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FLOW DATA

For Apollo® and Saturn® Ball Valves

The listed Cv "factors" are derived from actual flow testing, in the Apollo® Ball Valve Division, Conbraco Industries, Inc., Pageland, South Carolina. These tests were completed using standard "off the shelf" valves with no special preparation and utilizing standard schedule 40 pipe. It should be understood that these factors are for the valve only and also include the connection configuration. The flow testing is done utilizing water as a fluid media and is a direct statement of the gallons of water flowed per minute with a 1 psig pressure differential across the valve/connection unit. Line pressure is not a factor. Because the Cv is a factor, the formula can be used to estimate flow of most media for valve sizing.

Flow of Liquid

$$Q = Cv \sqrt{\frac{\Delta P}{SpGr}}$$

$$\text{or } \Delta P = \frac{(Q)^2 (SpGr)}{(Cv)^2}$$

Where:

Q = flow in US gpm
 ΔP = pressure drop (psig)
 SpGr = specific gravity at flowing temperature
 Cv = valve constant

Flow of Gas

$$Q = 1360 Cv \sqrt{\frac{(\Delta P) (P_1)}{(SpGr) (T)}}$$

$$\text{or } \Delta P = \frac{5.4 \times 10^{-7} (SpGr) (T) (Q)^2}{(Cv)^2 (P_2)}$$

Where:

Q = flow in SCFH
 ΔP = pressure drop (psig)
 SpGr = specific gravity (based on air = 1.0)
 P₁ = outlet pressure-psia (psig + 14.7)
 T = (temp. °F + 460)
 Cv = valve constant

Cv FACTORS

SERIES:

70-100, 71-100, 71AR, 73A-100,
 74-100, 76-100, 80-100
 81-100, 89-100

SIZE		1/4"	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
OPEN	90°	8.4	7.2	15	30	43	48	84	108	503	370	670

Cv FACTORS

76F,77,77AR SERIES

SIZE		1/4"	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"
OPEN	90°	8.1	15	15	51	68	125	177	389	503

Cv FACTORS

82-100/200, 83R-100/200/700,86R-100/200/700,83-500/600,86-500/600/900 SERIES

SIZE		1/4"	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
OPEN	90°	8.1	14	26	51	68	120	170	376	510	996	1893

C_v FACTORS
87-100 & 88-100 SERIES
87A-100 & 88A-100 SERIES

SIZE	1/2" ⁽²⁾	3/4" ⁽²⁾	1" ⁽²⁾	1-1/2"	2"	2-1/2"	3"	4"	6"	8"	10" ⁽¹⁾
FULL OPEN	15	19	47	86	104	234	375	673	1099	1902	3890

C_v FACTORS
87A-200 & 88A-200 SERIES

SIZE	1"	1-1/2"	2"	2-1/2"	3"	4"	6"	8" ⁽¹⁾	10" ⁽¹⁾	12" ⁽¹⁾
FULL OPEN	75	195	410	545	1021	2016	4837	9250	15170	22390

- (1) Calculated Data
(2) 87-100 & 88-100 Only

C_v FACTORS
9A-100, 90-100, 91-100,
92-100, 93-100 & 96-100 SERIES

SIZE	1/4"	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
OPEN 90°	8.3	6.7	5.7	10	16	25	40	62

C_v FACTORS
83-300/400, 85-100/200 SERIES

SIZE	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
FULL OPEN	16	18	35	48	84	104

C_v FACTORS
70-600 & 76-600 SERIES

SIZE	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
FULL OPEN	5.4	12	14	21	34	47

C_v FACTORS
"72" SERIES

SIZE	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
FULL OPEN	26	48	65	125	170	216



Engineering Data

CAUTION

IT IS THE RESPONSIBILITY OF THE INSTALLER AND/OR SYSTEM DESIGNER TO ENSURE THAT THESE VALVES ARE INSTALLED IN ACCORDANCE WITH APPLICABLE AND CURRENT ANSI B31 STANDARDS.

FOLLOWING, ARE SOME SAFEGUARDS THAT MUST BE CONSIDERED PRIOR TO INSTALLATION.

EASE OF OPERATION - BALL VALVES ARE EASIER TO OPERATE THAN OTHER TYPES OF SHUT-OFF VALVES. WHEN THESE VALVES ARE INSTALLED SO THAT THERE IS A POSSIBILITY THAT THE HANDLES CAN BE HOOKED OR SNAGGED, APPROPRIATE ACTION TO PREVENT ACCIDENTAL OR UN-WANTED OPENING OR CLOSING OF THE VALVE MUST BE TAKEN. VIBRATIONS IN, THROUGH OR AROUND THE VALVE CAN ALSO CAUSE ACCIDENTAL OR UN-WANTED OPENING OR CLOSING OF THE VALVE.

PRESSURE RELIEF - DETERMINE AND PROVIDE CORRECTIVE ACTION AGAINST EXCESSIVE PRESSURE BUILD UP IN THE VALVE OR PIPING SYSTEM DUE TO THERMAL EXPANSION. THERMAL EXPANSION CAN CREATE EXTREME PRESSURES WELL ABOVE THE WORKING PRESSURE LIMIT OF THE VALVE WHICH CAN CAUSE LEAKING OR BURSTING OF THE VALVE.

SUPPORTS - IF YOU CHOOSE TO CONNECT A FLEXIBLE HOSE OR OTHER NON-RIDGED CONDUIT TO THE VALVE, THE DESIGN OF SUCH INSTALLATION MUST PREVENT ANY "WHIPPING ACTION" THAT COULD INJURE OR DAMAGE PERSONNEL OR EQUIPMENT. VALVE MUST BE IMMOBILE.

FITTINGS - USE ONLY THOSE FITTINGS OR PIPING THAT ARE COMPATIBLE WITH THE VALVES BEING USED TO PREVENT BREAKAGE AND/OR LEAKAGE. (AS FOR ONE EXAMPLE, IT IS POOR PRACTICE AND NEVER RECOMMENDED TO USE PLASTIC PIPE OR FITTINGS WITH METALLIC VALVES SINCE THERMAL EXPANSION, EXTERNAL FORCES OR OTHER SITUATIONS CAN CAUSE BREAKAGE OR LEAKAGE AT OR NEAR THE JOINT).

PRESSURE/TEMPERATURE LIMITS - THE MAXIMUM WORKING PRESSURE LIMIT OF THE VALVE IS MARKED ON THE VALVE BODY. NEVER EXCEED THIS "WOG" RATING WHICH IS SPECIFIED UP TO 100°F. TEMPERATURES HIGHER THAN 100°F DECREASE THE MAXIMUM WORKING PRESSURE LIMIT. REFER TO THE APPROPRIATE PRESSURE/TEMPERATURE CHART THAT IS PUBLISHED IN THE CATALOG.

FREEZING - PROVIDE MEANS TO PROTECT THE VALVE FROM FREEZING AND BURSTING WHEN USED WITH LIQUIDS.

FLUID COMPATIBILITY - CONSIDER THE CORROSIVE, EROSION AND ADHESIVE EFFECTS OF FLUIDS ON THE VALVE AND PIPING COMPONENTS. IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE VALVE IS COMPATIBLE WITH THE MATERIAL(S) USED IN THE SYSTEM.

INSTALLATION - THE USE OF TFE PIPE TAPE AS A SEALANT IS RECOMMENDED FOR THREADED VALVES WHEN MAKING JOINTS. CORRECT LUBRICATION OF STAINLESS STEEL PIPE THREADS IS ESPECIALLY IMPORTANT TO PREVENT THREAD GALLING. DO NOT APPLY EXCESSIVE TORQUE WHEN INSTALLING THE VALVE. TO PREVENT DISTORTION OR DAMAGE TO THE VALVE, DO NOT APPLY TORQUE THROUGH THE VALVE. USE PROPER SUPPORTS IN HANDLING PRE-FABRICATED SECTIONS AND IN FINAL INSTALLATION. **ALWAYS TEST THE SYSTEM BEFORE USING.**

MAINTENANCE - DO NOT DISASSEMBLE THE VALVE WHILE UNDER PRESSURE. REQUEST A MAINTENANCE MANUAL BEFORE ATTEMPTING REPAIRS TO THE VALVE.

FOR BRONZE VALVES - WARNING - THIS PRODUCT IS MADE FROM BRONZE ALLOYS WHICH CONTAIN LEAD; A CHEMICAL KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER AND BIRTH DEFECTS AND OTHER REPRODUCTIVE HARM. (PLUMBER CALIFORNIA LAW REQUIRES THAT THIS WARNING BE GIVEN TO THE CONSUMER).

Torque Constants for Apollo AR™ Two Piece Actuator Ready Valves

DIFFERENTIAL PRESSURE psig		100	200	400	600	800	1000	1500	2000	LSSST***	-24 Adder
Valve Model	Size									(in.-lbs)	(in.-lbs.)
**STD PORT **71-ARX-64 89-ARX-64 76-ARX-64	1/4 - 1/2	25	26	27	28	30	32	35	38	50	45
	3/4	50	50	52	54	57	60	64	72	100	45
	1	85	86	88	90	94	97	110	138	170	56
	1-1/4	140	140	145	156	160	172	194		280	96
	1-1/2	160	164	173	186	195	201	235		320	96
	2	220	230	258	270	310	350	460		440	96
	2-1/2	450	495	596	680	790	900			900	96
3	500	540	700	820	920	1030			1000	96	
*FULL PORT **77-ARX-64	1-1/4 - 1/2	25	26	27	28					50	45
	3/4	50	54	60	70					100	56
	1	140	148	160	180					280	56
	1-1/2	290	300	310	340					580	96
	2	340	355	420	563					680	96

* Torques tested with multifilled seats. Does not require torque adjustment of -20%.

*** LSST - Long Stand Still Torque

** 71-ARX-64 and 77-ARX-64 rated to 600 psig maximum.

Torque Constants for Apollo End Entry Valves (1),(2)

TORQUE CONSTANT (lb-in) AT DIFFERENTIAL PRESSURE INDICATED (psig)										
DIFFERENTIAL PRESSURE psig		200	400	600	800	1000	1500	LSST*	-24 / -29 Adder	
Valve Model	Size							(in.-lbs)	(in.-lbs.)	
STD PORT 70-64X 71-14X 76-10X 76-60X 89-14X 399-10X	1/4 - 1/2	35	35	40	43	46	48	70	45	
	3/4	50	50	54	59	62	64	100	45	
	1	101	101	103	106	116	130	202	56	
	1-1/4	171	171	205	216	246	286	342	96	
	1-1/2	192	192	216	265	280	311	384	96	
	2	271	271	276	300	309	354	542	96	
	2-1/2 & 3	715	715	790		1200		1430	96	
full port bronze 77-14X	1/4 - 1/2	35	35	40				70	45	
	3/4	74	74	84				148	56	
	1	234	234	250				468	56	
	1-1/4	286	286	321				552	56	
	1-1/2	357	357	398				714	96	
	2	650	650	722				1300	96	
2-1/2 & 3	715	715	790				1430	111		
STD PORT 3-PIECE 83-34X & 44X 85R-10X & 20X	1/2	35	35	40	43	46	48	70	45	
	3/4	78	78	90	123	140	157	156	56	
	1	156	156	178	201	229	257	312	56	
	1-1/4	208	208	230	248	282	317	416	96	
	1-1/2	234	234	276	309	352	395	468	96	
	2	350	350	390	450	513	576	700	96	
FULL PORT 3-PIECE 82-14X & 24X 83R-14X,24X & 74X 83-54X & 64X 86R-10X,20X & 70X 86-50X & 60X 401R-10X	1/4 - 1/2	78	78	90	123	140	157	156	56	
	3/4	156	156	178	201	229	257	312	56	
	1	208	208	230	248	282	317	416	96	
	1-1/4	234	234	276	309	352	395	468	96	
	1-1/2	350	350	390	450	513	576	700	96	
	2	715	715	755	800	912	1024	1430	96	
	3	1030	1030	1087	1148	1212		2060	201	
	4	1830						3660	399	

* LSST - Long Stand Still Torque

Torque Constants for Apollo Flanged Ball Valves

Torques Shown in lb-in.		Pressure (psig)									LSST*** -24 Adder	
Valve Series	Valve Size	0	100	200	300	400	500	600	700	740	(in.-lbs)	(in.-lbs.)
87A-100's 88A-140's 87B-100's 88B-100's	1-1/2" SP 150	132	144	155	167						264	68
	2" SP 150	176	193	211	228						352	96
	2-1/2" SP 150	231	254	277	300						462	127
	3" SP 150	253	327	402	476						506	127
	4" SP 150	550	630	710	790						1100	292
	6" SP 150	770	911	1052	1193						1540	292
	8" SP 150	2200	2494	2788	3081						4400	661
	10" SP 150	3300	3580	3860	4140						6600	661
87A-200's 88A-240's	1/2" FP 150	22	22	22	22						44	45
	3/4" FP 150	39	43	47	51						77	68
	1" FP 150	132	144	155	167						264	68
	1-1/2" FP 150	176	193	211	228						352	96
	2" FP 150	231	254	277	300						462	127
	2-1/2" FP 150	253	327	402	476						506	127
	3" FP 150	550	630	710	790						1100	292
	4" FP 150	770	911	1052	1193						1540	292
	6" FP 150	2200	2494	2788	3081						4400	661
	8" FP 150	3300	3580	3860	4140						6600	661
	10" FP 150	4400	5059	5718	6377						8800	988
	12" FP 150	4950	8300	11650	15000						9900	988
87A-700's 88A-740's	1-1/2" SP 300	132	144	155	167	178	190	201	213	217	264	68
	2" SP 300	176	193	211	228	245	262	280	297	304	352	96
	2-1/2" SP 300	231	254	277	300	323	346	369	392	401	462	127
	3" SP 300	253	327	402	476	551	625	700	774	804	506	127
	4" SP 300	550	630	710	790	870	950	1030	1110	1142	1100	292
	6" SP 300	770	911	1052	1193	1333	1474	1615	1756	1812	1540	292
	8" SP 300	2200	2494	2788	3081	3375	3669	3963	4257	4374	4400	661
	10" SP 300	3300	3580	3860	4140	4420	4700	4980	5260	5372	6600	661
87A-900's 88A-940's	1/2" FP 150	22	22	22	22	23	23	23	23	23	44	45
	3/4" FP 150	39	43	47	51	55	59	63	67	69	77	68
	1" FP 300	132	144	155	167	178	190	201	213	217	264	68
	1-1/2" FP 300	176	193	211	228	245	262	280	297	304	352	96
	2" FP 300	231	254	277	300	323	346	369	392	401	462	127
	2-1/2" FP 300	253	327	402	476	551	625	700	774	804	506	127
	3" FP 300	550	630	710	790	870	950	1030	1110	1142	1100	292
	4" FP 300	770	911	1052	1193	1333	1474	1615	1756	1812	1540	292
	6" FP 300	2200	2494	2788	3081	3375	3669	3963	4257	4374	4400	661
	8" FP 300	3300	3580	3860	4140	4420	4700	4980	5260	5372	6600	661
	10" FP 300	4400	5059	5718	6377	7036	7696	8355	9014	9277	8800	988
	12" FP 300	4950	8300	11650	15000	18349	21699	25049	28399	29739	9900	988

Note (1) Constants are used to determine the in-service torque requirements of Conbraco's valves.

Note (2) Constants are based on RPTFE seats and clean dry air at the stated differential pressure.

