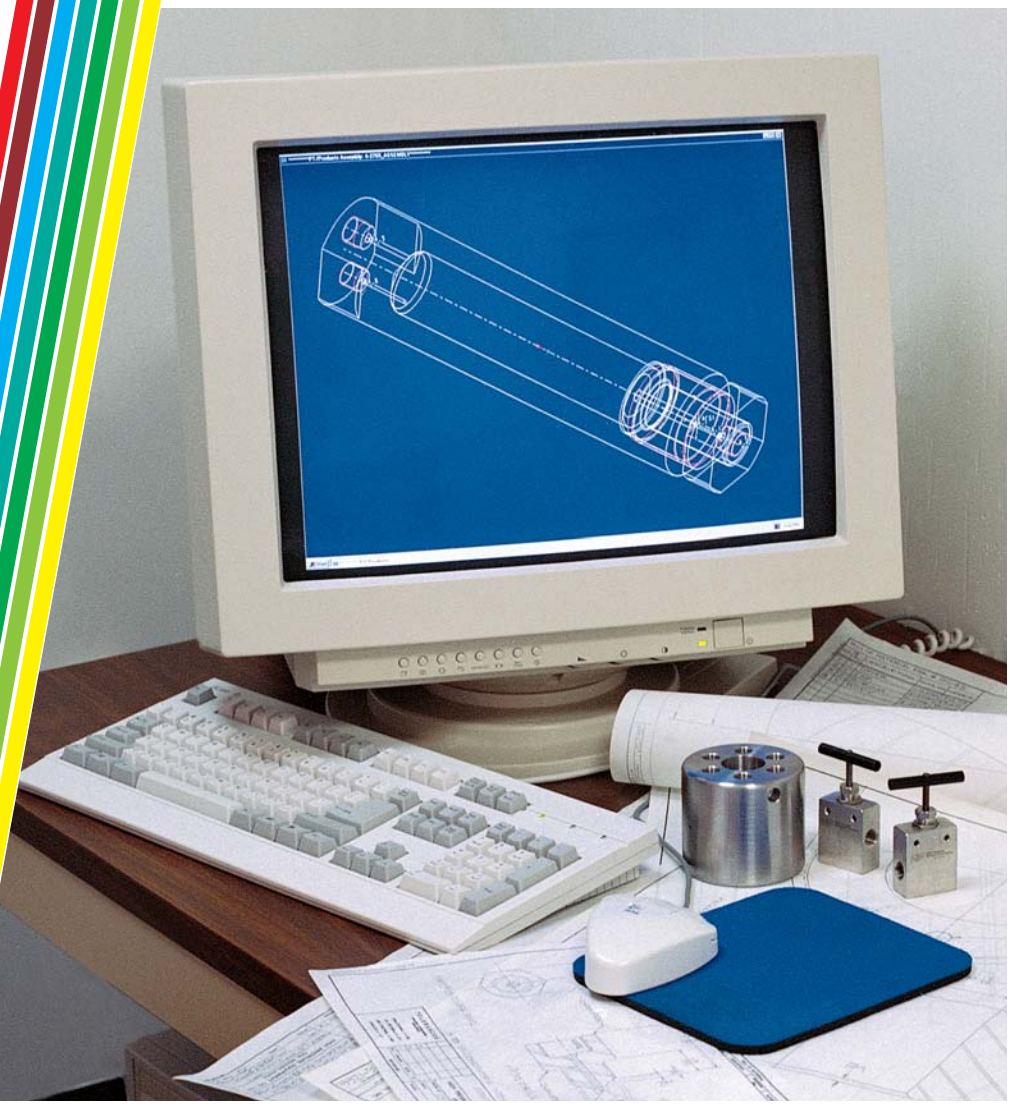
High Pressure Equipment

Technical Information

Selecting the right product to plumb your pressure system or conduct your research project is a critical decision. In this section, High Pressure Equipment Company provides a variety of technical information to assist you in this selection process. We have included a number of English to Metric conversion charts, flow coefficient formulas and valve ratings, reactor pressure ratings, and recommended torque values for our air operated valves and tubing connections.

