21.0 3,045	28.0 4,060
19	3/4	-12	10.5 1,523	21.5 3,118	5.2 754	2.1 305		2.1 305	8.7 1,262	15.7 2,277	28.0 4,060	35.0 5,075		42.0 6,090	21.5 3,118	21.0 3,045	21.0 3,045	28.0 4,060
25	1	-16	8.8 1,276	16.5 2,393	3.9 566	1.7 247			7.0 1,015	14.0 2,030	28.0 4,060	35.0 5,075		42.0 6,090	16.5 2,393	21.0 3,045	21.0 3,045	
31.5	1 1/4	-20	6.3 914	12.5 1,813	2.6 377	1.4 203					21.0 3,045	35.0 5,075		42.0 6,090	12.5 1,813			
38	1 1/2	-24	5.0 725	9.0 1,305		1.0 152					17.5 2,538	35.0 5,075		42.0 6,090				
51	2.0	-32	4.0 580	8.0 1,160		0.7 102					17.5 2,538	35.0 5,075						
63	2 1/2	-40		7.0 1,015		0.4 58												
78	3	48				0.4 58												
89	3 1/2	-56				0.3 44												
102	4	-64				0.2 36												

*The 100R5 and 100R14 hoses do not fit the same standard as the rest of the 100R Series. The sizes and pressure ratings are shown here.

ID																	
	mm	3.2	5	6.3	8	10	11	12.5	16	19	22	25	29	35	46	60	76
	Dash Size	-3	-4	-5	-6	-7	-8	-10	-12	-14	-16	-18	-20	-24	-32	-40	-48
	Fraction	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 3/8	1 13/16	2 3/8	3
	100R5		21 3,045	21 3,045	15.7 2,277		14 2,030	12.2 1,769	10.5 1,523		5.6 812		4.3 624	3.5 508	2.4 348	2.4 348	1.4 203
	100R14	10.5 1,523	10.5 1,523	10.5 1,523	10.5 1,523	10.5 1,523	7 1,015	5.6 812	5.6 812	5.6 812	5.6 812	5.6 812	4.2 609				

Copper Tubing Data

Burst pressures are calculated by Barlow's formula: P = (2t • S) / O in which P is burst pressure PSI; t is tubing wall thickness; S is ultimate strength of material (32,000 PSI for copper); O is outside diameter of tubing.

Tube OD	Wall Thickness	Tube ID	Inside Area	Burst PSI	Working PSI @ 6*	Working PSI @ 8**
1/4	0.030+ 0.049	0.190 0.152	0.02834 0.01814	7680 12,544	1280 2090	960 1568
5/16	0.032+ 0.049	0.249 0.215	0.04848 0.03612	6554 10,035	1092 1673	819 1254
3/8	0.032+ 0.058 0.072	0.311 0.259 0.231	0.07593 0.05266 0.04189	5461 9899 12,288	910 1650 2048	683 1237 1536
1/2	0.032+ 0.049 0.058 0.072	0.436 0.402 0.384 0.356	0.14922 0.12686 0.11575 0.09949	4096 6272 7424 5376	683 1045 1237 896	512 784 928 672
5/8	0.035+ 0.049 0.065	0.555 0.527 0.495	0.24180 0.21801 0.19234	3584 5018 6656	597 836 1109	448 627 832
3/4	0.035+ 0.049 0.065	0.680 0.652 0.620	0.36298 0.33371 0.30175	2987 4181 5547	498 697 924	373 523 693
7/8	0.045+ 0.065	0.785 0.745	0.48374 0.43570	3291 4754	549 792	411 594
1	0.065	0.870	0.59417	4160	693	520
1-1/8	0.050+	1.025	0.82474	2844	474	356
1-1/4	0.083	1.084	0.92242	4250	708	531
1-3/8	0.055+	1.265	1.2562	2560	427	320

*Safety factor of 6:1
**Safety factor of 8:1
+These are standard refrigeration sizes available at all mill supply houses

