Conversion Data

Summary of Common Conversion Factors

Multiply Left Hand Unit by Factor to obtain Right Hand Unit. Divide Right Hand Unit by Factor to obtain Left Hand Unit.

Measurement	Units	Factor
Length	inches ■ mm feet ■ metres	25.4 0.3048
Area	inch^2 ■ mm^2 ft^2 ■ m^2	645.16 0.0929
Volume	inch^3 ■ mm^3 ft^3 ■ m^3	16387 0.0283
Volume (Liquid)	gall (Imp) ■ gall US gall (Imp) ■ l gall (US) ■ l	1.20095 4.5456 3.785
Volume (Flow Rate) Liquid	gall/min (Imp) ■ l/sec gall/min (Imp) ■ l/min gall/min (Imp) ■ l/hour gall/min (US) ■ l/sec gall/min (US) ■ l/min gall/min (US) ■ l/hour	0.07575 4.5456 272.736 0.06308 3.785 227.1
Volume (Flow Rate) Air	cfm ■ l/sec cfm ■ l/min cfm ■ m^3/min cfm ■ m^3/hour m^3/hour ■ l/sec	0.472 28.32 42.372 1.6992 0.2778
Power	HP ■ Watts HP ■ kW	746 0.746

Measurement	Units	Factor
Heat Flow	BTU/hr ■ Watts Tons (Refrig) ■ BTU/hr Tons (Refrig) ■ kW kcal/hr ■ Watts kcal/hr ■ Tons (Refrig)	0.29307 12000 3.517 1.163 0.000331
Pressure	psi ■ kPa psi ■ mPa psi ■ bar psi ■ Atmos. In. Wg ■ Pa In. Wg ■ kPa Atmos. ■ kPa in. Hg ■ Pa in. Hg ■ kPa In. Hg ■ bar kg/cm2 ■ psi kg/cm2 ■ kPa	6.895 0.006895 0.06895 0.06895 248.6 0.249 101.325 3386 3.386 0.034 14.22 98.07
Velocity	ft/sec ■ km/hr ft/sec ■ m/sec ft/min ■ m/sec	1.609 0.3048 0.00508
Weight (Mass)	lbs ■ kg	0.4536

Conversion Factors

Multiply	By	To Obtain
Atmospheres	29.92	Inches of Mercury
Atmospheres	33.9	Feet of Water
Atmospheres	1.0333	kg/cm^2
Atmospheres	14.696	lbs/in^2 (psi)
Atmospheres	762.48	mmHg (torr)
Atmospheres	101.325	kPa
Bars	100	kPa
Bars	14.5	psi
British Thermal Units	0.252	Kilogram-calories
British Thermal Units	777.5	Foot-lbs
British Thermal Units	3.927 x 10-4	Horsepower-hrs
British Thermal Units	107.5	Kilogram-metre
British Thermal Units	2.928 x 10-4	Kilowatt-hrs
B.T.U./min	12.96	Foot-lbs/sec
B.T.U./min	0.02356	Horsepower
B.T.U./min	0.01757	Kilowatts
B.T.U./min	17.57	Watts
B.T.U./hr	0.293	Watts
Centimetres	0.3937	Inches
Centimetres	0.01	Metres
Centimetres	10	Millimetres
Centimetres of Mercury	0.4461	Feet of Water
Centimetres of Mercury	136	kgs/sq. metre
Centimetres of Mercury	0.1934	lbs/sq. inch

Conversion Factors

Multiply	By	To Obtain
Centimetres/second	1.969	Feet/min.
Centimetres/second	0.03281	Feet/sec.
Centimetres/second	0.6	Metres/min.
Cubic Centimetres	3.531 x 10-5	Cubic Feet
Cubic Centimetres	0.06102	Cubic Inches
Cubic Centimetres	10-6	Cubic Metres
Cubic Centimetres	0.001	Litres
Cubic Centimetres	0.001759	Pints (liq.)
Cubic Centimetres	0.002113	Imperial Pints (liq.)
Cubic Feet	1728	US Cubic Inches
Cubic Feet	0.02832	Cubic Metres
Cubic Feet	0.03704	Cubic Yards
Cubic Feet	6.22889	Gallons Imperial
Cubic Feet	7.48052	Gallons US
Cubic Feet	28.32	Litres
Cubic Feet	49.827	Pints (liq.) Imperial
Cubic Feet	59.84	Pints (liq.) US
Cubic Feet/minute	472	Cubic cms/sec.
Cubic Feet/minute	0.1038	Gallons/sec. Imperial
Cubic Feet/minute	0.1247	Gallons/sec. US
Cubic Feet/minute	0.472	Litres/sec.
Cubic Feet/minute	62.43	lbs. of water/min.
Cubic Feet/second	0.5382	Mill. Galls/day Imperial
Cubic Feet/second	0.646317	Mill. Galls/day US
Cubic Feet/second	373.733	Galls/min. Imperial
Cubic Feet/second	448.831	Galls/min. US