*LSST - Long Stand Still Torque

Torque Constants for Apollo End Entry Valves (1)

DIFFERENTIAL PRESSURE								
Seat Options	Valve Size	100	285	500	740	1480	LSST* (in.-lbs)	Graphoil® (in.-lbs.)
1 7 2 A 3 C 5 D U **6 Z**	1/2 thru 1	85	110	140	180	290	170	68
	1-1/2	205	260	330	415	660	410	96
	2	350	430	550	735	1200	700	127
	3	950	1250	1650	2000	3200	1900	245
	4	2000	2500	330	4100	6500	4000	399
	6	5300	6700	8200	11,400	18,000	10,600	661
	8	11,000	14,000	18,500	25,000	36,000	22,000	900
4 8 **** 9 B	10	18,500	22,000	30,000	40,000	62,000	37,000	1326
	1/2 THRU 1	115	160	210	260	450	230	68
	1-1/2	270	370	480	590	1000	540	96
	2	475	650	860	1050	1750	950	127
	3	1250	1850	2400	2950	4900	2500	245
	4	2700	3700	4-00	5900	10,000	5400	399
	6	7410	10,100	13,400	16,400	25,300	14,820	661
8	15,000	20,000	26,000	32,000	56,000	30,000	900	
10	25,000	32,000	45,000	60,000	96,000	50,000	1326	

*LSST - Long Stand Still Torque

** Rated torque for #6 and U seat add 30%.

*** Rated torque for #1 & #7 PTFE seats can be reduced by 30%.

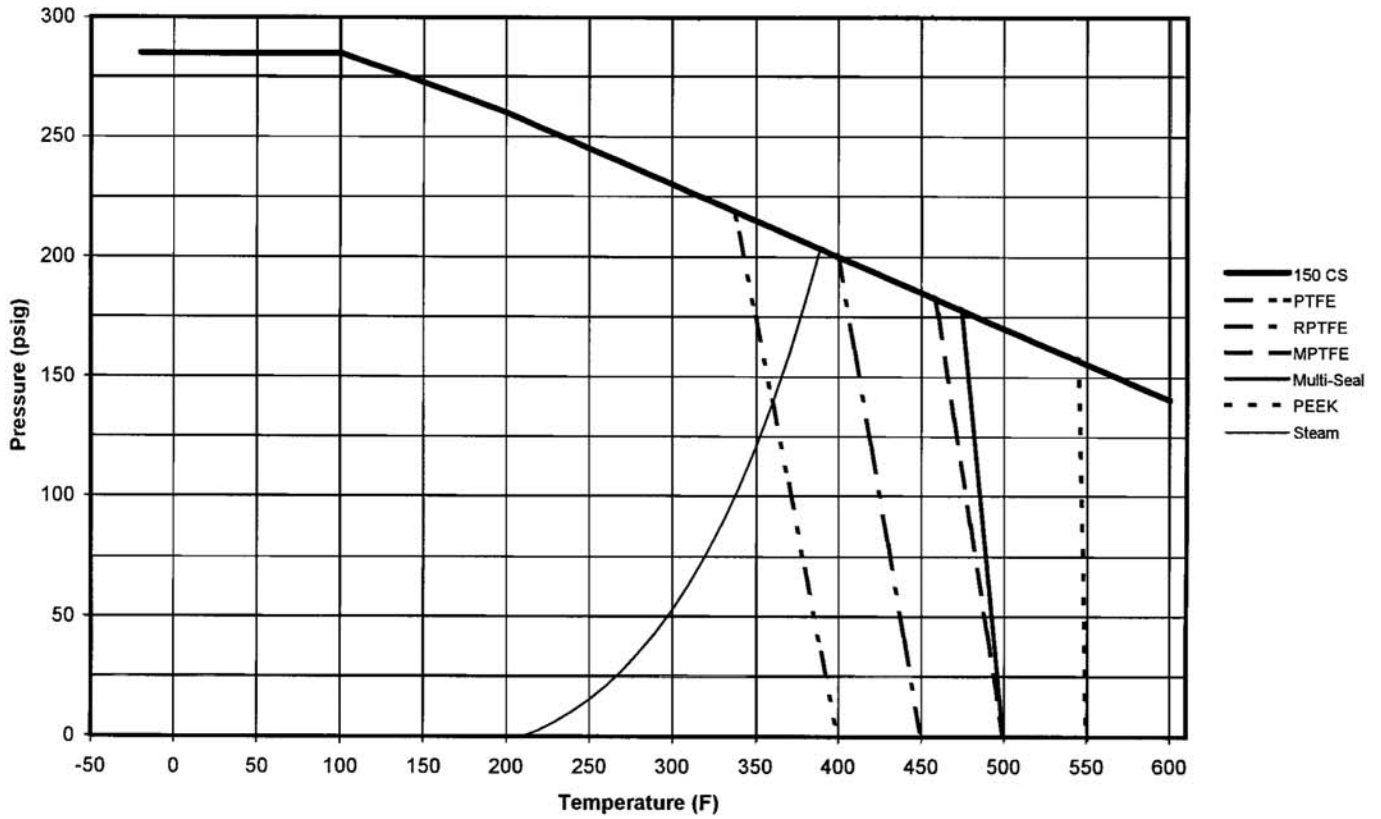
**** Rated torque for #9 ceramic seat is to be increased by 10%.

Conbraco Industries

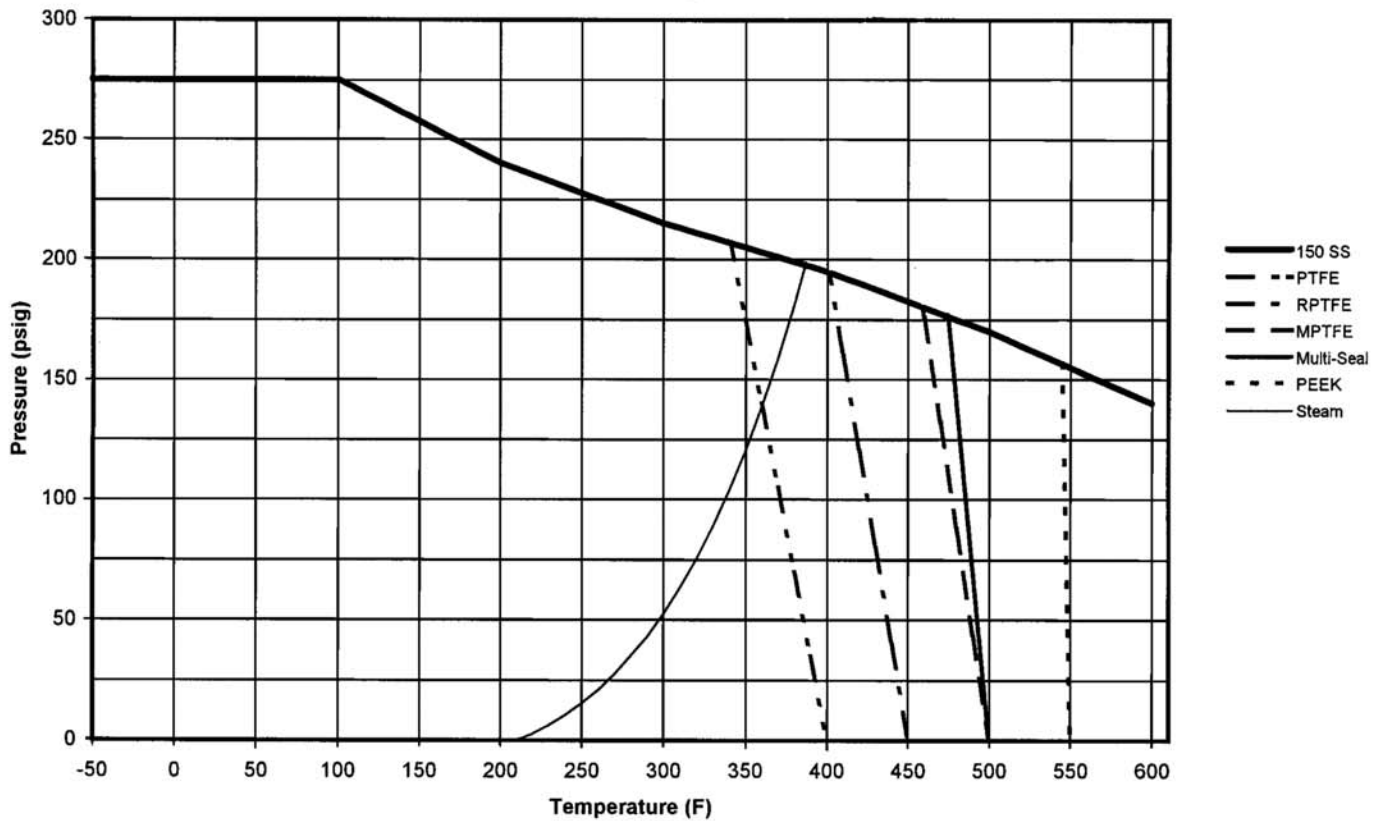
Apollo® Ball Valve Seat Application Guide

Designation	Range	General Description
-01 (RPTFE)	to 450°F	Glass Reinforced PolyTetraFluoroEthylene Seat Seals and Packings: Most commonly specified seat material. Maintains the chemical resistance of PTFE with increased resistance to wear and abrasion resulting in longer life.
-21 (UHMWPE)	to 180°F	Ultra High Molecular Weight Polyethylene Seats with Graphite Seals and Packings: Offers good abrasion resistance making it suitable for use in high solids or slurry applications. This seat is frequently specified in services where fluorine off-gassing in even the slightest amounts is objectionable, services such as food and tobacco processing, and Nuclear services. UHMWPE should be used with caution in the presence of solvents, and the operating torque can be expected to be 30% higher than RPTFE seat materials.
-35 (PTFE)	to 400°F	PolyTetraFluoroEthylene (PTFE) Seats, Seals and Packings: General application seat material, exhibiting lowest operating torque and excellent resistance to chemical attack.
-38 (PEEK)	to 550°F	PolyEtherEtherKetone Seats with Graphite Seals and Packings: Offers a high strength alternative to RPTFE, resistant to creep and cold flow. This seat offers good abrasion resistance. This material offers similar chemical resistance to PTFE but should be checked on application. Operating torque tends to be 40% higher than RPTFE.
-56 (Multifill)	to 500°F	Carbon and Graphite Reinforced PTFE Seats, Seals and Packings: Reduced creep and cold flow like any RPTFE but with 20% lower operating torque than the glass reinforced versions.
-64 (Multifill)	to 500°F	Carbon and Graphite Reinforced PTFE Seats, Seals and Packings: Reduced creep and cold flow like any RPTFE but with 20% lower operating torque than the glass reinforced versions. Includes handle graphics for 250 psig saturated steam.
-65 (Multifill)	to 500°F	Carbon and Graphite RPTFE Seats, Graphite Seals and Packings: Reduced creep and cold flow like any RPTFE but with 20% lower operating torque than the glass reinforced versions. This configuration is also good for steam applications.
-78 (Delrin)	to 230°F	Delrin is the homopolymer version of Acetal. The material is both strong and rigid but not brittle making it ideal for many high pressure applications. It's a preferred material for use in hydrocarbon systems, oils and gases, but should be used with caution in hot wet systems.
-79 (Nylon)	to 300°F	Nylon is a polyamide. This material has very good mechanical properties making it ideally suited for many high pressure applications. It's a preferred material for use in hydrocarbon systems, oils and gases, but should not be used in wet systems above 120°F.
-80 (Multiseal)	to 500°F	This material is the latest generation of PolyTetraFluoroEthylene. Currently offered only as seats in our Flanged and Top Entry products, this material improves on the chemical resistance of PTFE with increased resistance to wear, abrasion and creep resistance even above the glassed reinforced PTFE, without fillers. This material is particularly suited for primary monomer applications such as styrene, butadiene and latex offering performance nearly equal to PFA materials.

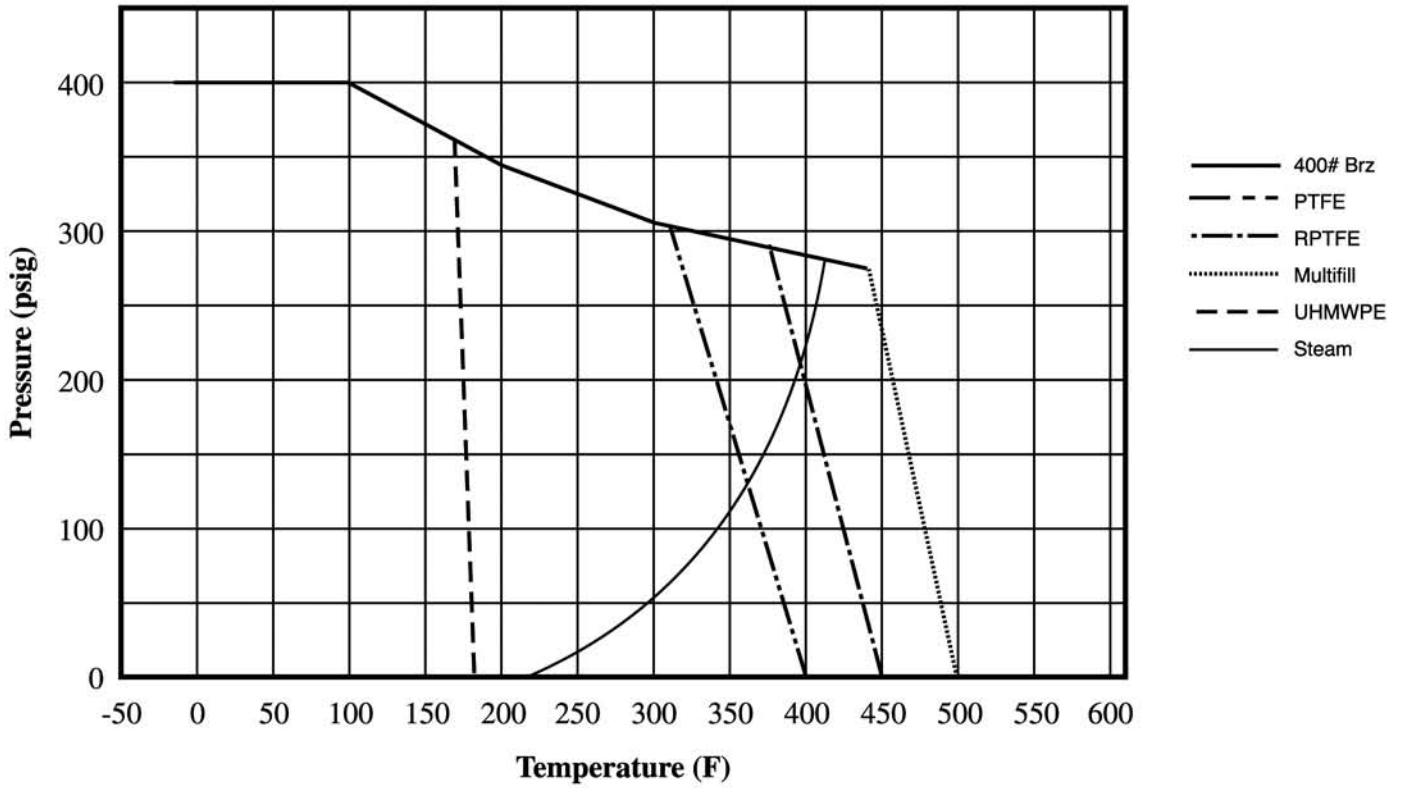
Class 150 CS P-T Rating (Graph 1)



