TECHNICAL/MATERIAL REFERENCE

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Form. EN23875 03/15

SEAL CHAMBER PRESSURE ESTIMATION

Seal chamber pressure must be known before the proper seal and flush plan can be selected. Seal chamber pressure can vary from pump design, flow rate, and fluid being pumped. Suction and discharge pressures are required to perform these calculations. Often, pump specification sheets can be old and outdated, i.e., design, operating points may have changed due to a change in process demands. It is, for this reason, that suction and discharge pressures should be physically measured with pressure gages.

Single Stage, Single Suction, Overhung Process Pumps
Overhung centrifugal pumps are the most common process pumps in the industry. The seal chamber is located behind the pump impeller. Seal chamber pressure can vary based on pump design. The following equations are based on closed throat design seal chambers. Pump designs include wear rings and balance holes in the impeller to reduce thrust load on the bearings. The seal chamber pressure is a function of wear ring clearance as well as size and location of the balance holes.

Quick estimate	Psb = Ps + .25(Pd – Ps)
Enclosed or semi-enclosed impellers with wear ring design and balance holes	Psb = Ps + .05(Pd – Ps)
Open impeller design with centrifugal pump-out vanes or repeller (no balance holes)	Psb = Ps + *D(Pd – Ps)

*D = .3 if the impeller is at minimum diameter and .1 if the impeller is at maximum diameter.

Single Stage, Double Suction Pumps
The single stage, double suction impeller is placed between bearings while the seal chambers are located adjacent to the suction eyes of the impeller. The stuffing box pressure is equal to the suction pressure.

Psb = Ps

Multi-Stage Pumps
Multi-stage pumps inherently have higher discharge pressures, but low-to-medium stuffing box pressures due to impeller arrangement, casing design, balance drums and the use of balance lines. These multi-stage pumps can be mounted horizontally or vertically.

Two Stage Horizontal Pumps
Impeller arrangement can have two configurations:

1.) Back to Back
In this arrangement, the seal chambers are located adjacent to the suction eye of the impeller. One chamber will see suction pressure and the other will see first stage discharge pressure.

Psb_1 = Ps
Psb_2 = Ps + .5(Pd – Ps)

2.) Eye to Eye
In this arrangement the seal chambers are located adjacent to the backside of the impeller. One chamber will see the discharge of the first stage and the other will see pump discharge pressure (second stage discharge).

Psb_1 = Ps + .5(Pd – Ps)
Psb_2 = Pd

Multi-Stage Horizontal Pumps
Multi-stage boiler feed pumps are used to develop high pressures, but the seal chamber is not necessarily at a high pressure. These pumps have a low pressure chamber (suction pressure) and a higher-pressure chamber (pressure between suction and discharge).

Psb_1 = Ps

Typically, a balance line is used to reduce pressure in the higher pressure seal chamber. Provided pump tolerances are in check, the higher-pressure seal chamber is as follows:

Psb_2 = Ps + 5 bar g(75 psig)

Note: If pump tolerances are not in check and, in the absence of a balance line, the higher-pressure chamber will be a pressure between suction and discharge pressure.

Psb_2 = Ps + .5(Pd – Ps)

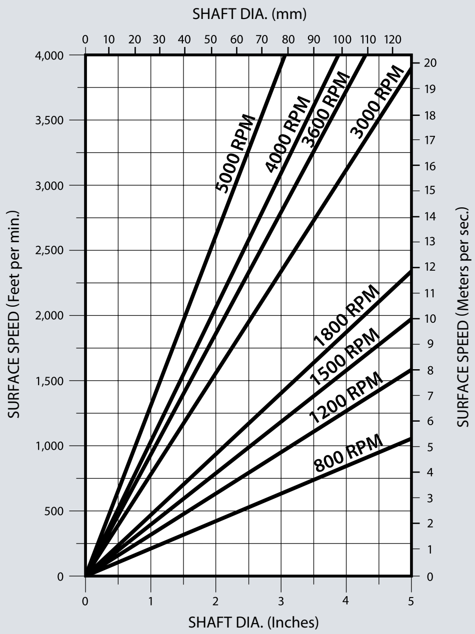
Multi-Stage Vertical Pumps (Can or Turbine)
In these pumps the seal chamber is located at the discharge elbow. Therefore the seal chamber pressure would see discharge pressure.