Conversion Data

Conversion Factors

Multiply	By	To Obtain
Cubic Inches	16.39	Cubic Centimetres
Cubic Inches	5.787×10^{-4}	Cubic Feet
Cubic Inches	1.639×10^{-5}	Cubic Metres
Cubic Inches	2.143×10^{-5}	Cubic Yards
Cubic Inches	0.004	Gallons Imperial
Cubic Inches	0.004	Gallons US
Cubic Inches	0.016	Litres
Cubic Metres	106	Cubic Centimetres
Cubic Metres	35.31	Cubic Feet
Cubic Metres	61026	Cubic Inches
Cubic Metres	1.308	Cubic Yards
Cubic Metres	220	Gallons Imperial
Cubic Metres	264.2	Gallons US
Cubic Metres	1000	Litres
Cubic Yards	27	Cubic Feet
Cubic Yards	46,656	Cubic Inches
Cubic Yards	0.765	Cubic Metres
Cubic Yards	764.6	Litres
Cubic Yards	1345.6	Pints (liq.) Imperial
Cubic Yards	1616	Pints (liq.) US
Cubic Yards/min.	0.45	Cubic
Cubic Yards/min.	2.804	Galls/sec.
Decilitres	0.1	Litres
Decimetres	0.1	Metres
Degrees (angle)	60	Minutes
Degrees (angle)	0.017	Radians
Degrees (angle)	3600	Seconds
Degrees/sec.	0.017	Radians/sec.
Degrees/sec.	0.167	Revolutions/min.
Degrees/sec.	0.003	Revolutions/sec.
Dekalitres	10	Litres
Dekametres	10	Metres
Feet	30.48	Centimetres
Feet	12	Inches
Feet	0.305	Metres
Feet	0.333	Yards
Feet of Water	0.030	Atmospheres
Feet of Water	0.883	Inches of Mercury
Feet of Water	0.030	kgs/sq. cm
Feet of Water	62.43	lbs/sq. ft
Feet of Water	0.434	lbs/sq. inch
Feet/minute	0.508	Centimetres/sec.
Feet/minute	0.017	Feet/sec.
Feet/minute	0.005	Metres/sec.
Feet/sec.	0.305	Metres/sec.
Feet/sec./sec.	30.48	cms/sec./sec.
Feet/sec./sec.	0.305	Metres/sec./sec.
Foot-pounds	1.286×10^{-3}	British Thermal Units
Foot-pounds	5.050×10^{-7}	Horsepower-hrs
Foot-pounds	3.241×10^{-4}	Kilogram-calories
Foot-pounds	0.138	Kilogram-metres
Foot-pounds	3.766×10^{-7}	Kilowatt-hrs
Foot-pounds/sec.	7.717×10^{-2}	B.T. Units/min.
Foot-pounds/sec.	1.818×10^{-3}	Horsepower
Foot-pounds/sec.	1.945×10^{-2}	kg-calories/min.
Foot-pounds/sec.	1.356×10^{-3}	Kilowatts
Gallons Imperial	0.161	Cubic Feet
Gallons Imperial	277.4	Cubic Inches
Gallons Imperial	4.546	Litres
Gallons Imperial	8	Pints Imperial
Gallons Imperial	4	Quarts Imperial

Conversion Factors

Multiply	By	To Obtain
Gallons Imperial	1.201	Gallons U.S.
Gallons U.S.	0.134	Cubic Feet
Gallons U.S.	231	Cubic Inches
Gallons U.S.	3.785	Litres
Gallons U.S.	8	Pints U.S.
Gallons U.S.	4	Quarts U.S.
Gallons U.S.	0.833	Gallons Imperial
Gallons Water Imperial	10.02	Pounds of Water
Gallons Water U.S.	8.345	Pounds of Water
Gallons/min. Imperial	0.027	Cubic Feet/sec.
Gallons/min. Imperial	0.076	Litres/sec.
Gallons/min. Imperial	10.713	Cubic feet/hr
Gallons/min. U.S.	0.022	Cubic Feet/sec.
Gallons/min. U.S.	0.063	Litres/sec.
Gallons/min. U.S.	8.921	Cubic Feet/hr.
Grams	0.001	Kilograms
Grams	1000	Milligrams
Grams	0.035	Ounces
Grams/litre	58.417	Grains/gal. U.S.
Grams/litre	8.345	Pounds/100 gals. U.S.
Grams/litre	0.062	Pounds/cubic foot
Grams/litre	1000	Parts/million
Hectolitres	100	Litres
Hectometres	100	Metres
Hectowatts	100	Watts
Horsepower	42.44	B.T. Units/min.
Horsepower	33,000	Foot-lbs/min
Horsepower	550	Foot-lbs/sec.
Horsepower	1.014	Horsepower (metric)
Horsepower	10.7	kg-calories/min.
Horsepower	0.746	Kilowatts
Horsepower-hours	2547	British Thermal Units
Horsepower-hours	1.98 x 106	Foot-lbs
Horsepower-hours	641.7	Kilogram-calories
Horsepower-hours	2.737 x 105	Kilogram-metres
Horsepower-hours	0.746	Kilowatt-hours
Inches	2.54	Centimetres
Inches of Mercury	0.033	Atmospheres
Inches of Mercury	1.133	Feet of Water
Inches of Mercury	0.035	kgs/sq. cm
Inches of Mercury	3.39	kPa
Inches of Mercury	0.491	lbs/sq. inch
Inches of Water	0.002	Atmospheres
Inches of Water	0.074	Inches of Mercury
Inches of Water	0.003	kgs/sq. cm
Inches of Water	0.249	kPa
Inches of Water	5.202	lbs/sq. foot
Inches of Water	0.036	lbs/sq inch
Kilograms	2.205	Pounds
Kilograms	1000	Grams
Kilograms/metre	0.672	lbs/foot
Kilograms/sq. cm	0.968	Atmospheres
Kilograms/sq. cm	32.81	Feet of Water
Kilograms/sq. cm	28.96	Inches of Mercury
Kilograms/sq. cm	2048	lbs/sq. foot
Kilograms/sq. cm	14.22	lbs/sq. inch
Kilolitres	1000	Litres
Kilometres	3281	Feet
Kilometres	1000	Metres
Kilometres	0.621	Miles
Kilometres	1094	Yards