As you work with this data, it is important to consider that it is general in nature and may vary depending on the actual parameters of your application. If you have any questions concerning this information or would like assistance in selecting an HiP product, our engineering staff is available and ready to help.



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High Pressure Equipment Conversion Tables

Pressure

	Pa	kPa	psi	kg/cm^2	bar	atm	MPa
Pa	1	0.001	1.450×10^{-4}	1.020×10^{-5}	1×10^{-5}	9.869×10^{-6}	1×10^{-6}
kPa	1000	1	0.145	0.01	0.01	0.01	0.001
psi	6.895×10^{3}	6.895	1	0.07	0.069	0.068	0.007
kg/cm^2	9.807×10^{4}	98.07	14.22	1	0.981	0.968	0.098
bar	1×10^{5}	100	14.50	1.02	1	0.987	0.1
atm	101.3×10^{5}	101.3	14.7	1.033	1.013	1	0.101
MPa	1×10^{6}	1000	145	10.2	10	9.869	1

Flow

	mL/min	in^3/min	ft^3/hr	liter/min	gal/min
mL/min	1	0.061	0.002	0.001	6.242×10^{-4}
in^3/min	16.39	1	0.035	0.016	0.004
ft^3/hr	472	28.8	1	0.472	0.125
liter/min	1000	61.02	2.119	1	0.264
gal/min	3785	231	8.021	3.785	1

Weight/Mass

	gram	oz	lb	kg
gram	1	0.035	0.002	0.001
oz	28.35	1	0.063	0.028
lb	453.6	16	1	0.454
kg	1000	35.28	2.205	1

Volume

	mL	in^3	liter	gal	ft^3	m^3
mL	1	0.061	0.001	2.642×10^{-4}	3.531×10^{-5}	1×10^{6}
in^3	16.39	1	0.016	0.004	5.787×10^{-4}	1.639×10^{5}
liter	1000	61.02	1	0.264	0.035	0.001
gal	3.785×10^{3}	231	3.785	1	0.134	0.004
ft^3	2.832×10^{4}	1.728×10^{3}	28.32	7.481	1	0.028
m^3	1×10^{6}	6.102×10^{4}	1000	264.2	35.32	1

Linear

	micron	millimeter	centimeter	inch	foot	meter
micron	1	0.001	1×10^{-4}	3.937×10^{-5}	3.281×10^{-6}	1×10^{-10}
millimeter	1000	1	0.1	0.03937	0.003	0.001
centimeter	1×10^{-4}	10	1	0.394	0.033	0.01
inch	2.540×10^{4}	25.4	2.54	1	0.083	0.025
foot	3.048×10^{5}	304.8	30.48	12	1	0.305
meter	1×10^{6}	1000	100	39.37	3.281	1

Taper Seal Assembly Procedure – AF2, AF4 and AF6 Connections

1. Lubricate the male threads of the Taperseal gland, and the back of the outer collar on the sleeve with a process compatible lubricant.
2. Put a small amount of lubricant on the area where the outer collar and inner sleeve come in contact with each other. This will reduce the friction when the outer collar slides over the inner sleeve.
3. Assemble the Taperseal gland, sleeve and tubing into the component or assembly mandrel and tighten finger-tight.
4. Using the appropriate size wrench, rotate the gland nut clockwise one half turn and stop. Back off the gland nut and repeat this step approximately 3 – 4 times until the gland stops rotating or "bottoms out". Do not rotate the gland nut continuously clockwise or galling between the outer collar and inner sleeve may occur.
5. Remove the tube with the gland and sleeve attached, and inspect the sleeve assembly to be sure the outer collar has slid completely down over the inner sleeve. No gaps should be present.
6. Refer to page 12.5 of the Technical Information Section of our catalog for Recommended Torque / Tubing Connections. Torque the tubing gland to the value listed on the chart.
7. Refer to the catalog page 2.A for proper connection diagram and component details.
   - Please note that a mandrel can be used to properly make-up the connection rather than using the actual component. Using the mandrel will prevent any galling of the female component threads. Mandrels can be purchased from HiP.