Psb = Pd

Note: The installation of a bleed-off line can reduce seal chamber pressure, provided pump tolerances are in check.

Psb_2 = Ps + 5 bar g(75 psig)

SHAFT SPEED CONVERSION CHART



Use formulas below to determine approximate shaft speeds if not shown in chart above.

$$\text{FPM} = \frac{\text{Dia. inches x R.P.M.}}{4} \qquad \text{M/S} = \frac{\text{Dia. millimeters x R.P.M.}}{18750}$$

METRIC FORMULAS:

$$\text{Head (m)} = \frac{\text{Pressure (bar) x 9.8}}{\text{SG}} = \frac{\text{mm Hg. x 0.0014}}{\text{SG}}$$

$$\text{Pressure (bar)} = \frac{\text{Head (m) x SG}}{9.8}$$

$$\text{Mm of Mercury} = \frac{\text{Head (m) x SG}}{0.0014}$$

$$\text{Power (kW)} = \frac{\text{Q (l/min) x Head (m) x SG}}{\text{efficiency x 6128}}$$

IMPERIAL FORMULAS:

$$\text{Head (ft.)} = \frac{\text{psi x 2.31}}{\text{sp. gr.}} = \frac{\text{In. Hg.}}{\text{sp. gr. x .88}}$$

$$\text{BHP (centrifugal)} = \frac{\text{GPM x head (ft.) x sp. gr.}}{\text{3960 x pump eff.}}$$

$$\text{PSI} = \frac{\text{head (ft.) x sp. gr.}}{2.31} = \text{.49 x In. Hg.}$$

$$\text{BHP (Positive Disp.)} = \frac{\text{GPM x psi}}{\text{1715 x pump eff.}}$$

UNITS OF MEASURE

Mariner's Measure

6 Feet = 1 Fathom
120 Fathoms = 1 Cable Length (U.S.N.)
8.439 Cable Lengths = 1 Nautical Mile
6076.12 Ft. = 1 Nautical Mile
1 Nautical Mile = 1.15 Statute Mile (International)

Inch System Conversion

Inches	x	0.0254	=	Meters
Feet	x	0.305	=	Meters
Yards	x	0.914	=	Meters
Miles	x	1609.	=	Meters
Miles	x	1.609	=	Kilometers
Millimeters	x	0.03937	=	Inches
Centimeters	x	0.3937	=	Inches
Meters	x	39.37	=	Inches
Meters	x	3.281	=	Feet
Meters	x	1.094	=	Yards
Kilometers	x	0.621	=	Miles
Sq. Centimeters	x	0.155	=	Square Inches
Sq. Meters	x	10.764	=	Square Feet
Sq. Meters	x	1.186	=	Square Yards
Cubic Centimeters	x	0.061	=	Cubic Inches
Cubic Inches	x	16.2	=	Cubic Centimeters
Liters	x	0.2642	=	Gallons
Gallons	x	3.78	=	Liters
Cubic Meters	x	1.308	=	Cubic Yards
Cubic Yards	x	0.765	=	Cubic Meters

Metric System Prefixes

Mega = 1,000,000	Deci = 0.1	Tera (T) = 10^{12}
Kilo = 1,000	Centi = 0.01	Giga (G) = 10^{9}
Hecto = 100	Milli = 0.001	Nano (N) = 10^{-9}
Deka = 10	Micro = 0.000001	Pico (P) = 10^{-12}

Length

1 centimeter	=	0.3937 inch	=	0.0328 foot
1 meter	=	39.37 inches	=	1.0936 yards
1 kilometer	=	0.62137 mile	=	3280 feet
1 inch	=	2.54 centimeters		
1 foot	=	0.3048 meter		
1 mil	=	0.001 inch		