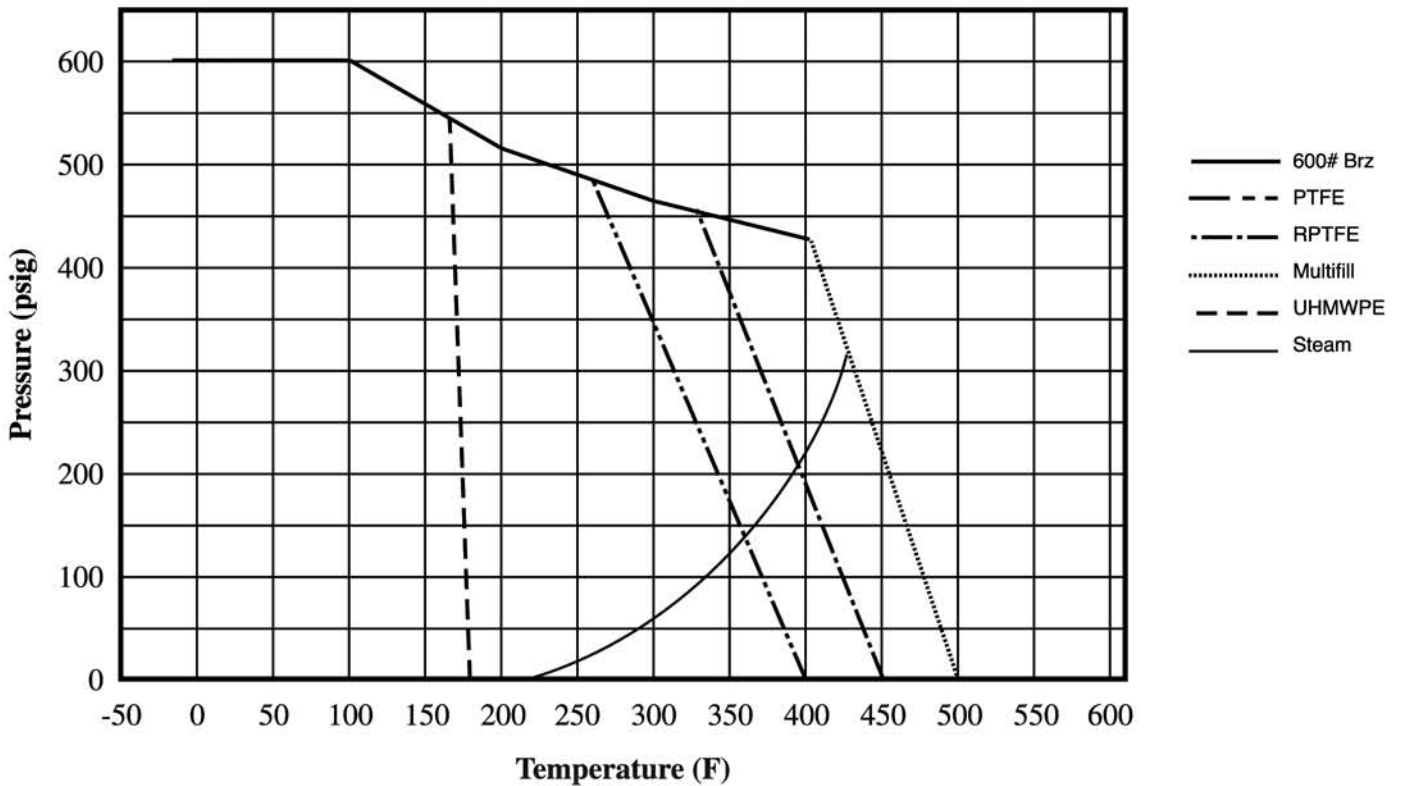
Class 150 SS P-T Rating (Graph 2)



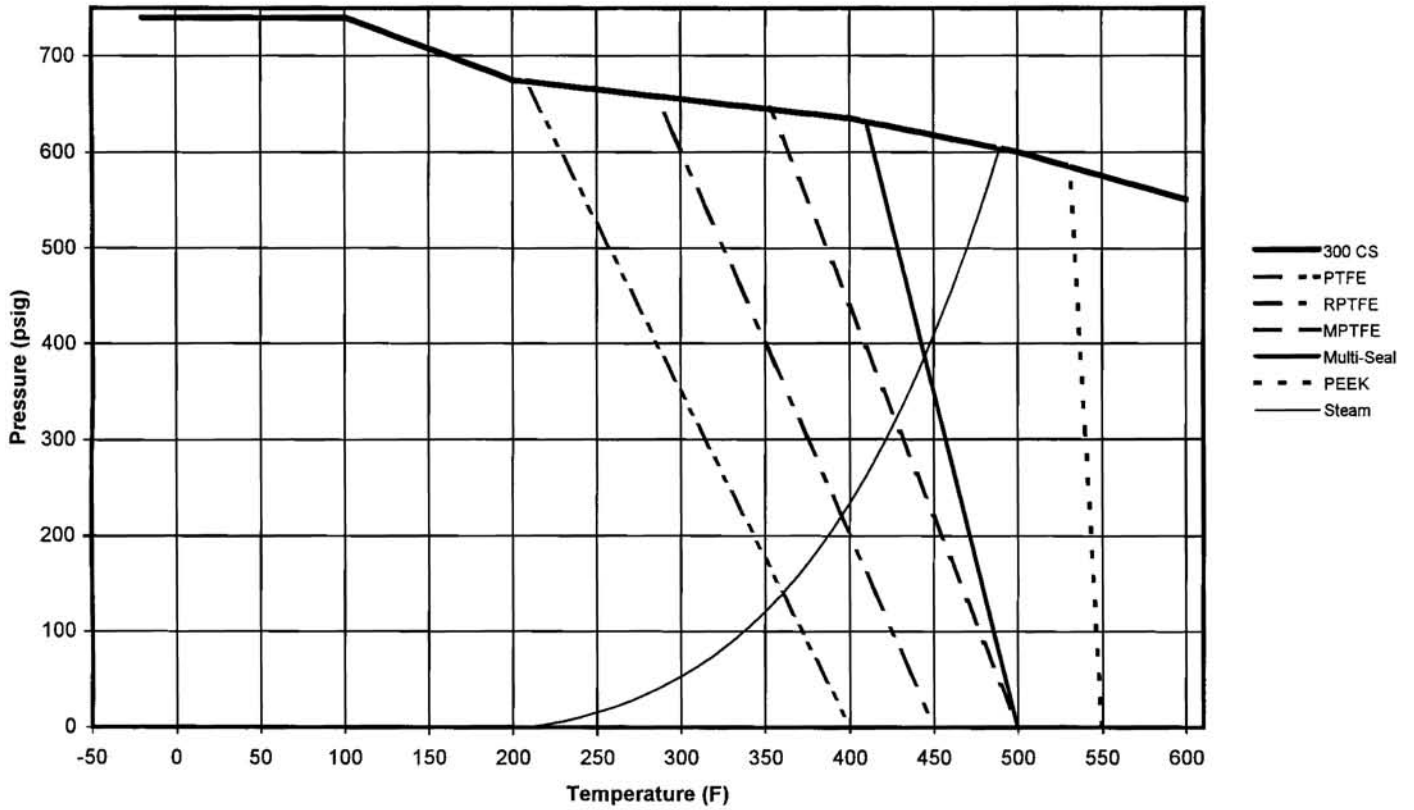
400# Bronze P-T Rating (Graph 3)



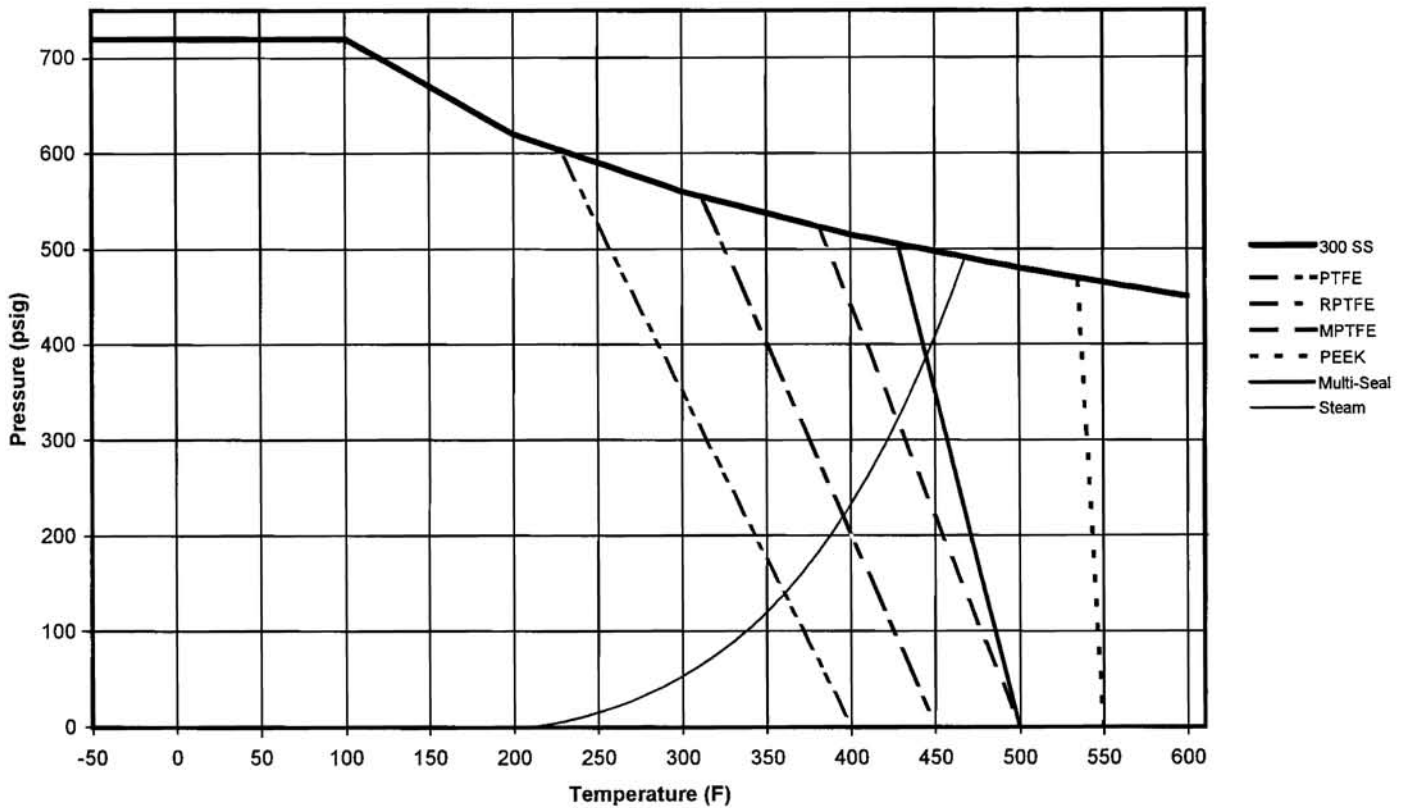
600# Bronze P-T Rating (Graph 4)



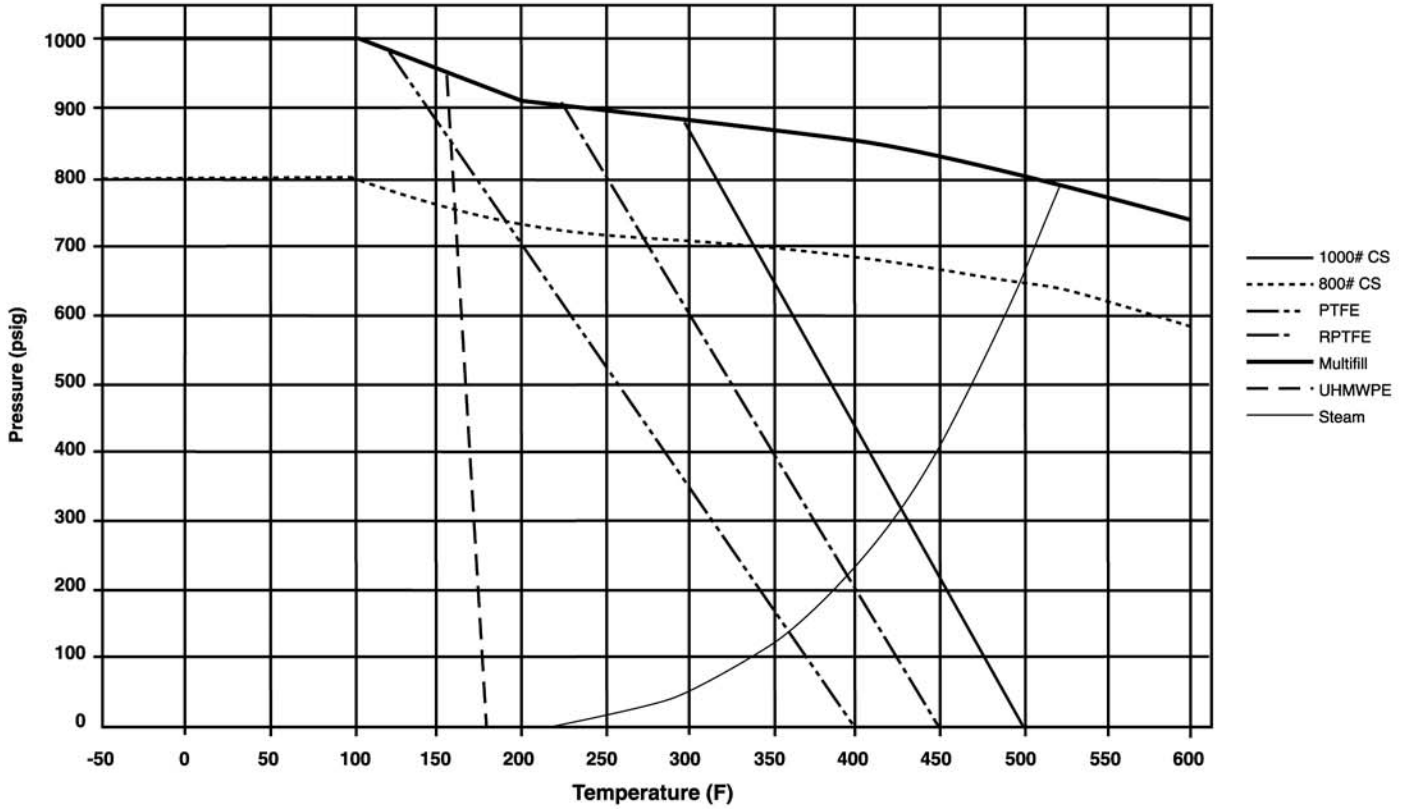
Class 300 CS P-T Rating (Graph 5)