Correctly Assembled Taper Seal Connection

Incorrect Assembly

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NPT Hand Valves

10,000 psi Series

Material	Part Number		
	NFA/NFB/ NFC	NFD	NFF - NFH
Teflon*	B-181	B-185	208741 Set
Grafoil	B-1417	B-1359	—
Buna-N	B-102	—	—
Viton	B-849	—	—
Silicone	B-147	—	—

15,000 psi Series

Material	Part Number	
	NFA NFB	NFC NFD
Teflon*	B-1392 Set	207341 Set
Grafoil	B-1391 Set	B-1386 Set
Polypak	B-1388 (1)	B-1387 (1)

Hand Valves

Taper Seal

Material	Part Number		
	AF1	AF2	AF4/ AF6
Teflon*	B-195	B-195	B-181
Grafoil	B-1379	B-1379	B-1417
Buna-N	B-101	B-101	B-102
Viton	B-614	B-614	B-849
Silicone	B-149	B-149	B-147

Medium Pressure

Material	Part Number			
	LF4/ LF6	LF9	LF12	LF16
Teflon*	B-1392 Set	207341 Set	208740 Set	208741 Set
Grafoil	B-1391 Set	B-1386 Set	B-1455 Set[1]	B-1440 Set[2]
Polypak	B-1388 (1)	B-1387 (1)	B-1431 (1)[1]	B-1742 (1)[2]

[1] LF12 Series: When Grafoil and Polypak are used, top washer 208937 and bottom washer 208939 must be installed

[2] LF16 Series: When Grafoil and Polypak are used, top washer 209308 and bottom washer 209309 must be installed

High Pressure 30,000 psi

Material	Part Number		
	HF2	HF4/HF6 HF9	HF16
Teflon*	B-195	B-181	208741 Set
Grafoil	B-1379	B-1417	B-1455 Set[3]
Buna-N	B-101	B-102	—
Viton	B-614	B-849	—
Silicone	B-149	B-147	—
Polypak	—	—	B-1431 (1)[3]

[3] HF16 Series: When Grafoil and Polypak are used, top washer 210779 and bottom washer 208939 must be installed

High Pressure 60,000 psi

Material	Part Number
	HF2/HF4/ HF6/HF9
Teflon/Nylon**	209689
Grafoil	B-1379
TFE/Viton	212401

Ultra High Pressure

Material	Part Number
	XF4/ XF6
Teflon/Nylon**	208691

* Teflon packing supplied as standard ** Teflon/Nylon packing supplied as standard Note: For pricing see Spare Parts list in Price List

NPT Air Operated Valves

HIPCO 10,000 psi Series

Material	Part Number NFA NFB
Teflon*	B-181
Grafoil	B-1417
Buna-N	B-102
Viton	B-849
Silicone	B-147

HIPCO 15,000 psi Series

Material	Part Number NFA NFB	Part Number NFC NFD
Teflon*	B-1392 Set	207341 Set
Grafoil	B-1391 Set	B-1386 Set
Polypak	B-1388 (1)	B-1387 (1)

HIPPO 15,000 psi Series

Material	Part Number NFA NFB	Part Number NFC NFD
Teflon*	B-1392 Set	207341 Set
Grafoil	B-1391 Set	B-1386 Set
Polypak	B-1388 (1)	B-1387 (1)

Air Operated Valves

HIPCO Taper Seal

Material	Part Number AF4 AF6
Teflon*	B-181
Buna-N	B-102
Viton	B-849
Silicone	B-147

HIPPO Taper Seal

Material	Part Number AF4 AF6
Teflon*	B-181
Buna-N	B-102
Viton	B-849
Silicone	B-147

Mini HIPPO

Material	Part Number AF2	Part Number AF4/ AF6	Part Number HF4/HF6/ HF9
Teflon*	B-195	B-181	B-181
Buna-N	B-101	B-102	B-102
Viton	B-614	B-849	B-849
Silicone	B-149	B-147	B-147

HIPCO Medium Pressure

Material	Part Number LF4/ LF6	Part Number LF9
Teflon*	B-1392 Set	207341 Set
Grafoil	B-1391 Set	B-1386 Set
Polypak	B-1388 (1)	B-1387 (1)