Square Measure

1 sq. cm.	= 0.1550 sq. in.		
1 sq. meter	= 1.196 sq. yd.	=	10.764 sq. ft.
1 sq. kilometer	= 0.386 sq. mile		
1 sq. inch	= 6.452 sq. cm.		
1 sq. foot	= 929.03 sq. cm.	=	0.092903 sq. meter
1 sq. yard	= 0.8361 sq. meter		
1 sq. mile	= 2.59 sq. kilometers		
1 circular mil	= 0.7854 sq. mil		
1 sq. inch	= 1,000,000 sq. mils		

Cubic Measure

1 cu. centimeter = 0.061 cu. inch   1 cu. in. = 16.39 cu cm.
1 cu. meter = 1.308 cu. yards = 35.316 cu. feet
1 gallon (U.S.) = 231 cubic inches
1 cu. ft. = 7.48 gallons   1 liter = 1,000 cu. centimeters

Time

1 day = 86,400 seconds   1 year = 8,760 hours (approx.)

Velocity

1 ft./sec. = 0.3048 meter/sec.	1 meter/sec. = 3.281 ft./sec.
1 ft./min. = 0.00508 meter/sec.	1 meter/sec. = 196.9 ft./min.
1 mile/hr. = 0.4470 meter/sec.	1 meter/sec. = 2.237 mi./hr.
1 kilometer/hr. = 0.2778 meter/sec.	1 meter/sec. = 3.60 km/hr.

Acceleration

1 ft./sec./sec.	=	0.3048 meter/sec./sec.
1 mile/hr./sec.	=	0.4470 meter/sec./sec.
1 kilometer/hr./sec.	=	0.2778 meter/sec./sec.
Standard gravitation	=	9.806 meters/sec./sec.
Standard gravitation	=	980.6 cm./sec./sec.
Standard gravitation	=	32.2 ft./sec./sec.

Mass

1 slug = 32.2 pounds mass = 14.606 kilograms
1 pound mass = 453.6 grams

Force

1 pound force	=	1 slug	x	1 foot sec./sec.
1 dyne	=	1 gram	x	1 centimeter/sec./sec.
1 newton	=	1 kilogram	x	meter/sec./sec.
1 pound force	=	4.452 newtons		
1 newton	=	100,000 dynes	=	0.224 pound force
1 gram force	=	980.6 dynes		

Pressure

1 atmosphere = 14.69 pounds/sq. inch = 29.92 in. of Hg.
= 76 cm of Hg. = 33.9 ft. of water
1 in Hg. =0.491 pounds/sq. inch
Water pressure pounds/sq. inch = head in ft. x 0.434

Torque

Torque is the product of force and perpendicular distance.
1 lb.-ft. = 1.356 newton-meter = 1.356 joule/radian
1 lb.-ft. = 1.356 x 10^7 dynes-centimeter
1 lb.-ft. = 1.383 x 10^4 grams-centimeter
1 lb.-ft. = 192 ounce-inches

Work and Energy - Mechanical

1 erg = 1 dyne x 1 centimeter
1 joule = 1 newton x 1 meter = 10^5 dynes x 10^2 cm = 10^7 ergs
1 ft.-lb. = 1 pound force x 1 foot = 1.356 joules

Work and Energy - Heat Equivalent

1 Btu raises 1 pound of water 1°F
1 gram calorie raises 1 gram of water 1°C
1 Btu = 252 gram calories = 778.3 ft.-lb. = 1054.8 joules
1 gram calorie = 0.003964 Btu = 4.184 joules
1 horsepower hour = 2545 Btu

Work and Energy - Electrical Equivalent

1 joule = 1 watt x 1 second = 1 amp (dc) x 1 volt (dc) x 1 sec.
W (joules) = 1/2 L (henries) x 1 $(\text{amperes})^2$
W (joules) = 1/2 C (farads) x E $(\text{volts})^2$
1 kilowatt hour = 3,600,000 joules