Conversion Data

Conversion Factors

Multiply	By	To Obtain
Kilometres/hour	54.68	Feet/minute
Kilometres/hour	0.540	Knots
Kilometres/hour	16.67	Metres/minute
Kilometres/hour	0.621	Miles/hour
Kilometres/hour/sec.	27.78	cm/sec./sec.
Kilometres/hour/sec.	0.911	ft./sec./sec.
Kilometres/hour/sec.	0.278	Metres/sec./sec.
Kilowatts	56.92	BTU/minute
Kilowatts	4.425×10^4	Foot-lbs/minute
Kilowatts	737.6	Foot/lbs/second
Kilowatts	1.341	Horsepower
Kilowatts	14.34	kg-calories/minute
Kilowatts	1000	Watts
Kilowatt-hours	3415	British Thermal Units
Kilowatt-hours	2.655×10^6	Foot-lbs
Kilowatt-hours	1.341	Horsepower-hours
Kilowatt-hours	860.5	Kilogram-calories
Kilowatt-hours	3.671×10^6	Kilogram-metres
Litres	1000	Cubic Centimetres
Litres	0.035	Cubic Feet
Litres	61.02	Cubic Inches
Litres	0.001	Cubic Metres
Litres	0.220	Gallons Imperial
Litres	0.264	Gallons US
Litres	1.760	Pints (liq.) Imperial
Litres	2.113	Pints (liq.) US
Litre/minute	5.886	Cubic ft/sec.
Litre/minute	0.004	Gallons/sec. Imperial
Litre/minute	0.004	Gallons/sec. US
Metres	100	Centimetres
Metres	3.281	Feet
Metres	39.37	Inches
Metres	0.001	Kilometres
Metres	1000	Millimetres
Metres	1.094	Yards
Metres/minute	1.667	Centimetres/second
Metres/minute	3.281	Feet/minute
Metres/minute	0.055	Feet/second
Metres/minute	0.06	Kilometres/hour
Metres/minute	0.037	Miles/hour
Metres/second	196.8	Feet/minute
Metres/second	3.281	Feet/second
Metres/second	3.6	Kilometres/hour
Metres/second	0.06	Kilometres/minute
Metres/second	2.237	Miles/hour
Microns	10^{-6}	Metres
Miles	1.609	Kilometres
Miles	1760	Yards
Miles/hour	88	Feet/minute
Miles/hour	1.609	Kilometres/hour
Miles/hour	0.868	Knots
Miles/hour	26.82	Metres/minute
Miles/minute	60	Miles/hour
Millilitres	0.001	Litres
Millimetres	0.1	Centimetres
Millimetres	0.039	Inches
Minutes (angle)	2.909×10^{-4}	Radians

Conversion Factors

Multiply	By	To Obtain
Ounces	0.063	Pounds
Ounces (fluid)	1.805	Cubic Inches
Ounces (fluid)	0.030	Litres
Pounds	16	Ounces
Pounds	0.454	Kilograms
Pounds	0.001	Tons (short)
Pounds of Water	0.016	Cubic Feet
Pounds of Water	27.68	Cubic Inches
Pounds of Water	0.100	Gallons Imperial
Pounds of Water	0.120	Gallons U.S.
Pounds of Water/min.	2.670×10^{-4}	Cubic ft/sec.
Pounds/cubic foot	16.02	kg/cubic metre
Pounds/cubic foot	5.787×10^{-4}	lbs/cubic inch
Pounds/cubic inch	27.68	grams/cubic cm
Pounds/cubic inch	2.768×10^4	kgs/cubic metre
Pounds/cubic inch	1728	lbs/cubic foot
Pounds/foot	1.488	kg/metre
Pounds/foot	178.6	Grams/cm
Pounds/sq. foot	0.016	Feet of Water
Pounds/sq. foot	4.883 x 10-4	kgs/sq. cm
Pounds/sq. foot	6.945 x 10-3	Pounds/sq. inch
Pounds/sq. inch	0.068	Atmospheres
Pounds/sq. inch	2.307	Feet of Water
Pounds/sq. inch	2.036	Inches of Mercury
Pounds/sq. inch	0.070	kg/sq. cm
Pounds/sq. inch	6.895	Kilopascals
Temperature (°C)	°C + 273.15	Abs. Temp. (°C)
Temperature (°C)	°C x 9 / 5 + 32	Temperature (°F)
Temperature (°F)	°F - 32 x 5 / 9	Abs. Temp. (°F)
Temperature (°F)	+ 459.67	Temp. (°C)
Tons (long)	1016	Kilograms
Tons (long)	2240	Pounds
Tons (long)	1.12	Tons (short)
Tonnes	1000	Kilograms
Tonnes	2205	Pounds
Tons Refrig.	3.517	kW
Tons (short)	2000	Pounds
Tons (short)	907.185	Kilograms
Tons (short)	0.893	Tons (long)
Tons (short)	0.907	Tonnes
Watts	3.412	B.T.U./hour
Watts	0.057	B.T.U./minute
Watts	44.26	Foot-pounds/minute
Watts	0.738	Foot-pounds/second
Watts	1.34×10^{-3}	Horsepower
Watts	0.014	kg-calories/minute
Watts	1000	Kilowatts
Watt-hours	3.415	British Thermal Units
Watt-hours	2655	Foot-pounds
Watt-hours	1.341×10^{-3}	Horsepower-hours
Watt-hours	0.861	Kilogram-calories
Watt-hours	367.1	Kilogram-metres
Watt-hours	1000	Kilowatt-hours