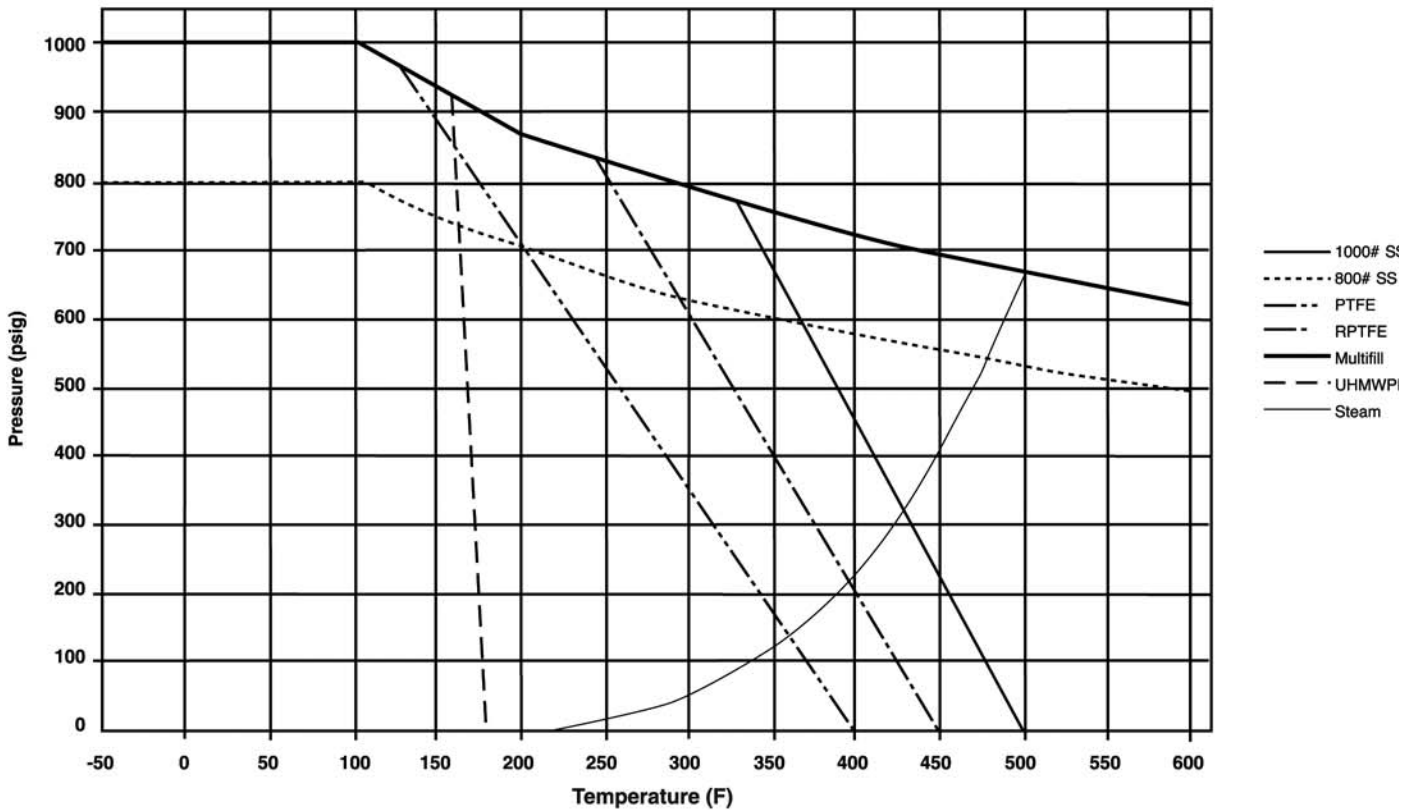
Class 300 SS P-T Rating (Graph 6)



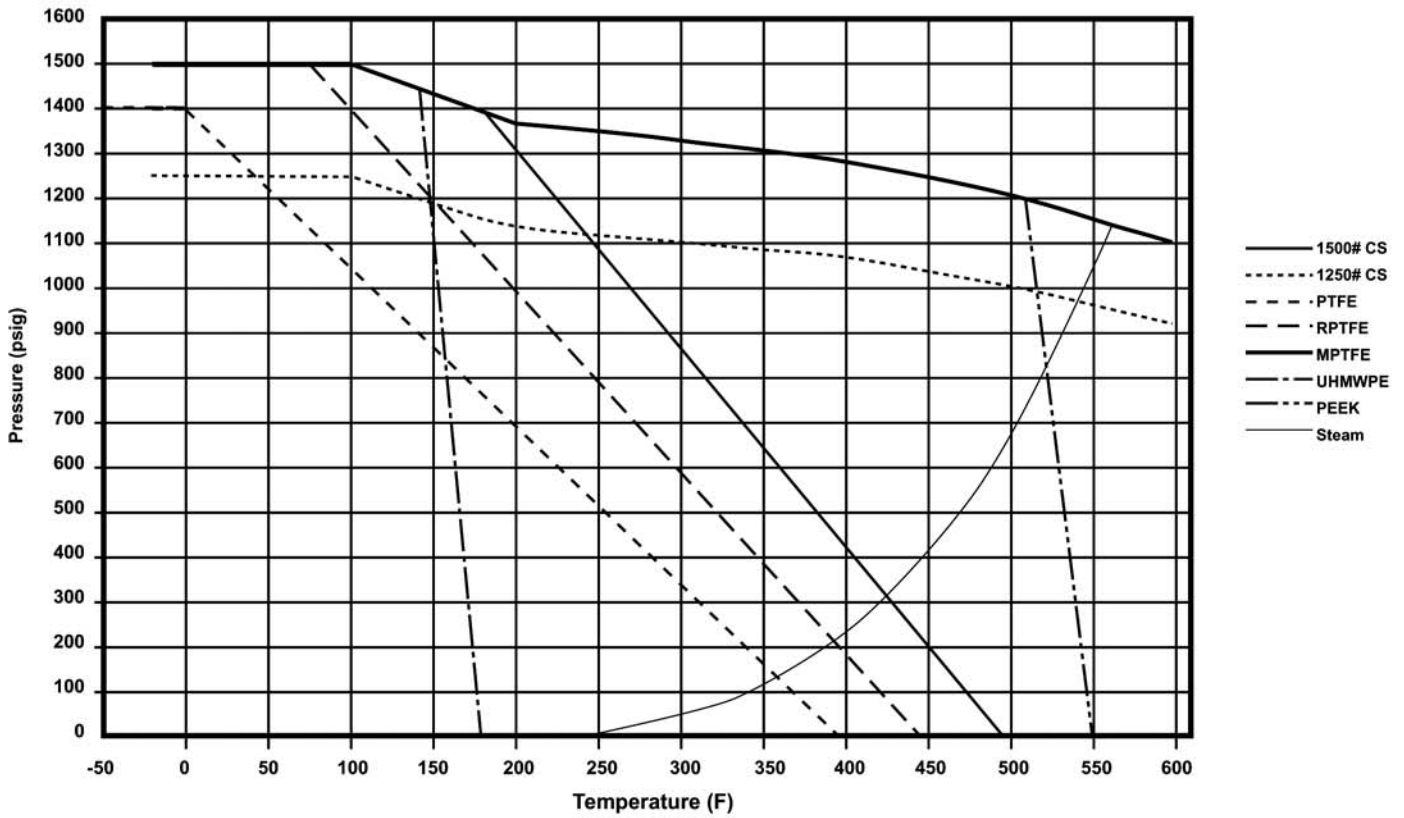
1000# CS P-T Rating (Graph 7)



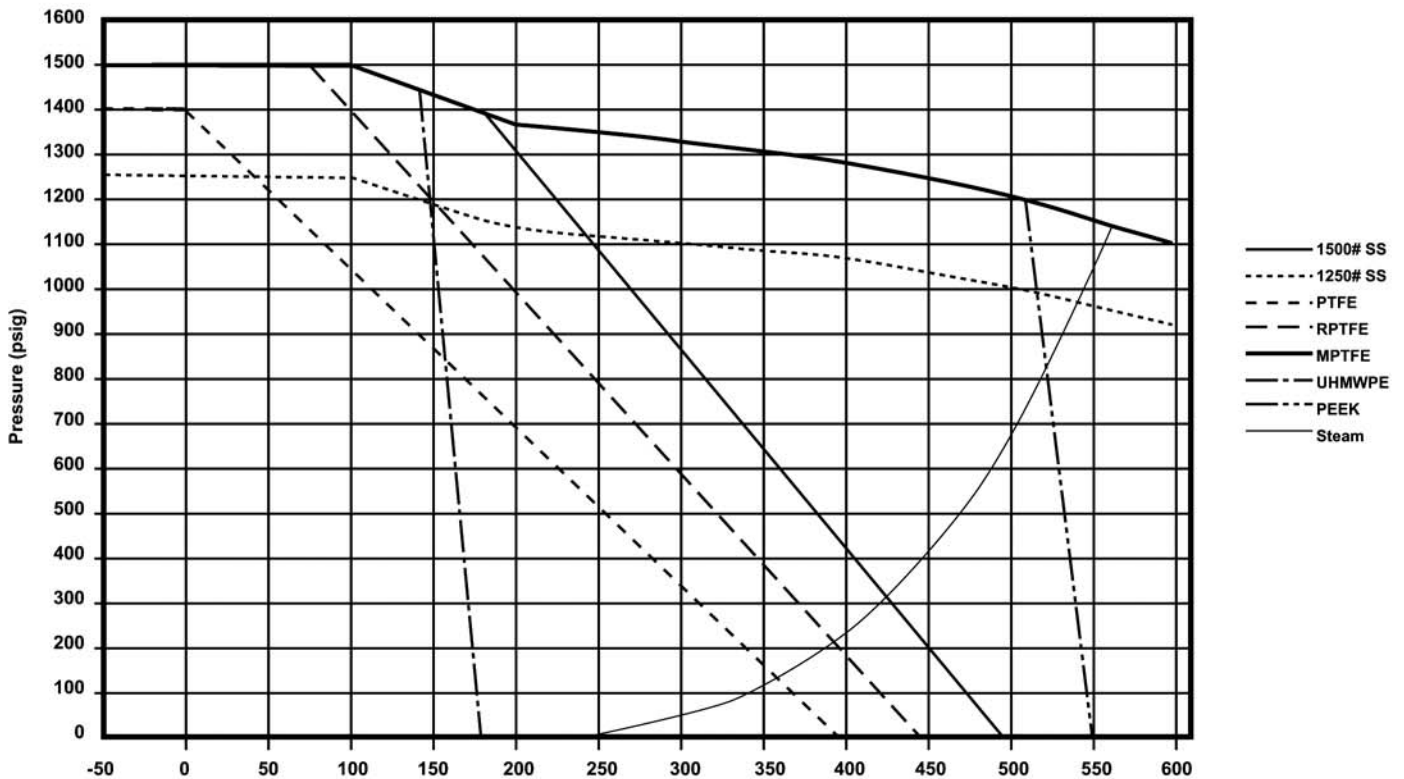
1000# SS P-T Rating (Graph 8)



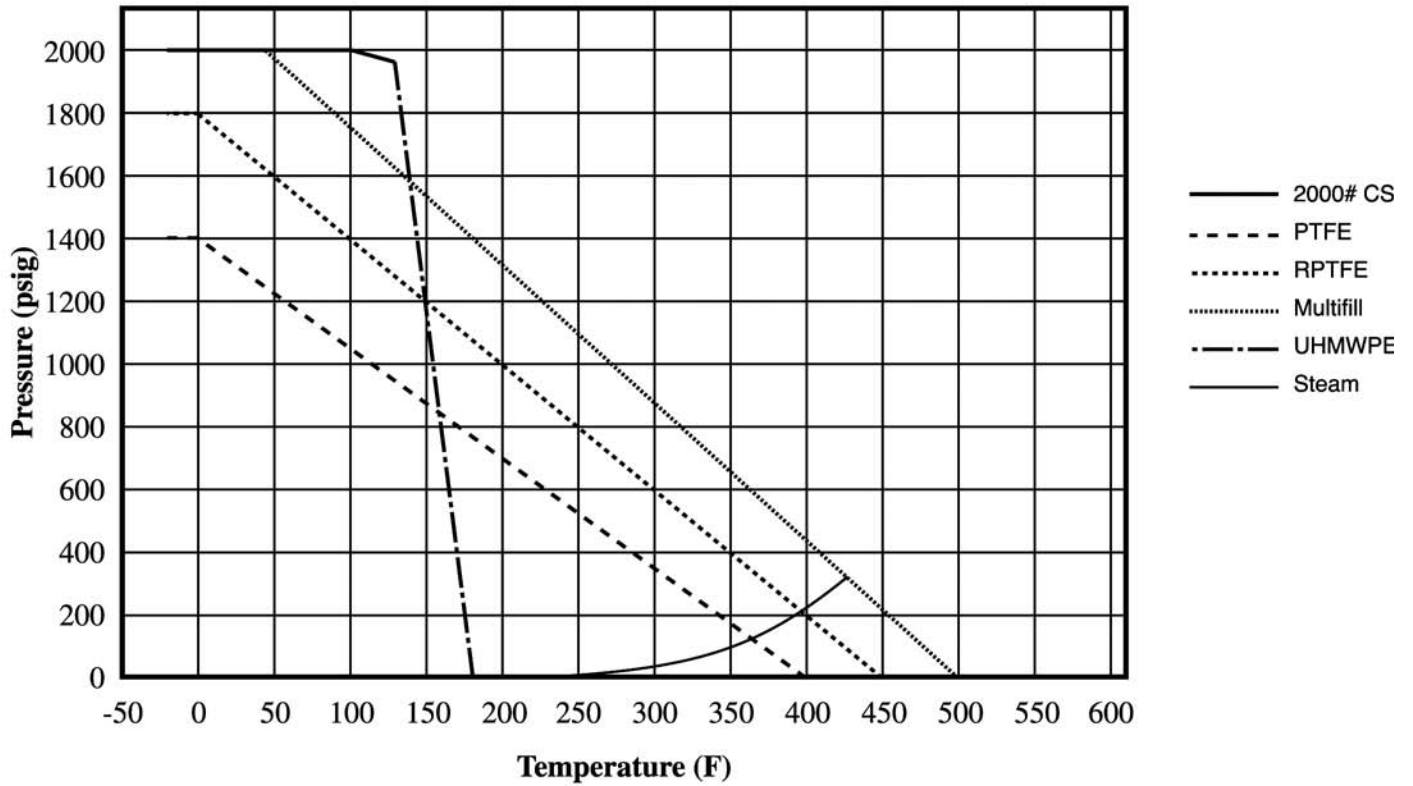
1500# CS P-T Rating (Graph 11)