Power

1 watt = 1 joule/sec.
1 horsepower = 550 ft. lb./sec. = 746 watts
1 watt = 3.413 Btu/hr = 0.239 gram calorie/sec.
P watts = R (ohms) x 1 $(\text{amperes})^2$

$$\text{P watts} = \frac{\text{E (volts)}^2}{\text{R (ohms)}}$$

Angles

1 circle = 2π radians = 360 degrees   1 radian = 57.3 degrees
1 degree = 0.01745 radians

Geometric Figures

Circle, area of = D^2 x 0.7854 = π^2 r = radius
Circle, circumference of = πD or 2πr
Sphere, area of = πD^2 = $4\pi r^2$ D = diameter
Sphere, volume of = D^3 x 0.5236 = $4/3\ \pi r^3$
Triangle, area of = 1/2 altitude x base
Cone, volume of = area of base x 1/3 altitude
Trapezoid, area of = 1/2 (sum of parallel sides) x altitude
Pyramid, volume of = area of base x 1/3 altitude

Miscellaneous Constants

π = 3.14159   e = 2.71828
$\text{Log}_e X = 2.30259 \log_{10} X$
Electronic charge = 4.5 x 10^{-10} e.s.u. = 1.60 x 10^{-20} e.m.u.
Mass units = 1.07 x 10^{-3} x Mev = 6.71 x 10^2 ergs
Speed of light = 3 x 10^8 meters/second
Speed of sound = (in air at sea level) = 1100 ft/second

TEMPERATURE CONVERSION TABLES

NOTE-The numbers in **BOLD FACE** refer to the temperature either in degrees Centigrade or Fahrenheit which is desired to convert into the other scale.