Conversion Data

Length

	Millimetres	Centimetres	Inches	Feet	Yards	Metres	Kilometres	Miles
Millimetres	1	0.1	0.03937	0.003281	0.0010936	0.001	0.000001	0.0000006214
Centimetres	10	1	0.3937	0.032808	0.010936	0.01	0.00001	0.000006214
Inches	25.4	2.54	1	0.08333	0.02777	0.0254	0.0000254	0.00001578
Feet	304.8	30.48	12	1	0.3333	0.3048	0.0003048	0.0001893
Yards	914.4	91.44	36	3	1	0.9144	0.0009144	0.0005682
Metres	1000	100	39.37	3.2808	1.0936	1	0.001	0.0006214
Kilometres	1,000,000	100,000	39,370	3280.8	1093.6	1000	1	0.6214
Miles	1,609,350	160,935	63,360	5280	1760	1609.35	1.60935	1

Mass

	Grams	Ounces	Pounds	Kilograms	U.S. Ton (Short)	Imp. Ton (Long)	Metric Tonne
Grams	1	0.03527392	0.00220462	0.001	0.05110231	0.0698426	0.051
Ounces	28.3496	1	0.0625	0.0283496	0.043125	0.04279	0.04283496
Pounds	453.593	16	1	0.453593	0.0005	0.0344642	0.03453593
Kilograms	1000	35.27392	2.20462	1	0.00110231	0.03984206	0.001
U.S. Ton (Short)	907,186	32,000	2000	907.186	1	0.89285	0.907186
Imp. Ton (Long)	1,016,050	35,840	2240	1016.05	1.12	1	1.01605
Metric Tonne	1,000,000	35,273.92	2204.62	1000	1.10231	0.984206	1

Energy or Work

	Joules (1 Joule=107 Ergs)	Foot - Pounds	Kilogram Metres	Litre - Atmospheres	Horsepower Hours	Kilowatts Hours	Kilogram Calories	British Thermal Units	lbs Carbon Oxidised with Perfect Efficiency	lbs Water Evaporated from and at 100°C
Joules (1 Joule=107 Ergs)	1	0.7373	0.101937	0.0098705	0.063727	0.06278	0.0323795	0.039486	0.07642	0.069662
Foot - Pounds	1.3562	1	0.138255	0.013826	0.06505	0.063766	0.0332396	0.0012861	0.078808	0.0513256
Kilogram Metres	9.81	7.233	1	0.09677	0.053653	0.052724	0.002343	0.009302	0.0663718	0.0595895
Litre - Atmospheres	1,013,667	747,386	10.333	1	0.043774	0.042794	0.0242	0.0961	0.056583	0.049907
Horsepower Hours	2,685,443	1,980,000	273,746	26,490.40	1	0.7457	641.477	2546.5	0.174	2.62
Kilowatts Hours	3,600,000	2,655,220	367,100	35,526.95	1.341	1	860.238	3415	0.234	3.52
Kilogram Calories	4185.8291	3087.35	426.843	41.309	0.001558	0.0011623	1	3.9683	0.0329909	0.004501
British Thermal Units	1054.198	778	107.5	10.40277	0.033927	0.032928	0.2519	1	0.04685	0.00103
lbs Carbon Oxidised with Perfect Efficiency	15,387,041.6	11,352,000	1.569,527.5	151,894.66	5.733	4.275	3,677.74	14,600	1	15.05
lbs Water Evaporated from and at 100°C	1,023,000	754,525	104.32	10,096.77	0.3811	0.2841	244.44	970.4	0.066466	1

Volume and Capacity

	Cubic Inches	Cubic Feet	Cubic Yards	Litres	US Quarts		US Gallons		Imperial Gallons	US Bushels	Water at Max. Density 4°C	
					Liquid	Dry	Liquid	Dry			Pounds of Water	Kilograms of Water
Cubic Inches	1	0.035787	0.042143	0.016384	0.01731	0.01488	0.004329	0.003721	0.0036065	0.034651	0.0361275	0.0163872
Cubic Feet	1728	1	0.037037	28.317	29.92208	25.713	7.48052	6.4282	6.2321	0.803564	62.4283	28.317
Cubic Yards	46,656	27	1	764.56	807.895	694.278	201.974	173.569	168.266	21.6962	1685.56	764.559
Litres	61,023.40	35.3145	1.307941	1000	1056.68	908.1	264.17	227.02	220.083	28.38	2204.62	1000
US Quarts - Liquid	61.0234	0.0353145	0.001308	1	1.05668	0.9081	0.26417	0.22702	0.220083	0.02838	2.20462	1
US Quarts - Dry	57.75	0.03342	0.001238	0.94636	1	0.8595	0.25	0.2149	0.20828	0.02686	2.08636	0.94635
US Gallons - Liquid	67.18	0.03888	0.00144	1.1009	1.1635	1	0.2909	0.25	0.24235	0.03125	8.34545	3.78543
US Gallons - Dry	231	0.133681	0.004951	3.78543	4	3.4378	1	0.8595	0.833111	0.10743	10.0172	4.54373
Imperial Gallons	268.75	0.15552	0.00576	4.404	4.654	4	1.1635	1	0.96932	0.125		
US Bushels	277.274	0.160459	0.0059429	4.54374	4.80128	4.1267	1.20032	1.0317	1	0.12896		
Pounds of Water	2150	1.24446	0.04609	35.238	37.2353	32	9.3088	8	7.81457	1		
Kilograms of Water	27.6798	0.0160184	0.035929	0.453592	0.4793	0.119825	0.0998281	1	0.453593			