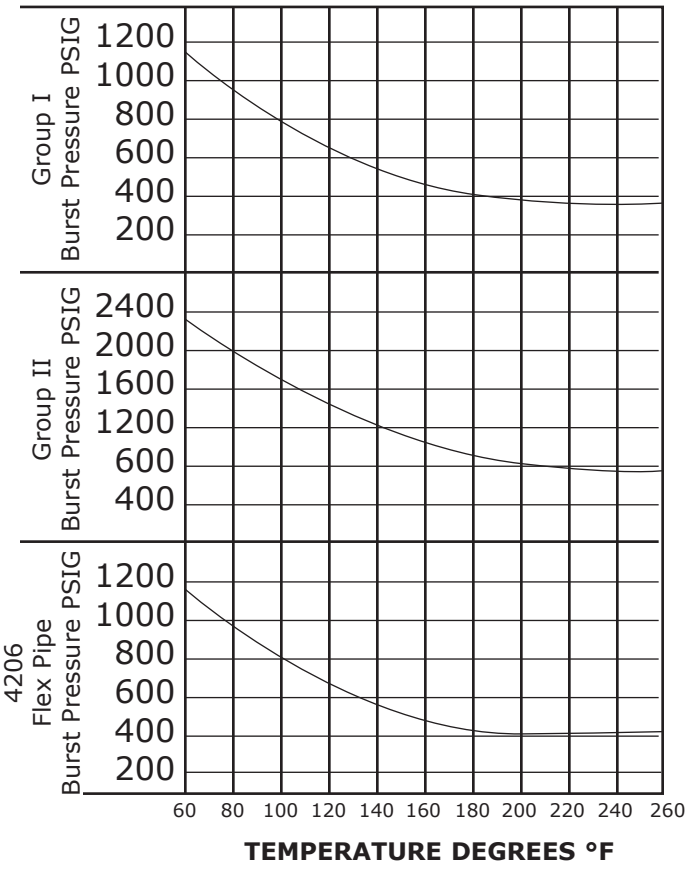
Nylon Tubing Data

	OD (inches)	ID (inches)	Wall Thickness (inches)	Min. bend radius (inches)	Wt. Per 100 (ft.)
Group 1 (1000 psi) burst) Based on 70°	1/8	0.093	0.016	1/2	0.28
	3/16	0.138	0.025	5/8	0.064
	1/4	0.180	0.035	7/8	1.15
	1/4	0.170	0.040	7/8	1.19
	5/16	0.233	0.040	1-1/8	1.65
	3/8	0.275	0.050	1-1/8	2.43
	1/2	0.375	0.062	1-1/4	4.02
Group 2 (2000 psi) burst)	1/8	0.064	0.031	1/4	0.44
	3/16	0.096	0.046	7/16	0.96
	1/4	0.127	0.062	1/2	1.69
	3/8	0.190	0.093	3/4	3.78
	1/2	0.253	0.124	1	6.69
	5/8	0.487	0.069	4	5.48

Physical Properties

Property	Unit	Test Method	Value
Specific Gravity	-	D792	1.04
Tensile Strength	PSI	D638	3500
Elongation	%	D638	100
Flexural Modulus of Elasticity	PSI	D790	40,000
Melting Point	°F	D790	350° min.
Water Absorption	%	D570 Method A	0.50
	%	100% RH & 75° (100 hrs.)	2
Hardness (Shore D)	—	—	63
Suggested Operating Temp. Range Continuous	°F	—	-40° to +200°

Pressure vs. Temperature



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Mobile Hydraulic Mechanic Job Performance Test

STATION 6

Bend, Flare, and Install a Tube to a Fixture

Instructions:

Bend, flare, and install a 3/8 in. tube as shown in the illustration.
Label the tube for later grading. Write the required length answer on the test sheet.

As long as tubing is measured and bent in the same direction, and is measured centerline to centerline, "pickup" will not affect the actual center-to-center measurement.

Nominal Tubing Gain vs. Radius Block Size						
Bend Angle	Tube OD, in					
	1/8	1/4	1/4	5/16	3/8	1/2
	Bend Radius, in					
	9/16	9/16	3/4	15/16	15/16	1 1/2
30°	0	0	0	0	0	1/16
45°	1/16	1/16	1/16	1/16	1/16	1/16
50°	1/16	1/16	1/16	1/16	1/16	1/8
55°	1/16	1/16	1/16	1/8	1/8	1/8
60°	1/16	1/8	1/16	1/8	1/8	3/16
65°	1/8	1/8	1/8	3/16	1/8	1/4
70°	1/8	1/8	1/8	3/16	3/16	5/16
75°	1/8	3/16	3/16	1/4	1/4	3/8
80°	3/16	3/16	3/16	5/16	5/16	7/16
85°	1/4	1/4	1/4	3/8	3/8	9/16
90°	1/4	5/16	5/16	7/16	7/16	11/16

Note: Many manufacturers of tube bending equipment publish gain tables. Often, these tables are based on the design and performance characteristics of the tube bender and not the true calculated value required to perform the bend. As a result, values provided in the gain table may not match the mathematically calculated value, but will be accurate when using both a specific manufacturer's tube bender and associated gain table. The table above illustrates a typical manufacturer's gain table.