°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F
-17.8	**0**	32.0	5.6	**42**	107.6	28.9	**84**	183.2	171	**340**	644	404	**760**	1400	638	**1180**	2156	871	**1600**	2912
-17.2	**1**	33.8	6.1	**43**	109.4	29.4	**85**	185.0	177	**350**	662	410	**770**	1418	643	**1190**	2174	877	**1610**	2930
-16.7	**2**	35.6	6.7	**44**	111.2	30.0	**86**	186.8	182	**360**	680	416	**780**	1436	649	**1200**	2192	882	**1620**	2948
-16.1	**3**	37.4	7.2	**45**	113.0	30.6	**87**	188.6	188	**370**	698	421	**790**	1454	654	**1210**	2210	888	**1630**	2966
-15.6	**4**	39.2	7.8	**46**	114.8	31.1	**88**	190.4	193	**380**	716	427	**800**	1472	660	**1220**	2228	893	**1640**	2984
-15.0	**5**	41.0	8.3	**47**	116.6	31.7	**89**	192.2	199	**390**	734	432	**810**	1490	666	**1230**	2246	899	**1650**	3002
-14.4	**6**	42.8	8.9	**48**	118.4	32.2	**90**	194.0	204	**400**	752	438	**820**	1508	671	**1240**	2264	904	**1660**	3020
-13.9	**7**	44.6	9.4	**49**	120.2	32.8	**91**	195.8	210	**410**	770	443	**830**	1526	677	**1250**	2282	910	**1670**	3038
-13.3	**8**	46.4	10.0	**50**	122.0	33.3	**92**	197.6	216	**420**	788	449	**840**	1544	682	**1260**	2300	916	**1680**	3056
-12.8	**9**	48.2	10.6	**51**	123.8	33.9	**93**	199.4	221	**430**	806	454	**850**	1562	688	**1270**	2318	921	**1690**	3074
-12.2	**10**	50.0	11.1	**52**	125.6	34.4	**94**	201.2	227	**440**	824	460	**860**	1580	692	**1280**	2336	927	**1700**	3092
-11.7	**11**	51.8	11.7	**53**	127.4	35.0	**95**	203.0	232	**450**	842	466	**870**	1598	699	**1290**	2354	932	**1710**	3110
-11.1	**12**	53.6	12.2	**54**	129.2	35.6	**96**	204.8	238	**460**	860	471	**880**	1616	704	**1300**	2372	938	**1720**	3128
-10.6	**13**	55.4	12.8	**55**	131.0	36.1	**97**	206.6	243	**470**	878	477	**890**	1634	710	**1310**	2390	943	**1730**	3146
-10.0	**14**	57.2	13.3	**56**	132.8	36.7	**98**	208.4	249	**480**	896	482	**900**	1652	716	**1320**	2408	949	**1740**	3164
-9.4	**15**	59.0	13.9	**57**	134.6	37.2	**99**	210.2	254	**480**	914	488	**910**	1670	721	**1330**	2426	954	**1750**	3182
-8.9	**16**	60.8	14.4	**58**	136.4	37.8	**100**	212.0	260	**500**	932	493	**920**	1686	727	**1340**	2444	960	**1760**	3200
-8.3	**17**	62.6	15.0	**59**	138.2				266	**510**	950	499	**930**	1706	732	**1350**	2462	966	**1770**	3218
-7.8	**18**	64.4	15.6	**60**	140.0	43.3	**110**	230	271	**520**	968	504	**940**	1724	738	**1360**	2480	971	**1780**	3236
-7.2	**19**	66.2	16.1	**61**	141.8	48.9	**120**	248	277	**530**	986	510	**950**	1742	743	**1370**	2498	977	**1790**	3254
-6.7	**20**	68.0	16.7	**62**	143.6	54.4	**130**	266	282	**540**	1004	516	**960**	1760	749	**1380**	2516	982	**1800**	3272
-6.1	**21**	69.8	17.2	**63**	145.4	60.0	**140**	284	288	**550**	1022	521	**970**	1778	754	**1390**	2534	988	**1810**	3290
-5.6	**22**	71.6	17.8	**64**	147.2	65.6	**150**	302	293	**560**	1040	527	**980**	1796	760	**1400**	2552	993	**1820**	3308
-5.0	**23**	73.4	18.3	**65**	149.9	71.1	**160**	320	299	**570**	1058	532	**990**	1814	765	**1410**	2570	999	**1830**	3326
-4.4	**24**	75.2	18.9	**66**	150.8	76.7	**170**	338	304	**580**	1076	538	**1000**	1832	771	**1420**	2588	1004	**1840**	3344
-3.9	**25**	77.0	19.4	**67**	152.6	82.2	**180**	356	310	**590**	1094	543	**1010**	1850	777	**1430**	2606	1010	**1850**	3362
-3.3	**26**	78.8	20.0	**68**	154.4	87.8	**190**	374	316	**600**	1112	549	**1020**	1868	782	**1440**	2624	1016	**1860**	3380
-2.8	**27**	80.6	20.6	**69**	156.2	93.3	**200**	392	321	**610**	1130	554	**1030**	1886	788	**1450**	2642	1021	**1870**	3398
-2.2	**28**	82.4	21.1	**70**	158.0	98.9	**210**	410	327	**620**	1148	560	**1040**	1904	793	**1460**	2660	1027	**1880**	3416
-1.7	**29**	84.2	21.7	**71**	159.8	100	**212**	413	332	**630**	1166	566	**1050**	1922	799	**1470**	2678	1032	**1890**	3434
-1.1	**30**	86.0	22.2	**72**	161.6	104	**220**	428	338	**640**	1184	571	**1060**	1940	804	**1480**	2696	1038	**1900**	3452
-.6	**31**	87.8	22.8	**73**	163.4	110	**230**	446	343	**650**	1202	577	**1070**	1958	810	**1490**	2714	1043	**1910**	3470
0	**32**	89.6	23.3	**74**	165.2	116	**240**	464	349	**660**	1220	582	**1080**	1976	816	**1500**	2732	1049	**1920**	3488
.6	**33**	91.4	23.9	**75**	167.0	121	**250**	482	354	**670**	1238	588	**1090**	1994	821	**1510**	2750	1054	**1930**	3506
1.1	**34**	93.2	24.4	**76**	168.8	127	**260**	500	360	**680**	1256	593	**1100**	2012	827	**1520**	2768	1060	**1940**	3524
1.7	**35**	95.0	25.0	**77**	170.6	132	**270**	518	366	**690**	1274	599	**1110**	2030	832	**1530**	2786	1066	**1950**	3542
2.2	**36**	96.8	25.6	**78**	172.4	138	**280**	536	371	**700**	1292	604	**1120**	2048	838	**1540**	2804	1071	**1960**	3560
2.8	**37**	98.6	26.1	**79**	174.2	143	**290**	554	377	**710**	1310	610	**1130**	2066	843	**1550**	2822	1077	**1970**	3578
3.3	**38**	100.4	26.7	**80**	176.0	149	**300**	572	382	**720**	1328	616	**1140**	2084	849	**1560**	2840	1062	**1980**	3596
3.9	**39**	102.2	27.2	**81**	177.8	154	**310**	590	388	**730**	1346	621	**1150**	2102	854	**1570**	2856	1088	**1990**	3614
4.4	**40**	104.0	27.8	**82**	179.6	160	**320**	608	393	**740**	1364	627	**1160**	2120	860	**1580**	2876	1093	**2000**	3632
5.0	**41**	105.8	28.3	**83**	181.4	166	**330**	626	399	**750**	1382	632	**1170**	2138	866	**1590**	2894			