Pressure

	psi.	atms.	ft. Hd. H2O at 20°C	Inches H2O	kg/cm2	Metres H2O	Inches Hg. at 20°C	mm Hg.	cm Hg.	Bar	Millibar (mb)	kPa
psi.	1	0.068	2.31	27.72	0.07	0.704	2.043	51.884	5.188	0.069	68.947	6.895
atms.	14.696	1	33.659	407.513	1.033	10.351	30.019	762.48	76.284	1.013	1013	101.325
ft. Hd. H_2O at 20°C	0.433	0.029	1	12	0.03	0.305	0.884	22.452	2.245	0.03	29.837	2.984
Inches H_2O	0.036	0.0025	0.833	1	0.0025	0.025	0.074	1.871	0.187	0.0025	2.486	0.249
kg/cm^2	14.233	0.968	32.867	394.408	1	10.018	29.054	737.959	73.796	0.981	980.662	98.066
Metres H_2O	1.422	0.097	3.287	39.37	0.099	1	2.905	73.796	7.379	0.098	98.066	9.807
Inches Hg. at 20°C	0.489	0.033	1.131	13.575	0.034	0.345	1	25.4	2.54	0.034	33.753	3.375
mm Hg.	0.019	0.0013	0.045	0.534	0.0014	0.0136	0.039	1	0.1	0.001	1.329	0.133
cm Hg.	0.193	0.0131	0.455	5.34	0.014	0.136	0.393	10	1	0.0133	13.29	1.328
Bar	14.503	0.987	33.514	402.164	1.02	10.211	29.625	752.47	75.247	1	1000	100
Millibar (mb)	0.014	0.0009	0.033	0.402	0.001	0.0102	0.029	0.752	0.075	0.001	1	0.1
kPa	0.145	0.0098	0.335	4.021	0.01	0.102	0.296	7.525	0.0752	0.01	10	1

Conversion Data

Inch to Millimetre Equivalents

Decimals to Millimetres			
Inches	mm	Inches	mm
0.001	0.0254	0.500	12.7000
0.002	0.0508	0.510	12.9540
0.003	0.0762	0.520	13.2080
0.004	0.1016	0.530	13.4620
0.005	0.1270	0.540	13.7160
0.006	0.1524	0.550	13.9700
0.007	0.1778	0.560	14.2240
0.008	0.2032	0.570	14.4780
0.009	0.2286	0.580	14.7320
0.010	0.2540	0.590	14.9860
0.020	0.5080	0.600	15.2400
0.030	0.7620	0.610	15.4940
0.040	1.0160	0.620	15.7480
0.050	1.2700	0.630	16.0020
0.060	1.5240	0.640	16.2560
0.070	1.7780	0.650	16.5100
0.080	2.0320	0.660	16.7640
0.090	2.2860	0.670	17.0180
0.100	2.5400	0.680	17.2720
0.110	2.7940	0.690	17.5260
0.140	3.5560	0.700	17.7800
0.150	3.8100	0.710	18.0340
0.160	4.0640	0.720	18.2880
0.170	4.3180	0.730	18.5420
0.180	4.5720	0.740	18.7960
0.190	4.8260	0.750	19.0500
0.200	5.0800	0.770	19.5580
0.210	5.3340	0.780	19.8120
0.220	5.5880	0.790	20.0660
0.250	6.3500	0.800	20.3200
0.260	6.6040	0.810	20.5740
0.270	6.8580	0.820	21.8280
0.280	7.1120	0.830	21.0820
0.290	7.3660	0.840	21.3360
0.300	7.6200	0.850	21.5900
0.310	7.8740	0.860	21.8440
0.320	8.1280	0.870	22.0980
0.330	8.3820	0.880	22.3520
0.360	9.1440	0.890	22.6060
0.370	9.3980	0.900	22.8600
0.380	9.6520	0.910	23.1140
0.390	9.9060	0.920	23.3680
0.400	10.1600	0.930	23.6220
0.410	10.4140	0.940	23.8760
0.420	10.6680	0.950	24.1300
0.430	10.9220	0.960	24.3840
0.440	11.1760	0.970	24.6380
0.450	11.4300	0.980	24.8920
0.460	11.6840	0.990	25.1460
0.470	11.9380	1.000	25.4000
0.480	12.1920		
0.490	12.4460		

Fractions to Decimals to Millimetres					
Inches		mm	Inches		mm
1/64	0.0156	0.3969	33/64	0.5156	13.0969
1/32	0.0312	0.7938	17/32	0.5312	13.4938
3/64	0.0469	1.1906	35/64	0.5469	13.8906
1/16	0.0625	1.5875	9/16	0.5625	14.2875
5/64	0.0781	1.9844	37/64	0.5781	14.6844
3/32	0.0938	2.3812	19/32	0.5938	15.0812
7/64	0.1094	2.7781	39/64	0.6094	15.4781
1/8	0.1250	3.1750	5/8	0.6250	15.8750
9/64	0.1406	3.5719	41/64	0.6406	16.2719
5/32	0.1562	3.9688	21/32	0.6562	16.6688
11/64	0.1719	4.3656	43/64	0.6719	17.0656
3/16	0.1875	4.7625	11/16	0.6875	17.4625
13/64	0.2031	5.1594	45/64	0.7031	17.8594
7/32	0.2188	5.5562	23/32	0.7188	18.2562
15/64	0.2344	5.9531	47/64	0.7344	18.6531
1/4	0.2500	6.3500	3/4	0.7500	19.0500
17/64	0.2656	6.7469	49/64	0.7656	19.4469
9/32	0.2812	7.1438	25/32	0.7812	19.8438
19/64	0.2969	7.5406	51/64	0.7969	20.2406
5/16	0.3125	7.9375	13/16	0.8125	20.6375
21/64	0.3281	8.3344	53/64	0.8281	21.0344
11/32	0.3438	8.7312	27/32	0.8438	21.4312
23/64	0.3594	9.1281	55/64	0.8594	21.8281
3/8	0.3750	9.5250	7/8	0.8750	22.2250
25/64	0.3906	9.9219	57/64	0.8906	22.6219
13/32	0.4062	10.3188	29/32	0.9062	23.0188
27/64	0.4219	10.7156	59/64	0.9219	23.4156
7/16	0.4375	11.1125	15/16	0.9375	23.8125
29/64	0.4531	11.5094	61/64	0.9531	24.2094
15/32	0.4688	11.9062	31/32	0.9688	24.6062
31/64	0.4844	12.3031	63/64	0.9844	25.0031
1/2	0.5000	12.7000	1	1.000	25.4000