Pre-measuring Bends

A series of bends may be pre-measured. Measure the first bend the correct length. Compensate for each bend after the first by subtracting the amount of gain from the chart for each 90° of bend to allow for stretch. Always custom measure for the last bend to allow for flaring. Making a 3/8 tube assembly with the first bend at 4 inches and the remaining bends at 4 1/4 inches (subtract gain from desired bend length to mark the measurements before bending).

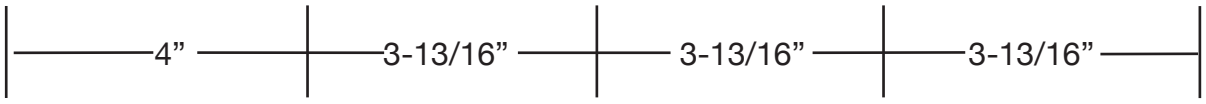


Figure 11

The Hand Bender: The RADIUS BLOCK OR BENDING BLOCK

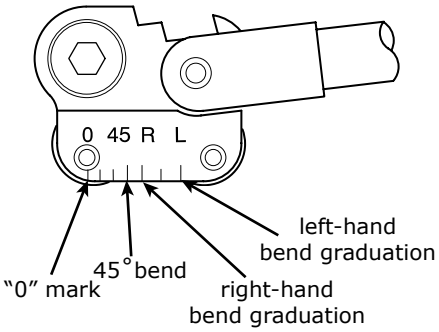


Fig. 1

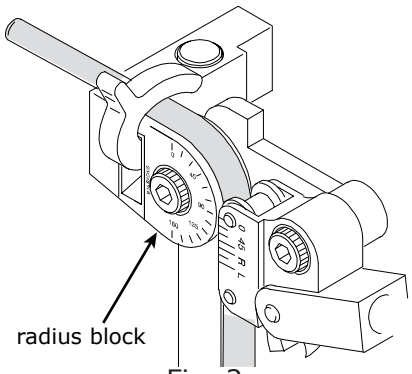


Fig. 2

The radius block (see Fig. 1) is that part of the bender which is a semi-circle block with a round groove on its edge equal to the diameter of the tube to be bent. The radius block also has a flat side which is fastened to the rigid or holding handle. The tube clamp is usually part of the block or attached to the handle at the block. This radius block has the *actual* radius of the block stamped on the side. For a 3/8" diameter tube bender, 15/16"R is the usual block used. The radius block also has numbers and marks stamped at specific points along its edge; these are reference points for various angles. *Note*: Keep bends square or parallel to the flat side of the bending block, not to the handle.

Clamp

This is affixed to either the radius block and/or the rigid handle and is used to hold the tube in place while bending. This device may be either part of the handle or attached to the handle.

Bending Handle

This handle is attached to the radius block by means of a link. It has a companion groove the same diameter as the tube to be bent. There are marks and numbers stamped on the block end of this handle (see Fig. 2). These are the reference marks used in the bending process.

Terms used in bending

Centerline of the Tubing

The centerline of the tubing is an imaginary line drawn along the radius point of the tube diameter at one end to the radius point of the tube diameter at the other end.

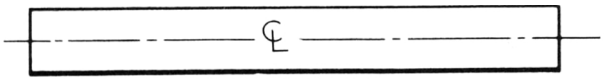


Fig. 3

Changes of Plane and/or Direction

Think of the tube as having an imaginary line drawer on the outside from one end to the other. (See Fig. 3) This could be considered as the main plane of the tubing. Changes of plane are accomplished by rotating the tube in the bender.

Note: On Fig. 2 the marks "L" and "R" are used depending on whether the mark on the tube is measured from the left "L" or from the right "R". See Fig. 4 and Fig. 5.