OTHER HANDY FORMULAS

Power Transmission by Shaft

HP = [Torque (in lb-ft) x rpm] ÷ 5250

Power to Drive Pumps

$$HP = \frac{\text{Gal. per min. x total head (inc. friction)}}{\text{3,960 x eff. of pump}}$$

Where: Approx.friction head (ft.) =

$$\frac{\text{pipe length (ft.) x [velocity of flow (fps)]}^2 \text{ x 0.02}}{\text{5.367 x diameter (in.)}}$$

Eff. = Approximately 0.50 to 0.85

Formula for Problems Involving Rotating Masses

Time required to change speed of rotating mass from N_1 to N_2 rpm.

$$t = \frac{(Wr^2)\ (N_2 - N_1)}{(308)\ (\text{torque lb-ft})}\ \text{Sec.}$$

Where (Wr^2) = Flywheel effect.

Kinetic energy of rotating mass.

$$K.E. = \frac{(WK^2)(rpm^2)}{5870}\ \text{ft-lbs} = \frac{(WK^2)(rpm^2)}{3.23 \times 10^6}\ \text{hp. sec.}$$

Where W = Weight (lbs.)

K = Radius of gyration (ft.)

Induction motor acceleration loss.

$$Loss \cong \left(1 + \frac{R_1}{R_2}\right) \frac{WK^2\,(N_2 - N_1)^2}{3.23 \times 10^6}\ \text{hp. sec.}$$

Where R_1 and r_2 = stator and rotor resistances.

Stored energy constant.

$$H = \frac{0.231\ (Wr^2)\ (rpm)^2\ 10^{-6}}{kva}\ \text{Kw. sec. per kva.}$$

Transfer of WK_2 through a gear.