Pressure - Vacuum Conversion

Pressure Pascal [Pa] absolute	Pressure KiloPascal [kPa] absolute	Pressure bar [bar] absolute	Millibar [millibar] absolute	Micron [millitorr]	Torr [mm Hg]	Inches Hg [Inches Mercury]	PSI [Pounds Per Square Inch]
101325 1 atmosphere	101.325 1 atmosphere	1.01325 1 atmosphere	1013 1 atmosphere	760000 1 atmosphere	760 1 atmosphere	0.00 1 atmosphere	14.70 1 atmosphere
100000	100	1	1000	750062	750	0.42	14.50
80000	80	0.8	800	600049	600	6.32	11.60
53300	53.3	0.533	533	399783	400	14.22	7.73
26700	26.7	0.267	267	200266	200	22.07	3.87
13300	13.3	0.133	133	99758	100	25.98	1.93
6000	6	0.06	60	45004	45	28.15	0.87
2700	2.7	0.027	27	20252	20	29.14	0.39
133	0.133	0.00133	1.33	998	1.0	29.88	0.02
93	0.093	0.00093	0.93	698	0.7	29.89	0.013
78	0.078	0.00078	0.78	585	0.6	29.90	0.011
66	0.066	0.00066	0.66	495	0.5	29.900	0.0096
53	0.053	0.00053	0.53	398	0.4	29.910	0.0077
40	0.04	0.0004	0.40	300	0.3	29.910	0.0058
26	0.026	0.00026	0.26	195	0.2	29.920	0.0038
13	0.013	0.00013	0.13	98	0.10		0.0019
9	0.009	0.00009	0.09	68	0.07		0.0013
8	0.008	0.00008	0.08	60	0.06		0.0012
7	0.007	0.00007	0.07	53	0.05		0.0010
5	0.005	0.00005	0.05	38	0.04		0.0007
4	0.004	0.00004	0.04	30	0.03		0.0006
3	0.003	0.00003	0.03	23	0.02		0.0004
1.3	0.0013	0.000013	0.013	10	0.01		0.0002

To obtain gauge pressure subtract 1 atmosphere.

Design Temperature/Pressure

The Australian/New Zealand Standards include minimum recommended design pressures (PS) for all pipe work, fittings and components use in fixed refrigeration and air conditioning systems. This covers all fixed systems other than automotive air conditioning. The design pressures are based on the saturated pressure of the refrigerant at the temperature listed in the table below at the design ambient temperature for the location in which the system is to operate. When evaporators can be subject to high pressure, e.g. during hot gas defrosting or reverse cycle operation, the high pressure side specified temperature shall be used.

Ambient Conditions	≤ 32 °C	≤ 38 °C	≤ 43 °C	≤ 55 °C
High pressure side with air cooled condenser	55 °C	59 °C	63 °C	67 °C
High pressure side with water cooled condenser and water heat pump	Maximum leaving temperature +8K			
High pressure side with evaporative condenser	43 °C	43 °C	43 °C	55 °C
Low pressure side with heat exchanger exposed to the outdoor ambient temperature	32 °C	38 °C	43 °C	55 °C
Low pressure side with heat exchanger exposed to the indoor ambient temperature	27 °C	33 °C	38 °C	38 °C

Specified design temperatures (Method 2) as per AS/NZS 1677.2:2016

Minimum design temperature as per AS/NZS 5149.2:2016

It is advisable to reference AS/NZS 5149.2:2016 for more complete information.

The pressure listed in the chart below represent the saturated pressure of each refrigerant and therefore the required minimum design pressure for the pipe work and components in that part of a refrigeration or air conditioning system.

Design High Side Pressure	55°C	59°C	63°C	67°C
R134a	1391	1542	1704	1880
R404A	2485	2723	2977	3252
R427A	2279	2498	2732	2981
R410A	3339	2659	4002	4370

When selecting components for use in a refrigeration or air conditioning systems care should be taken to ensure the maximum design pressure of the component selected is suitable for the intended use. This is especially important in R410A systems as the required pressure ratings are significantly higher than that required on systems using most other refrigerants.

Flare Nut Torque Data

Dimensional and Torque Data Standard for Flare Nuts

Flare Nut Size	Thread Size UNF	Across Flats (AF) Dimension				
		Heldon Standard Flare Nuts	Heldon R410A Flare Nut	*ARI Heldon Std. Flare Nut	Heldon R410A Flare Nut	R410A Torque Wrench Setting
1/4	7/16 - 20	15.9	n/a	11 - 14	n/a	n/a
5/16	1/2 - 20	19.0	19.1		14 - 18	16
3/8	5/8 - 18	20.6	22.3	20 - 30	33 - 42	42
1/2	3/4 - 16	23.8	25.4	34 - 47	50 - 62	50
5/8	7/8 - 14	27.0	28.7	54 - 75	63 - 77	65
3/4	11/8 - 14	33.3	36.0	68 - 81	n/a	n/a
7/8	11/4 - 12	41.0	41.0	n/a	n/a	n/a