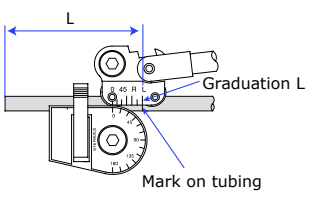


Fig. 4

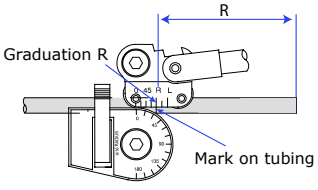
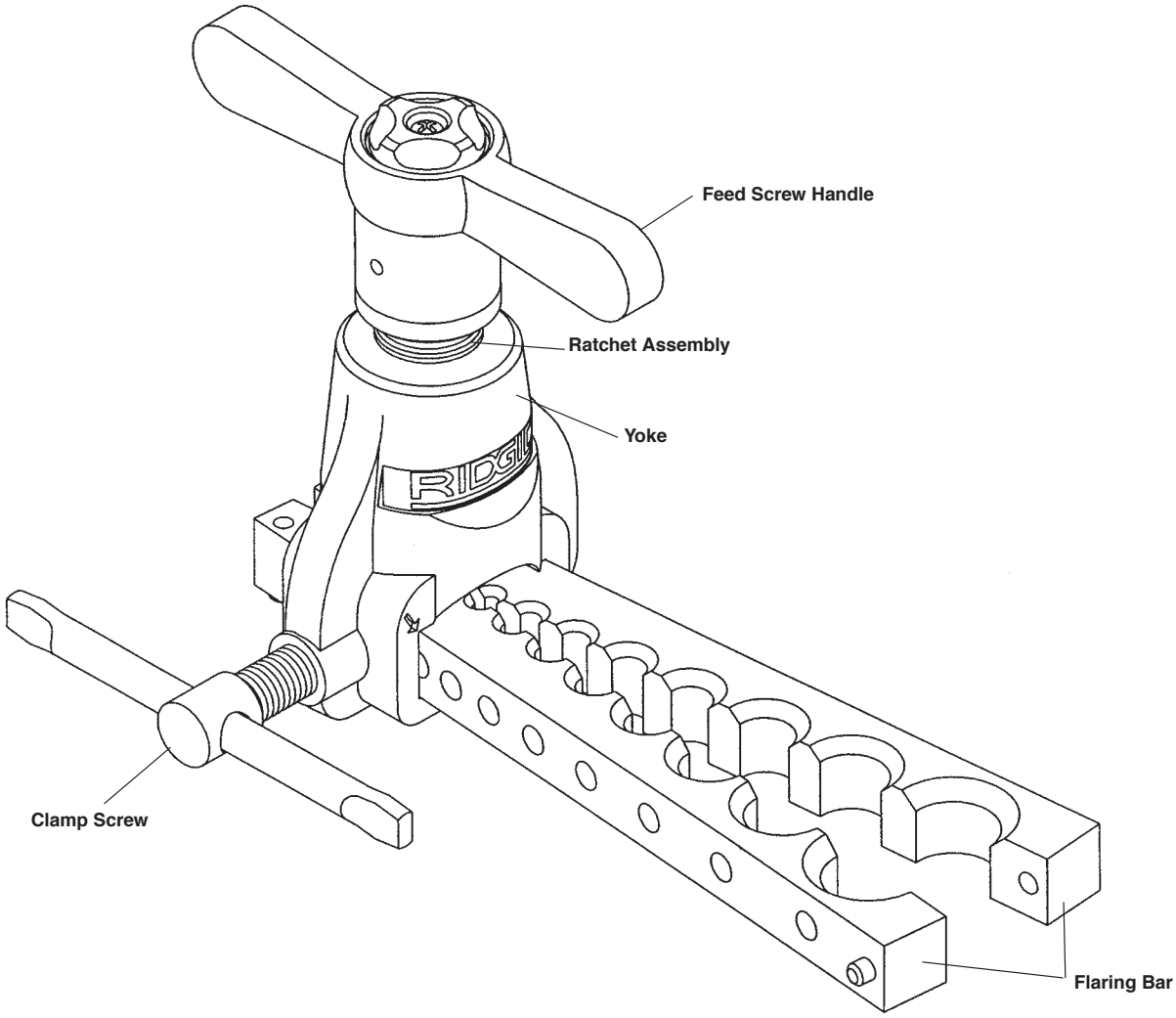


Fig. 5



Operating Instructions:

1. Cut and ream tubing.
2. Back off feed screw handle and clamp screw to permit flaring bars to slide freely through yoke. Slide yoke to hinged end of flaring bars.
3. Insert tube into proper size opening and close flaring bars. Push tube up from bottom of tool until it is even with top of flaring bars.

NOTE! OVERSIZE or UNDERSIZE flares can be made by adjusting tube position slightly above or below the top of flaring bars.

4. Slide yoke forward over tube until arrow on yoke meets line on flaring bars. Tighten clamp screw firmly.
5. Turn the feed screw handle clockwise until pressure kick-out releases. A few additional turns before backing off will burnish flare.
6. Back off feed screw handle as far as it will go. Release clamp screw and slide yoke back. Remove tube. If tube tends to stick, tighten clamp screw against tapered end of bars. This action will force bars open.