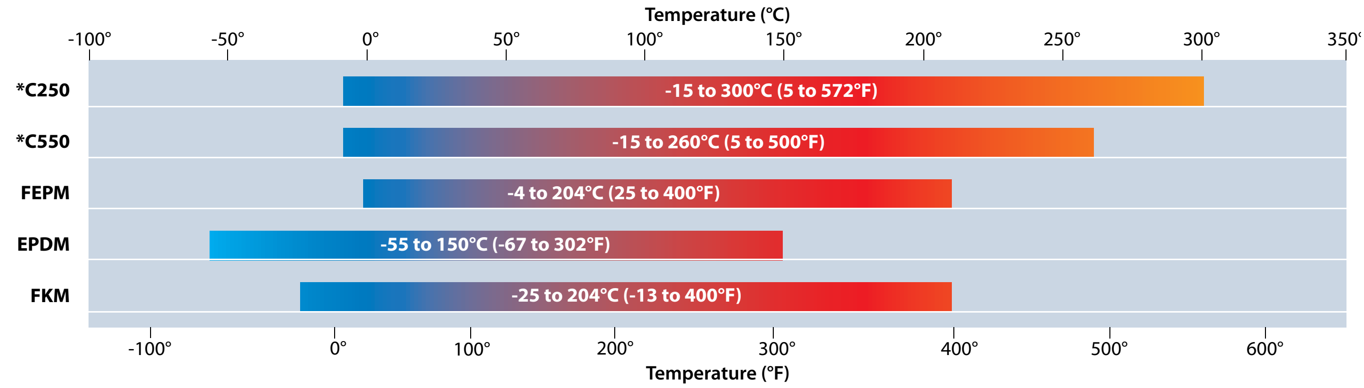
$$WK_1^2 = WK_2^2 \left(\frac{N_2}{N_1}\right)^2$$

COMMON FRACTIONS REDUCED TO DECIMALS

8ths	16ths	32nds	64ths	Decimal	8ths	16ths	32nds	64ths	Decimal
			1	.015625				33	.515625
		1	2	.03125			17	34	.53125
			3	.046875				35	.546875
	1	2	4	.0625		9	18	36	.5625
			5	.078125				37	.578125
		3	6	.09375			19	38	.59375
			7	.109375				39	.609375
1	2	4	8	.125	5	10	20	40	.625
			9	.140625				41	.640625
		5	10	.15625			21	42	.65625
			11	.171875				43	.671875
	3	6	12	.1875		11	22	44	.6875
			13	.203125				45	.703125
		7	14	.21875			23	46	.71875
			15	.234375				47	.734375
2	4	8	16	.25	6	12	24	48	.75
			17	.265625				49	.765625
		9	18	.28125			25	50	.78125
			19	.296875				51	.796875
	5	10	20	.3125		13	26	52	.8125
			21	.328125				53	.828125
		11	22	.34375			27	54	.84375
			23	.359375				55	.859385
3	6	12	24	.375	7	14	28	56	.875
			25	.390625				57	.890625
		13	26	.40625			29	58	.90625
			27	.421875				59	.921875
	7	14	28	.4375		15	30	60	.9375
			29	.453125				61	.953125
		15	30	.46875			31	62	.96875
			31	.484375				63	.934375
4	8	16	32	.5	8	16	32	64	1.00000

MATERIAL REFERENCE

Operating Limits of Elastomers



Key to Seal Materials

Component	Chesterton	EN12756	Description
Faces	CB	B	Carbon Graphite, Resin Impregnated
	SSC	Q_1	Silicon Carbide, Sintered Pressureless
	RSC	Q_2	Silicon Carbide, Reaction Bonded
	TC	U_2	Tungsten Carbide, Ni-Binder
	CR	V	Aluminum Oxide, 99.5%
Metals	316	G	CrNiMo steel (1.4401)
	Alloy-20	M_3	20 Cb3 (2.4660)
	Ti	T_2	Titanium (3.7035)
	HC	M_5	Hastelloy® C-276 (2.4819)
	HB	M_1	Hastelloy® B2 (2.4617)
	Monel®	M_4	Monel® Alloy K500 (2.4375)
Elastomers	FKM	V	Fluorocarbon
	EPDM	E	Ethylene Propylene
	FEPM	X	Tetrafluoroethylene-Propylene
	FFKM	K	Perfluoroelastomer
	C550	K_1	ChemLast 550™
	C250	K_2	ChemLast 250™

* Consult Chesterton Engineering on lowerwrature limits

All statements in this catalog pertaining to pressure, chemical compatibility, temperature, and service ratings are based on general service experience. Because of the wide variety of applications of our products, the broad range of products available, and the wide range of equipment conditions encountered, together with the unpredictable human factors involved in the installation of these products by the ultimate user, you should not follow recommendations shown without specific prior service experience or consultation with an authorized Chesterton representative.

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