HIPPO Medium Pressure

Material	Part Number LF4/ LF6	Part Number LF9
Teflon*	B-1392 Set	207341 Set
Grafoil	B-1391 Set	B-1386 Set
Polypak	B-1388 (1)	B-1387 (1)

HIPCO High Pressure 30,000 psi

Material	Part Number HF4/HF6/ HF9
Teflon*	B-181
Grafoil	B-1417
TFE/Buna-N	209276

HIPPO High Pressure 30,000 psi

Material	Part Number HF4/HF6/ HF9
Teflon*	B-181
Grafoil	B-1417
TFE/Buna-N	209276

HIPCO High Pressure 60,000 psi

Material	Part Number HF2/HF4/ HF6/HF9
Teflon/Nylon**	209689
Grafoil	B-1379
TFE/Viton	212401

HIPPO High Pressure 60,000 psi

Material	Part Number HF2/HF4/ HF6/HF9
Teflon/Nylon**	209689
Grafoil	B-1379
TFE/Viton	212401

Temperature Ratings for Packing Options

Material	Maximum Temperature Rating
Buna-N	200°F
Grafoil	800°F
PolyPak	200°F
Silicone	400°F
Teflon	450°F
TFE/Nylon	180°F
TFE/Viton	400°F
Viton	400°F

* Teflon packing supplied as standard ** Teflon/Nylon packing supplied as standard Note: For pricing see Spare Parts list in Price List

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High Pressure Equipment

Minimum Safety Head Hold Down Nut Torque

Pressure psi	Torque foot pounds
10,000	40
15,000	45
20,000	50
25,000	55
30,000	60
35,000	65
40,000	70
45,000	75
50,000	80
55,000	85
60,000	90

Minimum Recommended Bend Radius For High Pressure Tubing

Tube Size O.D. x I.D.	Minimum Bend Radius
0.250 x 0.062 0.250 x 0.083 0.250 x 0.109 0.250 x 0.125	1.25 in
0.375 x 0.062 0.375 x 0.125 0.375 x 0.203 0.375 x 0.250	1.75 in
0.562 x 0.188 0.562 x 0.250 0.562 x 0.312	2.62 in
0.750 x 0.438 0.750 x 0.516	3.50 in
1" x 0.438 1" x 0.562 1" x 0.688	4.62 in

Flow Coefficients

The flow coefficient Cv is a valve sizing designation commonly determined by laboratory test. It corresponds to the flow rate of water through a valve in US gallons per minute at 60˚F with a differential pressure drop of one psi.

Flow coefficients of various HiP valves

Valve	C_V
15-11AF1	0.03
15-11AF2	0.05
10-11AF4	0.15
10-11AF6	0.15
20-11LF4	0.17
20-11LF6	0.45
20-11LF9	1.12
10-11LF12	3.65
20-11LF12	2.29
10-11LF16	5.91
20-11LF16	3.86
30-11HF2	0.04
30-11HF4	0.09
30-11HF6	0.15
30-11HF9	0.15
30-11HF16	2.29

Valve	C_V
40-11HF9	0.15
60-11HF2	0.04
60-11HF4	0.04
60-11HF6	0.04
60-11HF9	0.04
100-11XF4	0.04
150-11XF6	0.04
10-11NFA	0.15
10-11NFB	0.15
10-11NFC	0.15
10-11NFD	1.12
15F-11NFA	0.45
15F-11NFB	0.45
15F-11NFC	1.12
15F-11NFD	1.12
10F-11NFF	5.91
10F-11NFH	5.91

With the Cv coefficient known, the following values can be calculated:

1. Liquid flow capacity in US gallons per minute

$$Q_l = C_v \cdot \sqrt{\frac{\Delta P}{G}}$$

2. Pressure drop across valve (liquid flow)

$$\Delta P = G \cdot \frac{Q_l^2}{C_v^2}$$

3. Gas flow capacity in standard cubic feet per hour (SCFH)

$$Q_g = 1360 \cdot C_v \cdot \sqrt{\frac{P \cdot \Delta P}{T \cdot G \cdot Z}}$$

4. Pressure drop across valve (gas flow)

$$\Delta P = \frac{T \cdot G \cdot Z}{P} \cdot \left(\frac{Q_g}{1360 \cdot C_v}\right)^2$$