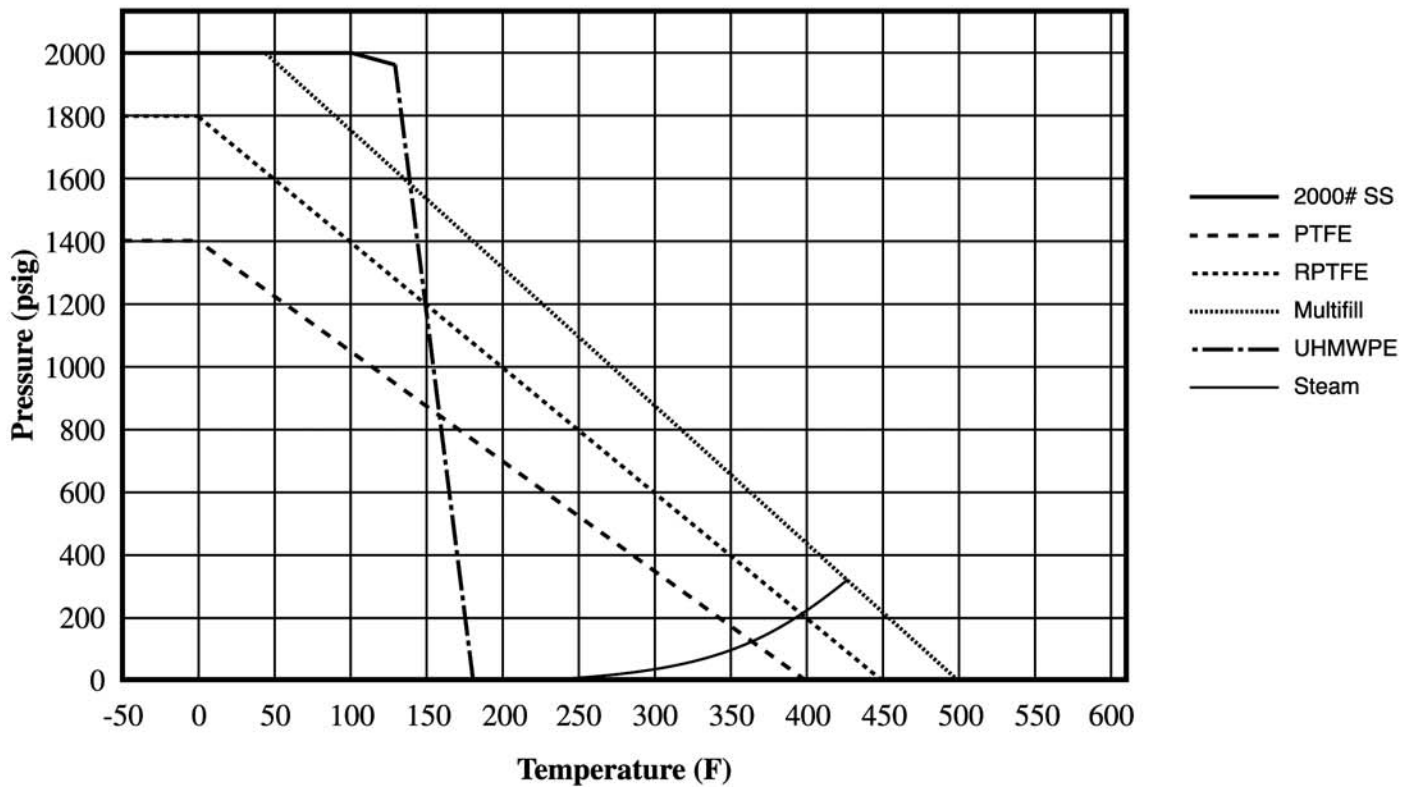
1500# SS P-T Rating (Graph 12)



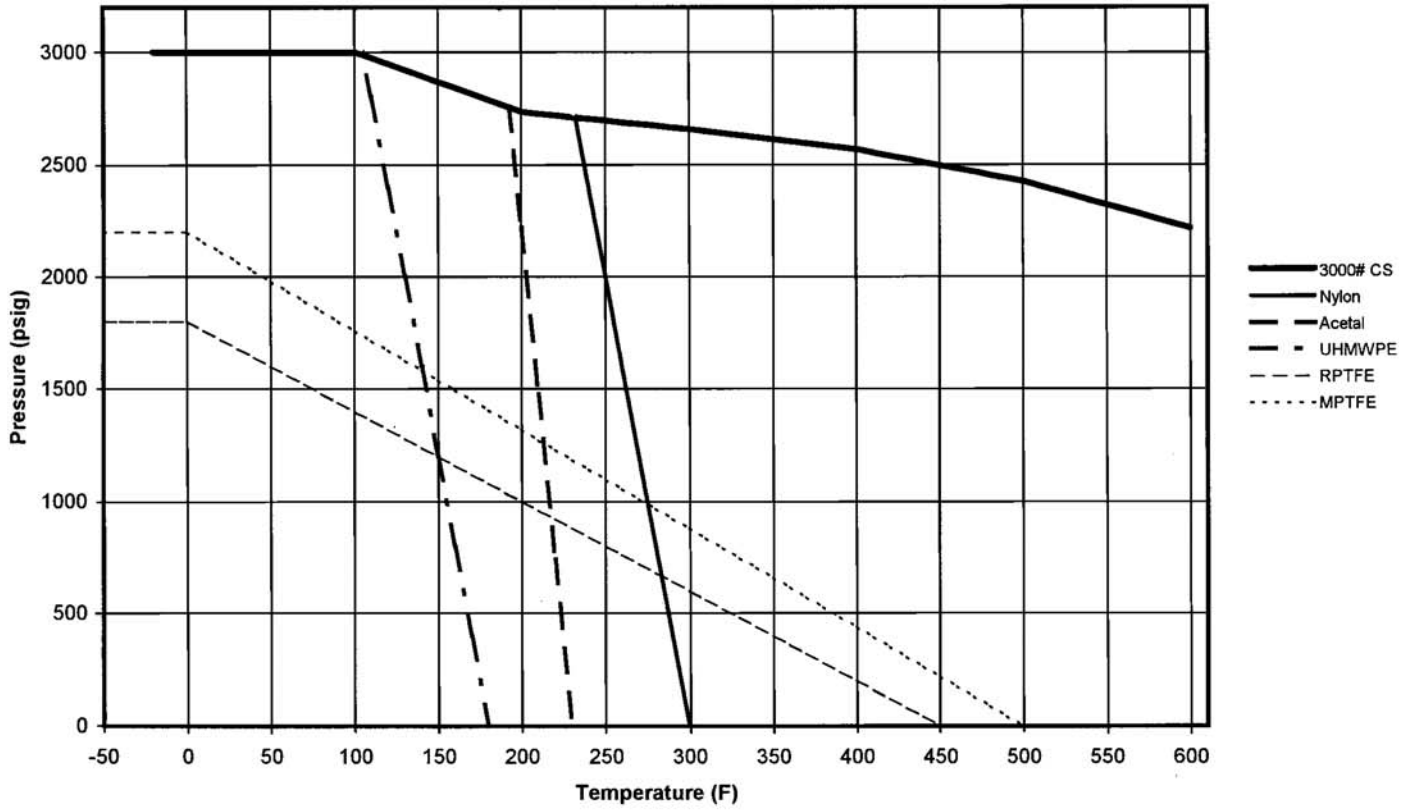
2000# CS P-T Rating (Graph 13)



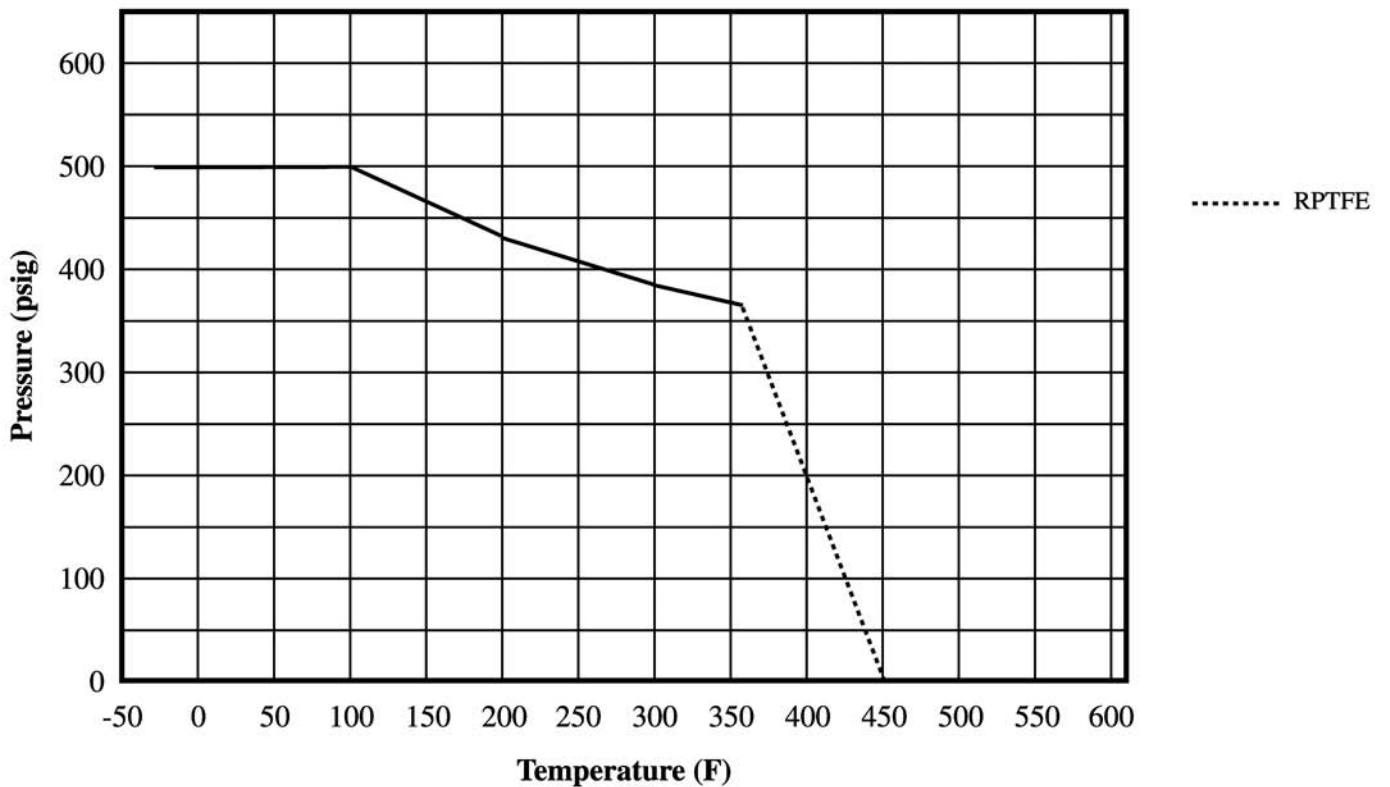
2000# SS P-T Rating (Graph 14)



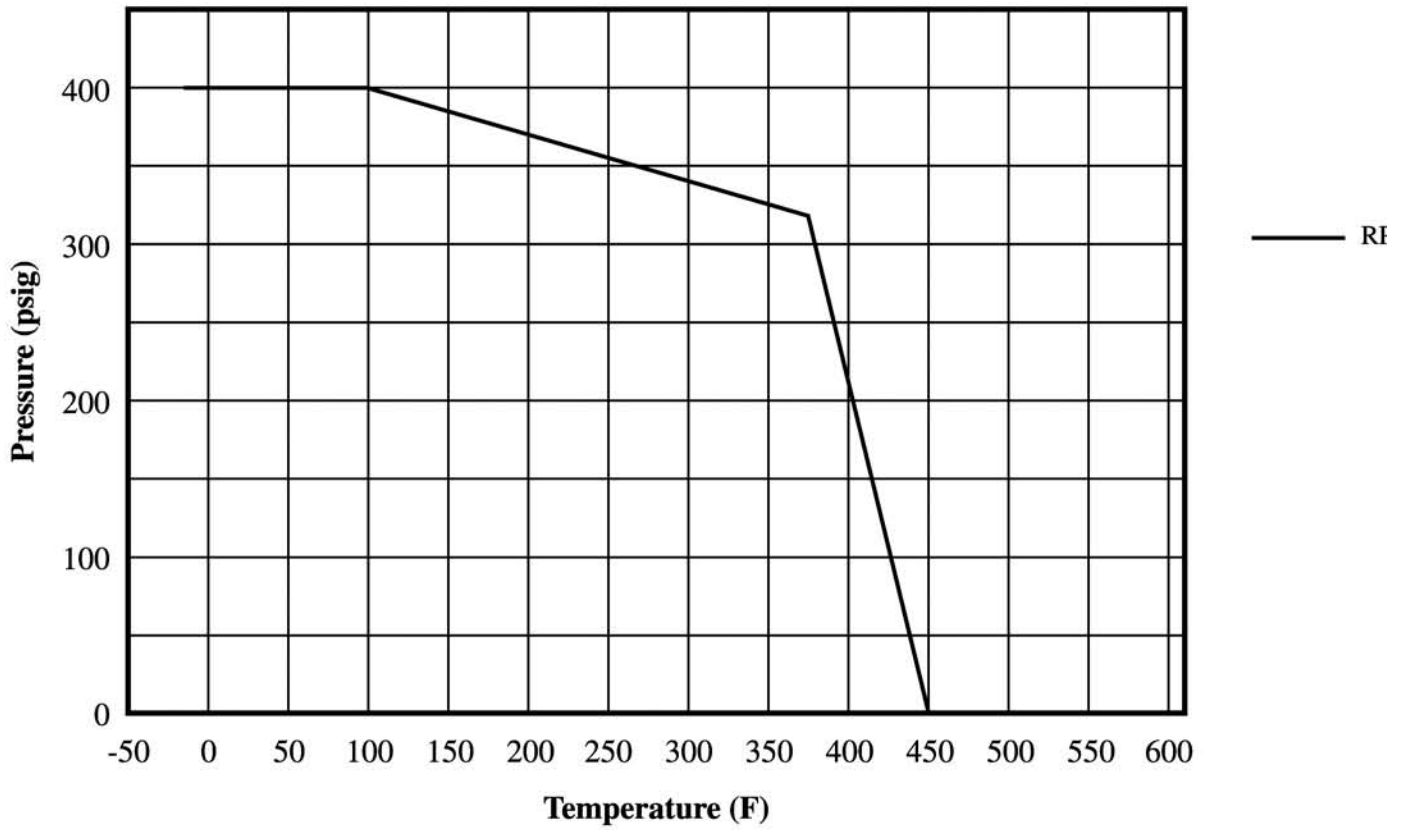
3000# CS P-T Rating (Graph 15)



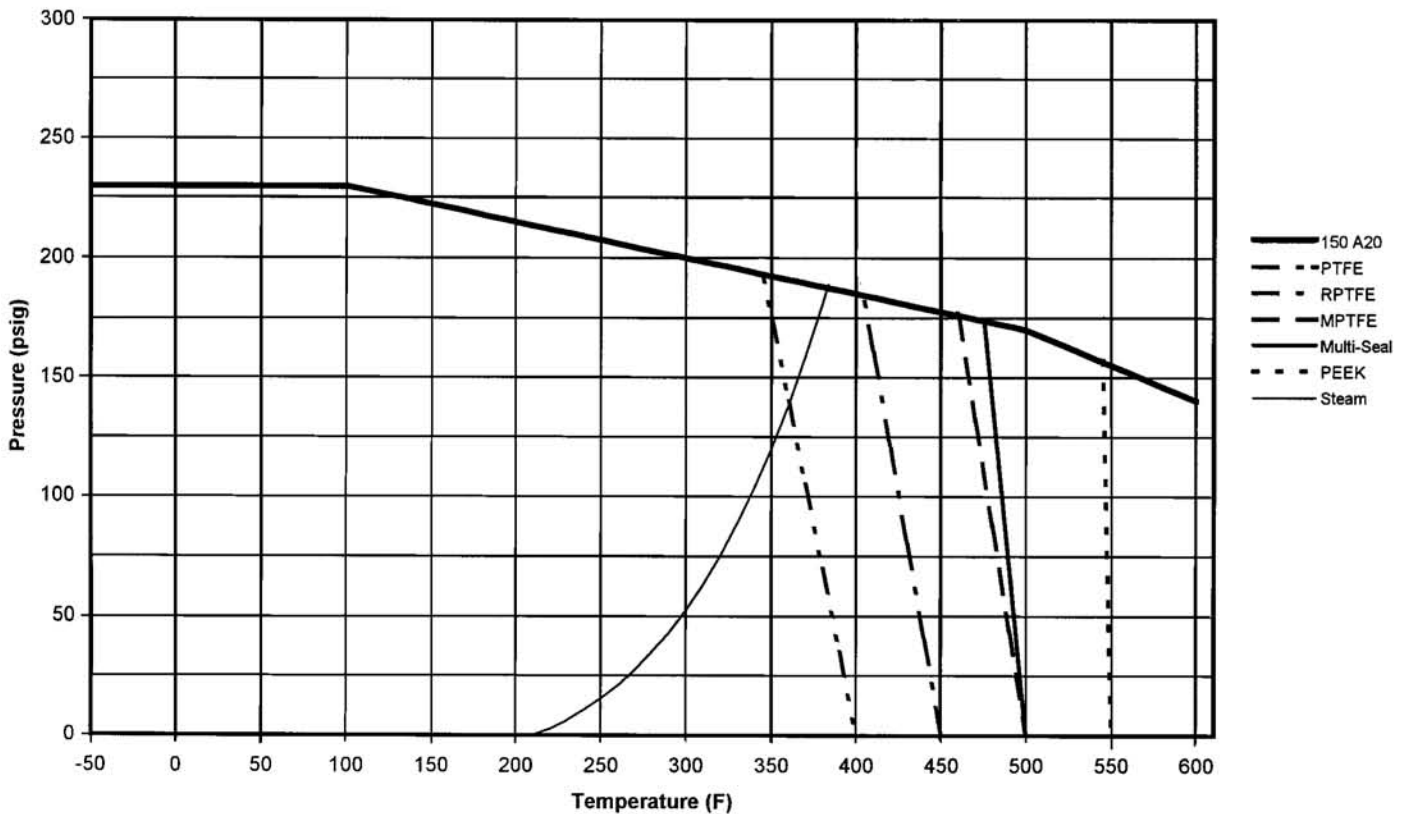
Refrigeration Valve P-T Rating (Graph 16)