Courtesy of Heldon Products

Temperature Pressure Data for Common Refrigerants

°C	R22		R32		34M		R123		R1234yf		R134a		R402A				R404A				R406A				°C
					DEW								BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		
	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	
-40	4	1	76	11	-46	14	-98	29	-39	6	-50	15	51	7	39	6	34	5	30	4	-29	9	-56	17	-40
-38	14	2	93	13	-40	12	-97	29	-33	5	-45	13	65	9	53	8	47	7	42	6	-22	7	-51	15	-38
-36	25	4	111	16	-34	10	-97	29	-26	4	-38	11	80	12	67	10	60	9	55	8	-15	4	-46	13	-36
-34	37	5	130	19	-26	8	-96	28	-19	3	-32	9	96	14	82	12	75	11	70	10	-6	2	-40	12	-34
-32	49	7	150	22	-19	6	-95	28	-11	2	-25	7	113	16	98	14	90	13	85	12	2	0	-34	10	-32
-30	63	9	172	25	-10	3	-95	28	-2	0	-17	5	131	19	115	17	106	15	101	15	12	2	-27	8	-30
-28	77	11	195	28	-2	0	-94	28	7	1	-9	3	150	22	134	19	124	18	118	17	22	3	-19	6	-28
-26	92	13	220	32	8	1	-93	27	16	2	0	0	170	25	153	22	143	21	137	20	32	5	-12	3	-26
-24	108	16	247	36	18	3	-92	27	27	4	10	1	191	28	174	25	162	24	156	23	44	6	-3	1	-24
-22	126	18	275	40	30	4	-91	27	38	5	20	3	214	31	196	28	183	27	177	26	56	8	6	1	-22
-20	144	21	304	44	41	6	-89	26	50	7	31	5	238	35	219	32	206	30	199	29	69	10	16	2	-20
-18	163	24	336	49	54	8	-88	26	62	9	43	6	264	38	244	35	229	33	222	32	82	12	26	4	-18
-16	184	27	369	54	68	10	-86	26	75	11	56	8	291	42	270	39	254	37	247	36	97	14	37	5	-16
-14	206	30	405	59	82	12	-85	25	90	13	69	10	319	46	298	43	281	41	273	40	112	16	49	7	-14
-12	229	33	442	64	98	14	-83	25	105	15	84	12	349	51	327	47	308	45	300	44	129	19	61	9	-12
-10	253	37	481	70	114	17	-81	24	120	17	99	14	381	55	358	52	338	49	329	48	146	21	75	11	-10
-8	279	40	523	76	132	19	-79	23	137	20	116	17	414	60	390	57	369	53	360	52	164	24	89	13	-8
-6	306	44	567	82	150	22	-77	23	155	22	133	19	449	65	424	62	401	58	392	57	183	27	104	15	-6
-4	335	49	613	89	170	25	-74	22	174	25	151	22	486	70	460	67	435	63	426	62	204	30	120	17	-4
-2	365	53	661	96	191	28	-72	21	194	28	171	25	524	76	498	72	471	68	462	67	225	33	137	20	-2
0	397	58	712	103	213	31	-69	20	215	31	191	28	564	82	537	78	509	74	499	72	247	36	155	22	0
2	430	62	765	111	236	34	-66	19	236	34	213	31	606	88	578	84	548	80	538	78	271	39	174	25	2
4	465	67	821	119	261	38	-62	18	260	38	236	34	651	94	622	90	590	86	579	84	296	43	194	28	4
6	501	73	880	128	287	42	-59	17	284	41	261	38	697	101	667	97	633	92	622	90	322	47	215	31	6
8	540	78	941	137	314	46	-55	16	309	45	286	42	745	108	715	104	678	98	667	97	349	51	237	34	8
10	580	84	1006	146	343	50	-51	15	336	49	313	45	796	115	764	111	726	105	714	104	377	55	261	38	10
12	622	90	1073	156	373	54	-46	14	364	53	342	50	848	123	816	118	775	112	764	111	407	59	285	41	12
14	665	97	1143	166	405	59	-42	12	394	57	372	54	903	131	870	126	827	120	815	118	438	64	311	45	14
16	711	103	1217	176	439	64	-37	11	425	62	403	58	960	139	927	134	881	128	869	126	471	68	338	49	16
18	759	110	1293	188	474	69	-31	9	457	66	436	63	1020	148	986	143	937	136	925	134	505	73	367	53	18
20	809	117	1373	199	511	74	-26	8	490	71	470	68	1082	157	1047	152	996	144	983	143	540	78	397	58	20
22	861	125	1457	211	549	80	-20	6	526	76	507	73	1147	166	1111	161	1057	153	1044	151	577	84	428	62	22
24	915	133	1544	224	590	86	-13	4	562	82	544	79	1214	176	1177	171	1121	163	1107	161	616	89	461	67	24
26	971	141	1634	237	632	92	-7	2	601	87	584	85	1284	186	1247	181	1187	172	1173	170	656	95	495	72	26
28	1030	149	1728	251	676	98	1	0	641	93	626	91	1356	197	1319	191	1256	182	1242	180	697	101	531	77	28
30	1091	158	1826	265	722	105	8	1	682	99	669	97	1432	208	1393	202	1327	192	1313	190	741	107	568	82	30
32	1154	167	1928	280	771	112	16	2	726	105	714	104	1510	219	1471	213	1401	203	1387	201	786	114	607	88	32
34	1220	177	2034	295	821	119	25	4	771	112	761	110	1591	231	1552	225	1479	214	1464	212	833	121	648	94	34
36	1288	187	2144	311	873	127	34	5	818	119	811	118	1675	243	1635	237	1559	226	1544	224	881	128	690	100	36
38	1359	197	2258	328	928	135	43	6	866	126	862	125	1763	256	1722	250	1642	238	1627	236	932	135	734	107	38
40	1432	208	2377	345	985	143	53	8	917	133	915	133	1853	269	1812	263	1728	251	1713	249	984	143	781	113	40
42	1508	219	2500	363	1044	151	64	9	970	141	971	141	1947	282	1905	276	1818	264	1803	261	1038	151	828	120	42
44	1587	230	2628	381	1106	160	75	11	1024	149	1029	149	2043	296	2002	290	1910	277	1895	275	1094	159	878	127	44
46	1669	242	2760	400	1170	170	86	13	1081	157	1089	158	2144	311	2102	305	2007	291	1992	289	1152	167	930	135	46
48	1754	254	2898	420	1237	179	98	14	1140	165	1152	167	2248	326	2206	320	2106	305	2091	303	1212	176	984	143	48
50	1841	267	3040	441	1306	189	111	16	1201	174	1217	176	2355	342	2313	335	2209	320	2194	318	1275	185	1040	151	50
52	1932	280	3187	462	1378	200	125	18	1264	183	1284	186	2466	358	2424	352	2316	336	2301	334	1339	194	1098	159	52
54	2026	294	3340	484	1453	211	139	20	1330	193	1354	196	2581	374	2539	368	2427	352	2412	350	1405	204	1159	168	54
56	2123	308	3498	507	1530	222	153	22	1398	203	1427	207	2700	392	2658	386	2542	369	2527	367	1474	214	1221	177	56
58	2223	322	3662	531	1611	234	169	24	1468	213	1502	218	2823	409	2782	403	2661	386	2646	384	1545	224	1286	187	58
60	2326	337	3832	556	1694	246	185	27	1541	223	1581	229	2950	428	2909	422	2784	404	2770	402	1618	235	1353	196	60
62	2433	353	4008	581	1780	258	201	29	1616	234	1662	241	3081	447	3041	441	2911	422	2898	420	1693	246	1423	206	62
64	2543	369	4190	608	1870	271	219	32	1694	246	1745	253	3217	467	3178	461	3043	441	3031	440	1771	257	1495	217	64
66	2657	385	4378	635	1963	285	237	34	1774	257	1832	266	3357	487	3320	482	3181	461	3169	460	1851	268	1570	228	66
68	2775	402	4573	663	2059	299	256	37	1857	269	1922	279	3502	508	3467	503	3323	482	3313	480	1933	280	1647	239	68
70	2896	420	4776	693	2158	313	276	40	1943	282	2158	313	3653	530	3620	525	3471	503	3463	502	2018	293	1727	251	70