Where:

C_v = Valve flow coefficient
G = Specific gravity of fluid
ΔP = Differential pressure drop across valve (psi)
P = System pressure at valve inlet (psia)
Q_l = Liquid flow in US gallons per minute (GPM)
Q_g = Gas flow in standard cubic feet per hour (SCFH)
T = System temperature (˚R)
Z = Gas compressibility factor at operating conditions

Pressure Ratings

Bolted Closure Reactors (psi) at Elevated Temperatures

Temperature °F (°C)	BC-1	BC-2, BC-3, BC-5	BC-4, BC-6
100 (38)	5600	5250	3150
200 (93)	5600	5250	3150
300 (149)	5500	5100	3100
400 (204)	5400	5050	3050
500 (260)	5350	5050	3050
600 (316)	5100	5050	3050
650 (343)	5000	5000	3000

Temperature °F (°C)	BC-1	BC-2, BC-3, BC-5	BC-4, BC-6
700 (371)	4900	4900	2950
750 (399)	4800	4800	2850
800 (427)	4200	4200	2500
850 (454)	3400	3400	2050
900 (482)	2500	2500	1500
950 (510)	1700	1700	1000
1000 (538)	900	900	550

Recommended Torque

Tubing Connections

Connection	Recommended Torque
AF1	55 inch pounds
AF2	10 foot pounds initial to compress sleeve onto tube 25 foot pounds to tighten connection
AF4	30 foot pounds initial to compress sleeve onto tube 50 foot pounds to tighten connection
AF6	40 foot pounds initial to compress sleeve onto tube 60 foot pounds to tighten connection
LF4	20 foot pounds
LF6	30 foot pounds
LF9	50 foot pounds
LF12	90 foot pounds
LF16	125 foot pounds
LF24	200 foot pounds
HF2	75 inch pounds
HF4	25 foot pounds
HF6	50 foot pounds
HF9	110 foot pounds
HF16	150 foot pounds
XF4	45 foot pounds
XF6	70 foot pounds

Minimum Packing Gland Torque for Valves

Valve Series	Pressure Rating	Packing Gland Torque
15-**AF1 15-**AF2	15,000 psi	15 foot pounds
10-**AF4 10-**AF6	10,000 psi	30 foot pounds
10-**NFA 10-**NFB 10-**NFC	10,000 psi	35 foot pounds
10-**NFD	10,000 psi	50 foot pounds
20-**LF4 20-**LF6	20,000 psi 20,000 psi	35 foot pounds
20-**LF9	20,000 psi	70 foot pounds
30-**HF2 30-**HF4 30-**HF6 30-**HF9	30,000 psi	30 foot pounds
60-**HF2 60-**HF4 60-**HF6 60-**HF9	60,000 psi	40 foot pounds
100-**XF4	100,000 psi	60 foot pounds
150-**XF6	150,000 psi	90 foot pounds

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Pressure Ratings

Equipment in Various Common Materials

Material	316SS CW (std rating)	316 SS Annealed	316L SS Annealed	Duplex 2205	Duplex 2507	Hast C276 Annealed
Pressure Rating at Room Temperature	60,000 psi	30,000 psi	26,250 psi	54,000 psi	60,000 psi	41,000 psi
	30,000 psi	20,000 psi	13,000 psi	27,000 psi	30,000 psi	20,500 psi
	20,000 psi	10,000 psi	8,750 psi	18,000 psi	20,000 psi	13,500 psi
	15,000 psi	12,000 psi	10,000 psi	15,000 psi	15,000 psi	15,000 psi
	10,000 psi	10,000 psi	10,000 psi	10,000 psi	10,000 psi	10,000 psi