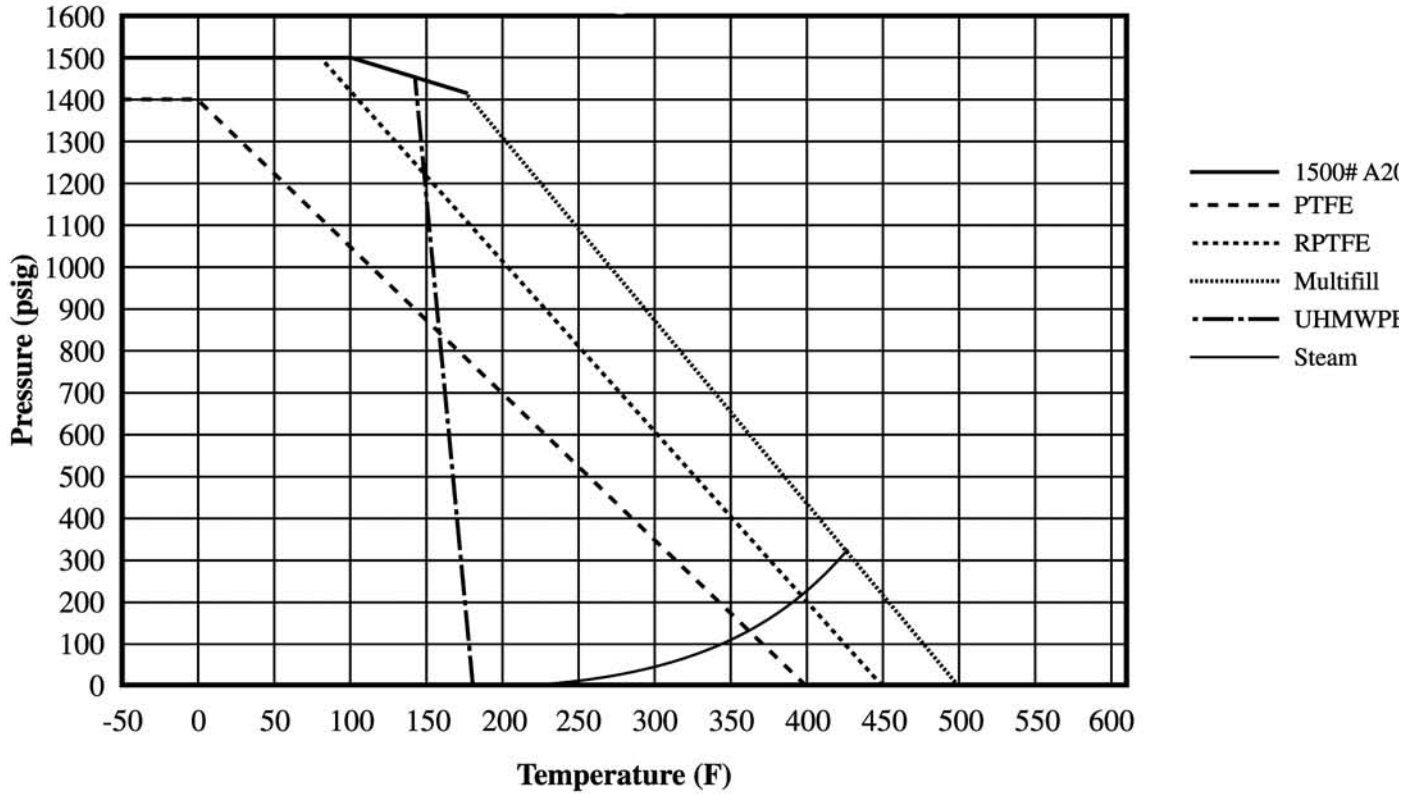
400# CS P-T Rating (Graph 17)



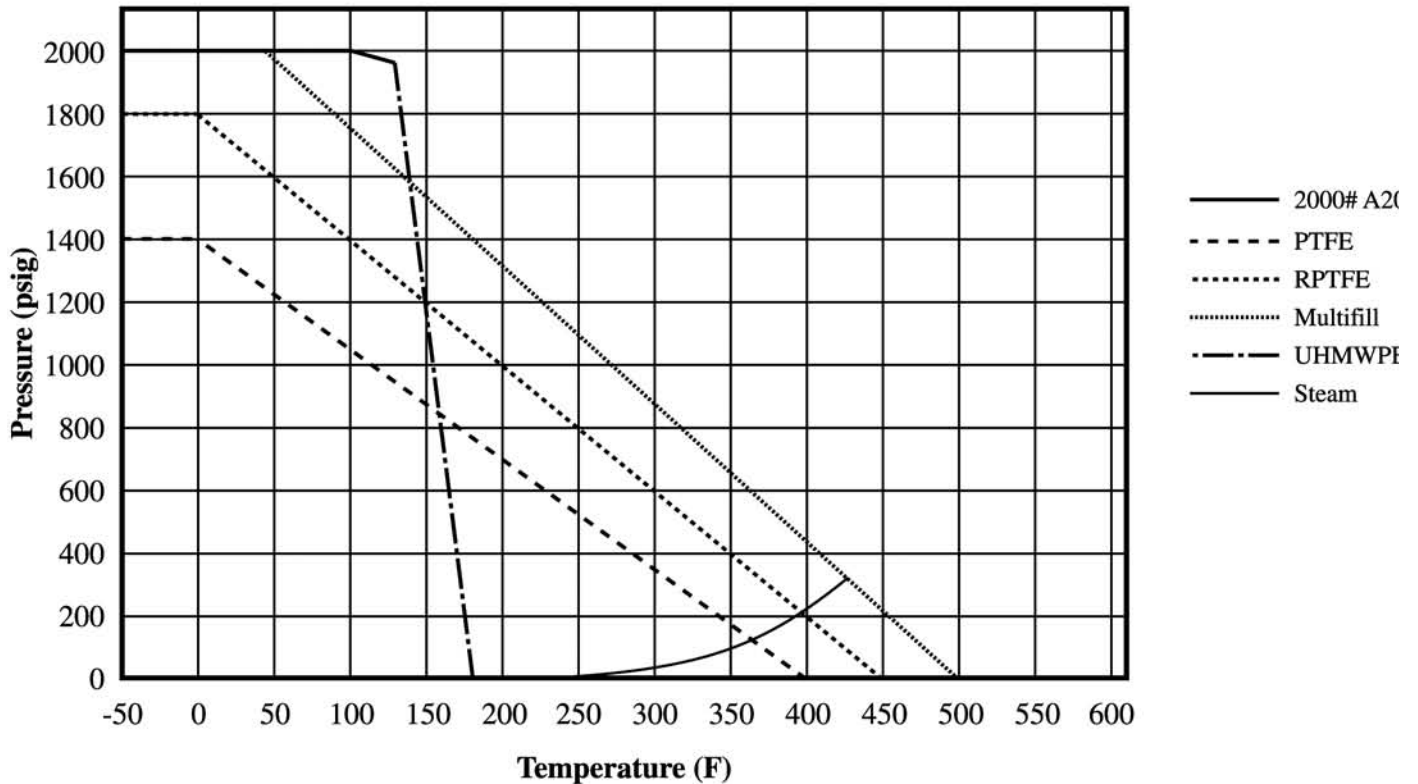
Class 150 Alloy 20 P-T Rating (Graph 18)



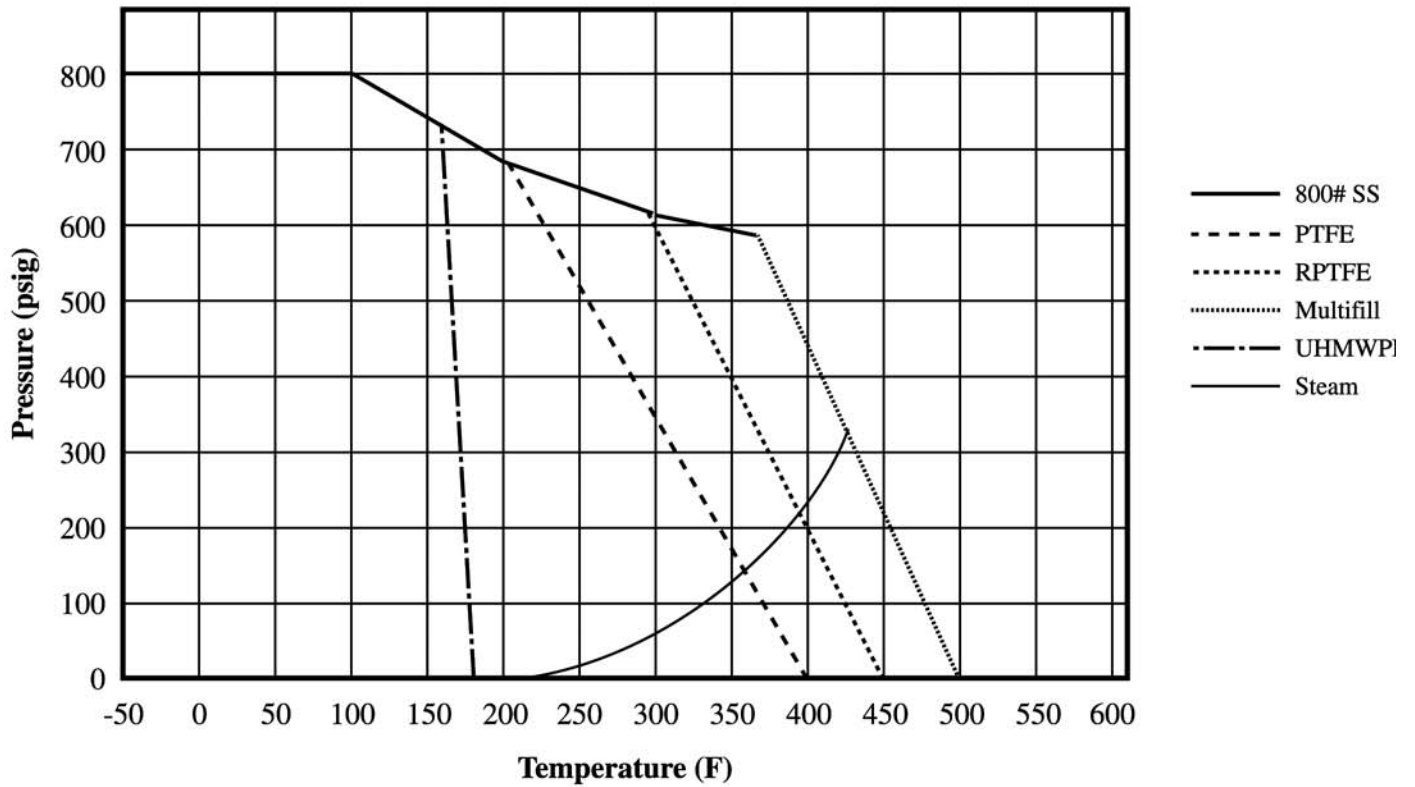
1500# Alloy 20 P-T Rating (Graph 19)



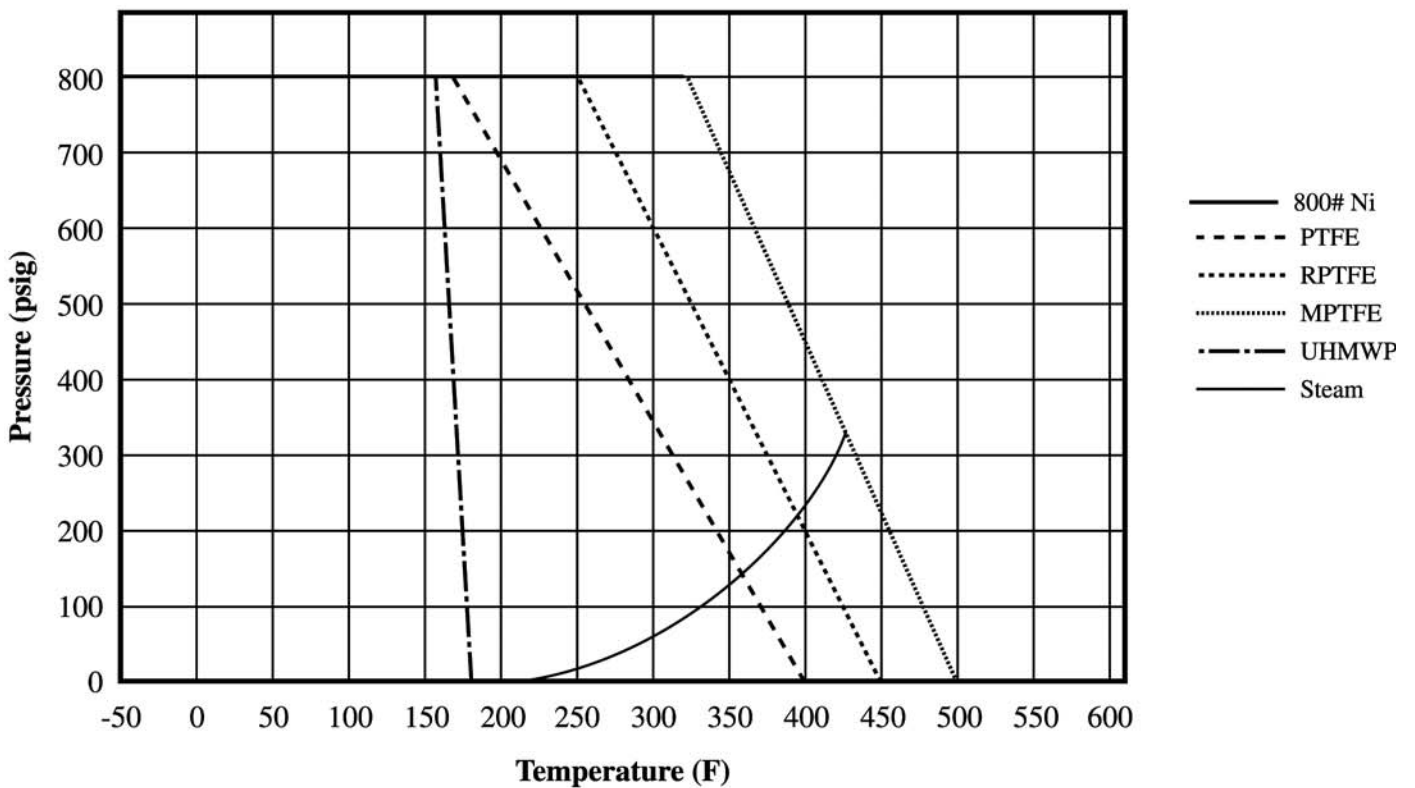
2000# Alloy 20 P-T Rating (Graph 20)



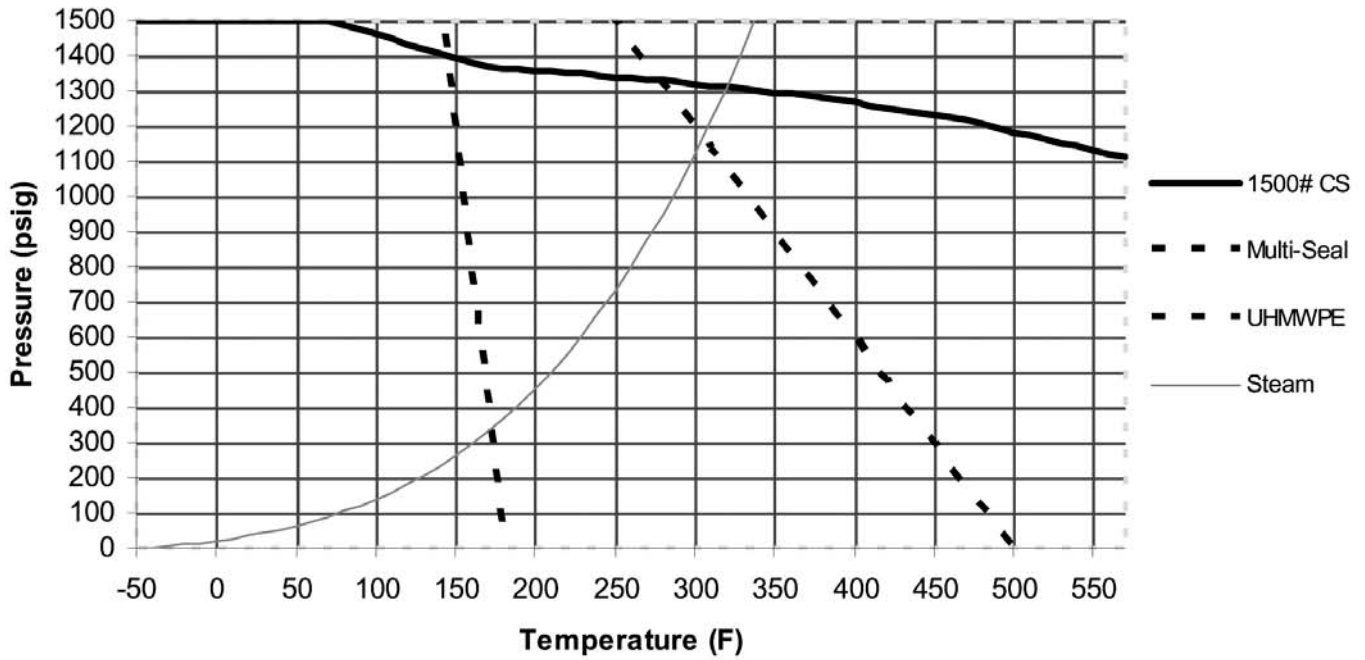
800# SS P-T Rating (Graph 21)



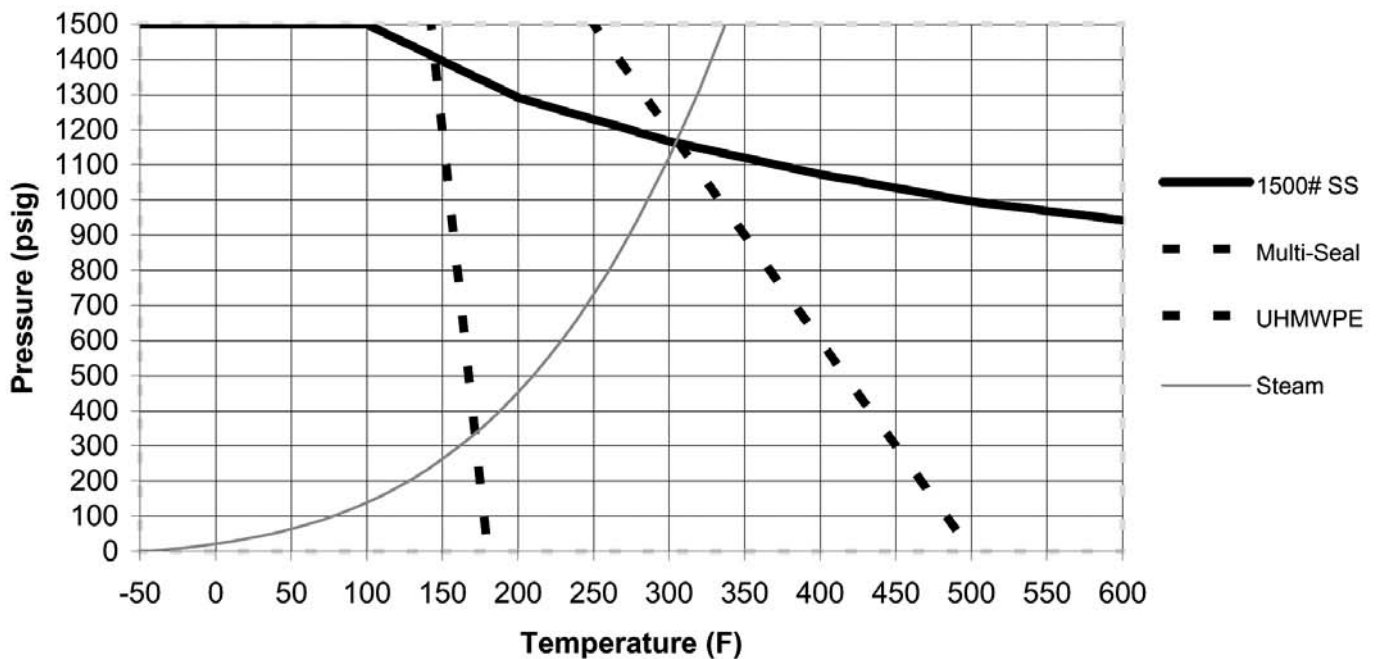
800# Nickel P-T Rating (Graph 22)



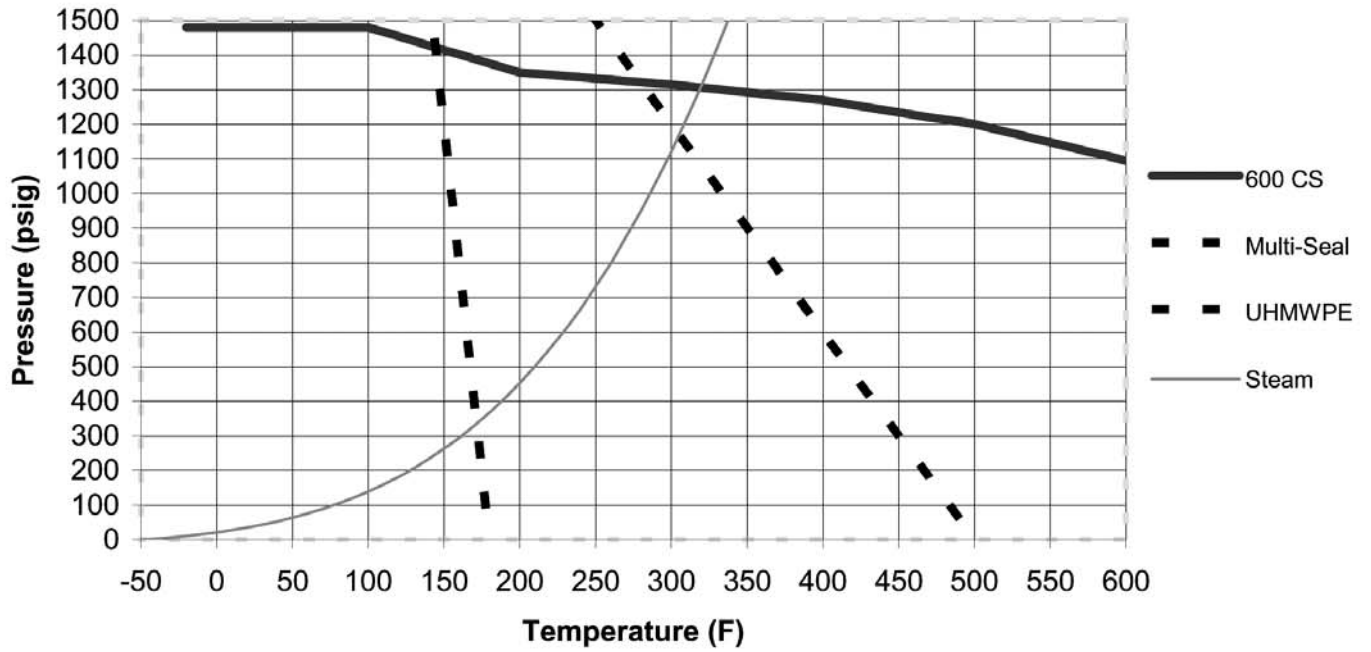
**1500 CWP Carbon Steel
3 Piece Ball Valve
(Graph 23)**



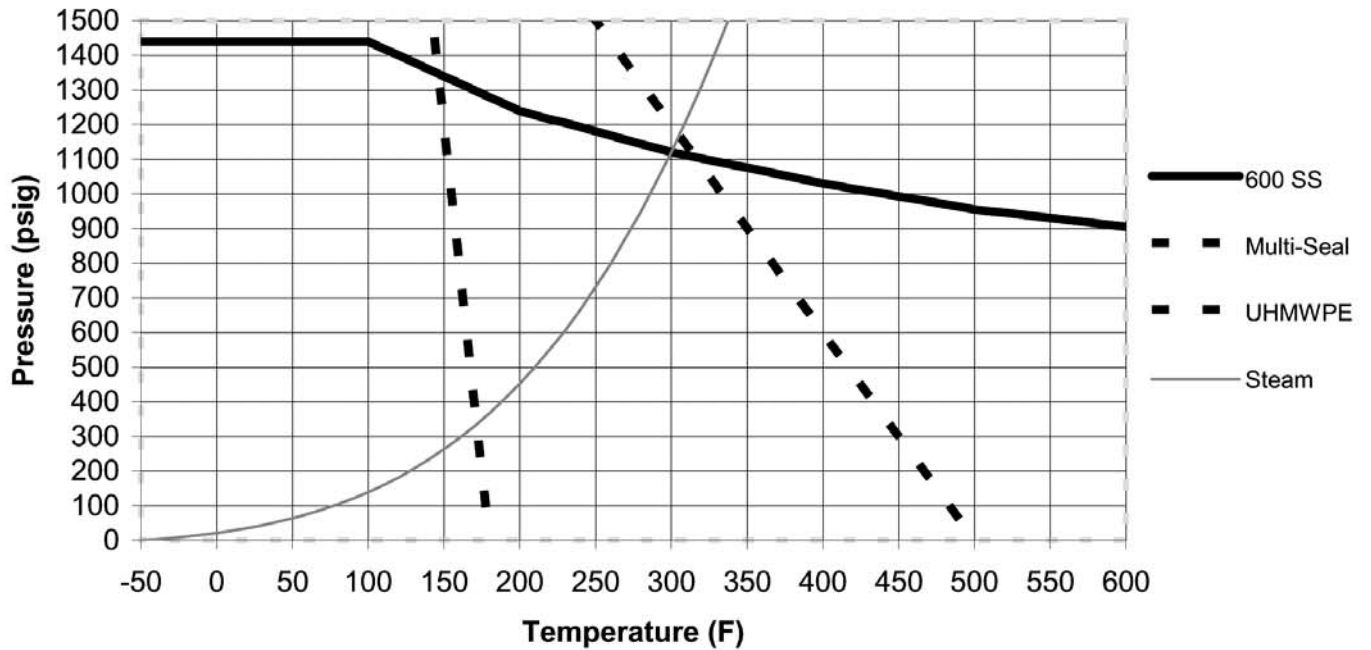
**1500 CWP Stainless Steel
3 Piece Ball Valve
(Chart 24)**



**ASME Class 600 Carbon Steel
3 Piece Ball Valve
(Graph 25)**



**ASME Class 600 Stainless Steel
3 Piece Ball Valve
(Graph 26)**





MATERIAL REFERENCE DATA

Item/Property	Barstock	Casting	Forging
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Carbon Steel			
ASTM Specifications	A108-1215	A216-WCB	A105
Unified Numbering System	G12150	J03002	K03504
<u>MAJOR ELEMENTS</u>			
Carbon	0.09% max.	0.30% max.	0.35% max.
Manganese	0.75 - 1.05%	1.00% max.	0.60 - 1.05%
Phosphorus	0.04 - 0.09%	0.04% max.	0.04% max.
Sulfur	0.26 - 0.35%	0.045% max	0.05% max.
Silicon	-	0.60% max.	0.35% max.
<u>MECHANICAL PROPERTIES</u>			
Tensile Strength	70,000 psi min.	70,000 psi min.	70,000 psi min.
Yield Strength	36,000 psi min.	36,000 psi min.	36,000 psi min.

316 Stainless Steel			
ASTM Specifications	A276-316	A351-CF8M	A182-F316
Unified Numbering System	S31600	J92900	S31600
<u>MAJOR ELEMENTS</u>			
Carbon	0.08% max.	0.08% max.	0.08% max.
Chromium	16.00 - 18.00%	18.00 - 21.00%	16.00 - 18.00%
Molybdenum	2.00 - 3.00%	2.00 - 3.00%	2.00 - 3.00%
Nickel	10.00 - 14.00%	9.00 - 12.00%	10.00 - 14.00%
<u>MECHANICAL PROPERTIES</u>			
Tensile Strength	75,000 psi min.	70,000 psi min.	75,000 psi min.
Yield Strength	30,000 psi min.	30,000 psi min.	30,000 psi min.

316L Stainless Steel			
ASTM Specifications	A276-316L	A351-CF3M	A182-F316L
Unified Numbering System	S31603	J92800	S31603
<u>MAJOR ELEMENTS</u>			
Carbon	0.03% max.	0.03% max.	0.03% max.
Chromium	16.00 - 18.00%	17.00 - 21.00%	16.00 - 18.00%
Molybdenum	2.00 - 3.00%	2.00 - 3.00%	2.00 - 3.00%
Nickel	10.00 - 14.00%	9.00 - 13.00%	10.00 - 15.00%
<u>MECHANICAL PROPERTIES</u>			
Tensile Strength	70,000 psi min.	70,000 psi min.	75,000 psi min.
Yield Strength	25,000 psi min.	30,000 psi min.	30,000 psi min.