Material	Inconel 600 Annealed	Inconel 625 sol Annealed	Inconel 718	Monel Annealed	Titanium Grade 2	Titanium Grade 5 (6A14V)	254 SMo
Pressure Rating at Room Temperature	34,500 psi	40,500 psi	60,000 psi	28,250 psi	30,000 psi	60,000 psi	43,500 psi
	17,250 psi	20,250 psi	30,000 psi	14,000 psi	15,000 psi	30,000 psi	21,750 psi
	11,500 psi	13,500 psi	20,000 psi	9,250 psi	10,000 psi	20,000 psi	14,500 psi
	15,000 psi	15,000 psi	15,000 psi	11,000 psi	10,000 psi	15,000 psi	15,000 psi
	10,000 psi	10,000 psi	10,000 psi	10,000 psi	10,000 psi	10,000 psi	10,000 psi

Tubing in Various Materials*

	Tubing Size OD x ID (inches)	Material vs Pressure Rating					
		316 CW	Hastelloy C276	Inconel 600	Monel 400	Nickel 200	Titanium Gr 2
Low Pressure	1/8 x 0.060	15,000 psi	10,400 psi	8,750 psi	7,150 psi	4,125 psi	7,675 psi
	1/4 x 0.125	10,000 psi	6,750 psi	5,650 psi	4,625 psi	2,675 psi	4,975 psi
	3/8 x 0.250	10,000 psi	6,750 psi	5,650 psi	4,625 psi	2,675 psi	4,975 psi
Medium Pressure	1/4 x 0.109	20,000 psi	13,500 psi	11,325 psi	9,275 psi	5,350 psi	9,950 psi
	3/8 x 0.203	20,000 psi	13,500 psi	11,325 psi	9,275 psi	5,350 psi	9,950 psi
	9/16 x 0.359	10,000 psi	6,750 psi	5,650 psi	4,625 psi	2,675 psi	4,975 psi
	9/16 x 0.312	20,000 psi	13,500 psi	11,325 psi	9,275 psi	5,350 psi	9,950 psi
	3/4 x 0.516	10,000 psi	6,750 psi	5,650 psi	4,625 psi	2,675 psi	4,975 psi
	3/4 x 0.438	20,000 psi	13,500 psi	11,325 psi	9,275 psi	5,350 psi	9,950 psi
	1 x 0.688	10,000 psi	6,750 psi	5,650 psi	4,625 psi	2,675 psi	4,975 psi
	1 x 0.562	20,000 psi	13,500 psi	11,325 psi	9,275 psi	5,350 psi	9,950 psi
High Pressure	1/8 x 0.020	60,000 psi	41,700 psi	35,000 psi	28,650 psi	16,575 psi	30,700 psi
	1/8 x 0.040	30,000 psi	20,850 psi	17,500 psi	14,325 psi	8,275 psi	15,350 psi
	1/4 x 0.083	60,000 psi	35,975 psi	30,175 psi	24,725 psi	14,300 psi	26,475 psi
	3/8 x 0.125	60,000 psi	35,975 psi	30,175 psi	24,725 psi	14,300 psi	26,475 psi
	9/16 x 0.188	60,000 psi	35,975 psi	30,175 psi	24,730 psi	14,300 psi	26,475 psi
	9/16 x 0.250	40,000 psi	27,000 psi	22,675 psi	18,575 psi	10,725 psi	19,900 psi
	1 x 0.437	30,000 psi	20,275 psi	17,000 psi	13,925 psi	8,050 psi	14,925 psi

* Not all tubing sizes available in all materials.

Volumetric Flow Rate

Maximum Recommended Volumetric Flow Rate for Water through a Tube

Orifice Size (inches)	Max Flow (gpm)	Approximate △ P (psi/ft)
0.016	0.030	525
0.020	0.050	390
0.030	0.112	230
0.031	0.119	220
0.040	0.198	160
0.047	0.274	130
0.052	0.335	115
0.060	0.446	95
0.062	0.476	90
0.078	0.754	70
0.083	0.854	65
0.094	1.09	55
0.109	1.47	45
0.125	1.93	40
0.141	2.46	35
0.156	3.01	30
0.172	3.66	25
0.188	4.38	23
0.203	5.10	21
0.219	5.94	20
0.234	6.78	18
0.250	7.74	17
0.266	8.77	15
0.281	9.78	14
0.294	10.7	13
0.312	12.0	13
0.328	13.3	12
0.344	14.6	11
0.359	15.9	11
0.375	17.4	10
0.391	18.9	<10
0.406	20.4	<10
0.422	22.0	<10
0.438	23.7	<10
0.453	25.4	<10