Alloy 20			
ASTM Specifications	B473-N08020	A351-CN7M	B462-N08020
Unified Numbering System	N08020	N08007	N08020
<u>MAJOR ELEMENTS</u>			
Chromium	19.00 - 21.00%	19.00 - 22.00%	19.00 - 21.00%
Copper	3.00 - 4.00%	3.00 - 4.00%	3.00 - 4.00%
Manganese	2.00% max.	1.50% max.	2.00% max.
Molybdenum	2.00 - 3.00%	2.33 - 3.00%	2.00 - 3.00%
Nickel	32.00 - 38.00%	27.50 - 30.50%	32.00 - 38.00%
<u>MECHANICAL PROPERTIES</u>			
Tensile Strength	80,000 psi min.	62,000 psi min.	80,000 psi min.
Yield Strength	35,000 psi min.	25,000 psi min.	35,000 psi min.



MATERIAL REFERENCE DATA

Item/Property	Barstock	Casting	Forging
Hastelloy			
ASTM Specifications Unified Numbering System	B574-C276 N10276	A494-CW12MW N30002	B564-N10276 N10276
MAJOR ELEMENTS			
Chromium	14.5 - 16.5%	15.5 - 17.5%	14.5 - 16.5%
Molybdenum	15.0 - 17.0%	16.0 - 18.0%	15.0 - 17.0%
Nickel	51.0 - 63.5%	49.2 - 60.0%	51.0 - 63.5%
Tungsten	3.0 - 4.5%	3.75 - 5.25%	3.0 - 4.5%
MECHANICAL PROPERTIES			
Tensile Strength	100,000 psi min.	72,000 psi min.	100,000 psi min.
Yield Strength	41,000 psi min.	40,000 psi min.	41,000 psi min.
Nickel			
ASTM Specifications Unified Numbering System	B160-N02200 N02200	A494-CZ100 N02100	B160-N02200 N02200
MAJOR ELEMENTS			
Molybdenum	2.00 - 3.00%	2.33 - 3.00%	2.00 - 3.00%
Nickel	99.00% max.	95.00% min.	99.00% max.
MECHANICAL PROPERTIES			
Tensile Strength	55,000 psi min.	50,000 psi min.	55,000 psi min.
Yield Strength	15,000 psi min.	18,000 psi min.	15,000 psi min.
Nickel-Copper Alloy			
ASTM Specifications Unified Numbering System	B164-N04400 N04400	A494-M35-1 N/A	B564-N04400 N04400
MAJOR ELEMENTS			
Copper	28.00 - 34.00%	26.00 - 33.00%	28.00 - 34.00%
Iron	2.50% max.	3.50% max.	2.50% max.
Manganese	2.00% max.	1.50% max.	2.00% max.
Molybdenum	2.00 - 3.00%	2.33 - 3.00%	2.00 - 3.00%
Nickel	63.00% min.	60.00% min.	63.00% min.
MECHANICAL PROPERTIES			
Tensile Strength	70,000 psi min.	65,000 psi min.	70,000 psi min.
Yield Strength	25,000 psi min.	25,000 psi min.	25,000 psi min.
Leaded Brass & Bronze Alloys			
ASTM Specification Unified Numbering System	B16 C36000	B584-C84400 C84400	
MAJOR ELEMENTS			
Copper	60.0 - 63.0%	78.0 - 82.0%	
Tin		2.3 - 3.5%	
Lead	2.5 - 3.7%	6.0 - 8.0%	
Zinc	33.0 - 37.5%	7.0 - 10.0%	
MECHANICAL PROPERTIES			
Tensile Strength	25,000 psi min.	29,000 psi min.	
Yield Strength	10,000 psi min.	13,000 psi min.	
85-5-5-5 Bronze Alloys			
ASTM Specification Unified Numbering System	N/A C83600	B62-C83600 C83600	
MAJOR ELEMENTS			
Copper	84.0 - 86.0%	84.0 - 86.0%	
Tin	4.0 - 6.0%	4.0 - 6.0%	
Lead	4.0 - 6.0%	4.0 - 6.0%	
Zinc	4.0 - 6.0%	4.0 - 6.0%	
MECHANICAL PROPERTIES			
Tensile Strength	30,000 psi min.	30,000 psi min.	
Yield Strength	14,000 psi min.	14,000 psi min.	

CONVERSION FACTORS

TO CONVERT INTO MULTIPLY BY

atmospheres	cms of mercury	76.0
atmospheres	ft. of water (at 4°C)	33.90
atmospheres	in. of mercury (at 0°C)	29.92
atmospheres	kgs/sq cm	1.0333
atmospheres	kgs/sq meter	10,332
atmospheres	pounds/sq. in.	14.70
Bar	newtons/sq m	10 ⁵
bar	atmospheres	0.9869
bar	at (tech.)	1.0197
bar	psi	14.504
Barrels-Oil	gals-oil	42
BT Units	kg-calories	0.2520
BTU's	ft-lbs	777.9
BTU's	hp-hrs	3.927 x 10 ⁻⁴
BTU's	kgs-meters	107.5
BTU's	kw-hrs	2.928 x 10 ⁻⁴
BTU/Min	ft-lbs/sec	12.96
BTU/min	hp	0.02356
BTU/min	kw	0.01757
BTU/min	watts	17.57
Centimeters	inches	0.3937
cm	meters	0.01
cm	mm	10
Cms Mercury	atm	0.01316
cms mercury	ft water	0.4461
cms mercury	kgs/sq meter	136.0
cms mercury	lbs/sq ft	27.85
cms mercury	lbs/sq in	0.1934
Cms/Second	ft/min	1.969
cms/sec	ft/sec	0.03281
cms/sec	km/hr	0.036
cms/sec	meters/min	0.6
cms/sec	miles/hr	0.02237
cms/sec	miles/min	3.728 x 10 ⁻⁴
Cms/Sec/Sec	ft/sec/sec	0.03281
Cubic Cms	cu ft	3.531 x 10 ⁻⁵
Cu cms	cu in	6.102 x 10 ⁻²
cu cms	cu meters	10 ⁻⁶
cu cms	cu yds	1.308 x 10 ⁻⁶
cu cms	gals	2.642 x 10 ⁻⁴
cu cms	liters	10 ⁻³
cu cms	pints (liq)	2.113 x 10 ⁻³
cu cms	quarts (liq)	1.057 x 10 ⁻³
Cubic Feet	cubic cms	2.832 x 10 ⁴
cu ft	cu inches	1728
cu ft	cu meters	0.02832
cu ft	cu yds	0.03704
cu ft	gals	7.48052
cu ft	liters	28.32
cu ft	pints (liq)	59.84
cu ft	quarts (liq)	29.92
Cu Ft/min	cu cms/sec	472.0
cu ft/min	gals/sec	0.1247
cu ft/min	liters/sec	0.4720
cu ft/min	lbs water/min	62.43
cu ft/sec	gals/min	448.831
Cu Inches	cc	16.39
cu ins	cu ft	5.787 x 10 ⁻⁴
cu ins	cu meters	1.639 x 10 ⁻⁵
cu ins	cu yds	2.143 x 10 ⁻⁵
cu ins	gals	4.329 x 10 ⁻³
cu ins	liters	1.639 x 10 ⁻²
cu ins	pints (liq)	0.03463
cu ins	quarts (liq)	0.01732
Cu Meters	cc	10 ⁴

TO CONVERT INTO MULTIPLY BY

cu M	cu ft	35.31
cu M	cu ins	61,023
cu M	cu yds	1.308
cu M	gals	264.2
cu M	liters	10 ³
cu M	pints (liq)	2113
cu M	quarts (liq)	1057
Cu Yards	cu cms	7.646 x 10 ⁵
cu yds	cu ft	27
cu yds	cu ins	46,656
cu yds	cu meters	0.7646
cu yds	gals	202.0
Decimeters	meters	0.1
Deg (Angle)	minutes	60
degs (angle)	radians	0.01745
degs (angle)	secs	3600
Degrees/Sec	radians/sec	0.01745
degs/sec	revs/min	0.1667
degs/sec	revs/sec	0.002778
Feet	cms	30.48
ft	ins	12
ft	meters	0.3048
ft	yds	1/3
Ft of Water	atms	0.02950
ft of w	ins mercury	0.8826
ft of w	kgs/sq cm	0.03048
ft of w	lbs/sq ft	62.32
ft of w	lbs/sq in	0.4328
Feet/Min	cms/sec	0.5080
ft/min	ft/sec	0.01667
ft/min	kms/hr	0.01829
ft/min	meters/min	0.3048
ft/min	miles/hr	0.01136
Ft/Sec/Sec	cms/sec/sec	30.48
ft/sec/sec	Meters/sec/sec	0.3048
Ft-Pounds	BTU s	1.286 x 10 ⁻³
ft lbs	hp-hrs	5.050 x 10 ⁻⁷
ft lbs	kg-calories	3.241 x 10 ⁻⁴
ft lbs	kg-meters	0.1383
ft lbs	kw-hrs	3.766 x 10 ⁻⁷
Ft-lbs/Min	BTUs/min	1.286 x 10 ⁻³
ft-lbs/min	ft-lbs/sec	0.01667
ft-lbs/min	hp	3.030 x 10 ⁻⁵
ft-lbs/min	kg-calories/min	3.241 x 10 ⁻⁴
ft-lbs/min	kws	2.260 x 10 ⁻⁵
Ft-Lbs/Sec	BTUs/min	7.717 x 10 ⁻²
ft-lbs/sec	hp	1.818 x 10 ⁻³
ft-lbs/sec	kg-calories/min	1.945 x 10 ⁻²
ft-lbs/sec	kws	1.356 x 10 ⁻³
Gallons	ccs	3785
gals	cu ft	0.1337
gals	cu ins	231
gals	cu meters	3.785 x 10 ⁻³
gals	liters	3.785
gals	pints (liq)	8
gals	quarts (liq)	4
Gallons, Imp	US gals	1.20095
gallons, US	imp gals	0.83267
Gals Water	lbs water	8.3304
Gallons/Min	cu ft/sec	2.228 x 10 ⁻³
gals/min	liters/sec	0.06308
gals/min	cu ft/hr	8.0208
Horse-Power	BTUs/min	42.44
hp	ft-lbs/min	33,000
hp	ft-lbs/sec	550

CONVERSION FACTORS

TO CONVERT	INTO	MULTIPLY BY	TO CONVERT	INTO	MULTIPLY BY
hp	hp (metric)	1.014	meters	mms	10 ³
hp	kg-calories/min	10.70	meters/min	cms/sec	1.667
hp	kws	0.7457	meters/min	ft/min	3.281
hp	watts	745.7	meters/min	ft/sec	0.05468
Hp-Hours	BTUs	2547	meters/min	kms/hr	0.06
hp-hrs	ft-lbs	1.98 x 10 ⁶	meters/min	miles/hr	0.03728
hp-hrs	kg-calories	641.7	Meters/Sec	ft/min	196.8
hp-hrs	kg-meters	2.737x10 ⁵	meters/sec	ft/sec	3.281
hp-hrs	kw-hrs	0.7457	meters/sec	kms/hr	3.6
Inches	cms	2.540	meters/sec	kms/min	0.06
Inches	mms	25.4	meters/sec	miles/hr	2.237
Ins Mercury	atms	0.03342	meters/sec	miles/min	0.03728
ins mercury	ft water	1.133	Microns	meters	10 ⁻⁶
ins mercury	kgs/sq cm	0.03453	microns	in	39 x 10 ⁻⁶
ins mercury	lbs/sq ft	70.73	Miles/Hr	cms/sec	44.70
ins mercury	lbs/sq in	0.4912	miles/hr	ft/min	88
Ins of Water	atms	0.002458	miles/hr	ft/sec	1.467
ins of w	ins mercury	0.07355	miles/hr	kms/hr	1.609
ins of w	kgs/sq cm	0.002540	miles/hr	meters/min	26.82
ins of w	lbs/sq ft	5.202	Millimeters	cms	0.1
ins of w	lbs/sq in	0.03613	mms	ins	0.03937
Kilograms	dynes	980,665	Minutes (Angle)	radians	2.909 x 10 ⁻⁴
kgs	lbs	2.205	Newton	kgs	0.1020
kgs	tons (short)	1.102 x 10 ⁻³	Ounces	lbs	0.0625
kgs	grams	1000	ozs.	gram	28.349527
Kgs/Sq Cm	atms	0.9678	Ozs (Fluid)	cu in	1.805
kgs/sq cm	ft water	32.81	ozs. (fluid)	liters	0.02957
kgs/sq cm	ins mercury	28.96	Pounds	ozs.	16
kgs/sq cm	lbs/sq ft	2048	lbs.	kgs	0.4536
kgs/sq cm	lbs/sq in	14.22	lbs.	tons (short)	0.0005
Kilometers	cms	10 ⁵	lbs.	newtons (N)	4.44
kms	ft	3281	lbs.	gram	453.5924
kms	meters	10 ³	Pounds/Inch	newton-meters	0.113
kms	miles	0.6214	Pounds/Foot	newton-meters	1.356
Kms/Hr	cms/sec	27.78	Lbs of Water	cu ft	0.01605
kms/hr	ft/min	54.68	lbs of water	cu in	27.73
kms/hr	ft/sec	0.9113	lbs of water	gals	0.1204
kms/hr	meters/min	16.67	Lbs of Water/Min	cu ft/sec	2.679 x 10 ⁻⁴
kms/hr	miles/hr	0.6214	Pounds/Cu Ft	lbs/cu in	5.787 x 10 ⁻⁴
Kms/Hr/Sec	cms/sec/sec	27.78	Pounds/Cu In	lbs/cu ft	1728
kms/hr/sec	ft/sec/sec	0.9113	Pounds/Sq In	atms	0.06804
kms/hr/sec	Meters/sec/sec	0.2778	lbs/sq in	ft water	2.311
Kilowatts	BTUs/min	56.92	lbs/sq in	in mercury	2.036
kws	ft-lbs/min	4.425 x 10 ⁴	lbs/sq in	kgs/sq cm	0.07031
kws	ft-lbs/sec	737.6	Radians	degrees	57.29578
kws	hp	1.341	Tons (Long)	kgs	1016
kws	kg-calories/min	14.34	tons (long)	lbs	2240
kws	watts	10 ³	tons (long)	tons (short)	1.12000
Kilowatt-Hrs	BTUs	3415	Tons (Short)	kgs	2000
kw-hrs	ft-lbs	2.655 x 10 ⁶	tons (short)	kps	907.18486
kw-hrs	hp-hours	1.341	tons (short)	tons (long)	0.89287
kw-hrs	kg-calories	860.5	tons (short)	tons (metric)	0.90718
kw-hrs	kg-meters	3.671 x 10 ⁵	Watts	BTUs/min	0.05692
Liters	ccs	10 ³	watts	ft-lbs/min	44.26
liters	cu ft	0.03531	watts	ft-lbs/sec	0.7376
liters	cu ins	61.02	watts	hp	1.341 x 10 ⁻³
liters	cu meters	10 ⁻²	watts	kg-calories/min	0.01434
liters	gals	0.2642	watts	kws	10 ⁻³
liters	quarts (liq)	1.057	Watts/Hours	BTUs	3.415
Liters/Min	gals/sec	4.403 x 10 ⁻³	watts-hrs	ft-lbs	2655
Meters	cms	100	watts-hrs	hp-hrs	1.341 x 10 ⁻³
meters	ft	3.281	watts-hrs	kg-calories	0.8605
meters	ins	39.37	watts-hrs	kg-meters	367.1
meters	kms	10 ⁻³	watts-hrs	kw-hrs	10 ⁻³