Orifice Size (inches)	Max Flow (gpm)	Approximate △ P (psi/ft)
0.469	27.2	<10
0.484	29.0	<10
0.500	30.9	<7
0.516	33.0	<7
0.531	34.9	<7
0.547	37.0	<7
0.562	39.1	<7
0.578	41.4	<7
0.594	43.7	<7
0.609	45.9	<7
0.625	48.4	<7
0.641	50.9	<7
0.656	53.3	<7
0.672	55.9	<5
0.688	58.6	<5
0.703	61.2	<5
0.719	64.0	<5
0.734	66.7	<5
0.750	69.7	<5
0.766	72.7	<5
0.781	75.6	<5
0.797	78.7	<5
0.812	81.7	<5
0.828	84.9	<5
0.844	88.3	<5
0.859	91.4	<5
0.875	94.9	<5
0.891	98.4	<5
0.906	101	<5
0.922	105	<5
0.938	109	<5
0.953	112	<5
0.969	116	<5
0.984	120	<5
1.000	123	<5

Pressure Rating Reduction

316 and 304 SS components at elevated levels.

Temperature °F (°C)	Percent of Room Temperature Rating
Up to 100 (38)	100
200 (93)	100
300 (149)	100
400 (204)	96.5
500 (260)	90
600 (316)	85

Temperature °F (°C)	Percent of Room Temperature Rating
650 (343)	83
700 (371)	81.5
750 (399)	80.5
800 (427)	79.5
850 (453)	78.5

Intermediate values may be linearly interpolated.

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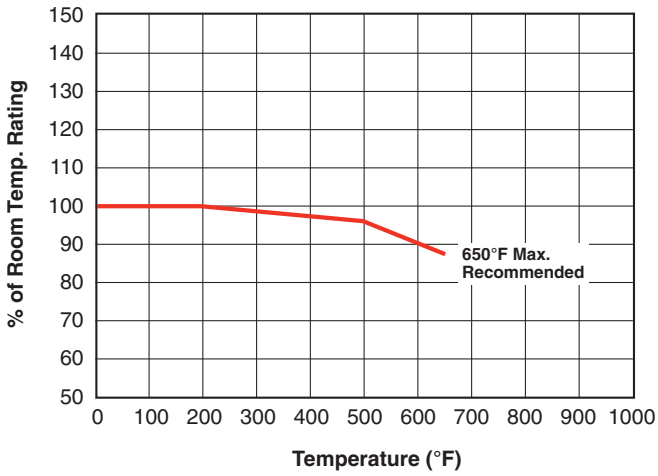
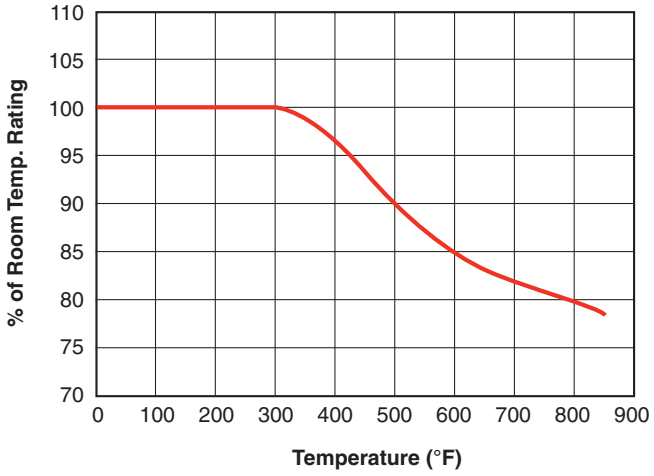
Temperature Rating

Taper Seal Series Valves and Fittings



Pressure Rating Reduction

316 and 304 SS Components at Elevated Temperatures



Micrometering Valve Flow

60-11HF4-V