Use Dew pressure for superheat calculations and Bubble pressure for sub-cooling calculations

Red figures under kPa are negative kilopascals gauge and red figures under psi are inches of mercury

Temperature Pressure Data for Common Refrigerants

	R407B				R407C				R407F				R408A				R409A				R410A				
	BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		
°C	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	°C
-40	37	5	12	2	19	3	-16	5	34	5	-2	0	24	3	21	3	-23	7	-50	15	74	11	74	11	-40
-38	50	7	23	3	31	4	-7	2	47	7	9	1	36	5	33	5	-15	4	-45	13	91	13	90	13	-38
-36	64	9	36	5	43	6	3	0	60	9	20	3	48	7	45	7	-7	2	-38	11	108	16	108	16	-36
-34	79	11	49	7	56	8	14	2	75	11	32	5	61	9	58	8	2	0	-32	9	127	18	126	18	-34
-32	95	14	63	9	71	10	25	4	91	13	45	7	76	11	73	11	12	2	-25	7	147	21	147	21	-32
-30	112	16	78	11	86	12	37	5	108	16	59	9	91	13	88	13	22	3	-17	5	169	25	168	24	-30
-28	131	19	95	14	102	15	51	7	126	18	74	11	107	16	104	15	33	5	-9	3	192	28	191	28	-28
-26	150	22	112	16	119	17	65	9	145	21	90	13	125	18	121	18	44	6	0	0	216	31	215	31	-26
-24	171	25	131	19	138	20	80	12	166	24	107	16	143	21	139	20	57	8	9	1	242	35	241	35	-24
-22	193	28	151	22	158	23	96	14	188	27	125	18	163	24	159	23	70	10	19	3	270	39	269	39	-22
-20	216	31	172	25	179	26	113	16	211	31	145	21	183	27	179	26	84	12	30	4	299	43	298	43	-20
-18	241	35	194	28	201	29	132	19	235	34	166	24	205	30	201	29	99	14	42	6	330	48	329	48	-18
-16	267	39	218	32	224	33	152	22	261	38	188	27	228	33	224	32	115	17	54	8	363	53	362	52	-16
-14	295	43	243	35	249	36	173	25	289	42	211	31	253	37	248	36	131	19	68	10	398	58	396	57	-14
-12	324	47	270	39	276	40	195	28	318	46	237	34	279	40	274	40	149	22	82	12	435	63	433	63	-12
-10	355	52	299	43	303	44	218	32	348	51	263	38	306	44	301	44	168	24	97	14	473	69	471	68	-10
-8	388	56	329	48	333	48	244	35	381	55	291	42	335	49	329	48	188	27	113	16	514	75	512	74	-8
-6	422	61	361	52	364	53	270	39	415	60	321	47	365	53	359	52	209	30	130	19	557	81	555	80	-6
-4	458	66	394	57	396	57	298	43	450	65	353	51	397	58	391	57	231	33	148	21	602	87	600	87	-4
-2	496	72	429	62	431	62	328	48	488	71	386	56	430	62	424	62	254	37	167	24	650	94	647	94	-2
0	536	78	466	68	467	68	359	52	528	77	421	61	465	67	459	67	278	40	187	27	699	101	697	101	0
2	578	84	505	73	504	73	393	57	569	83	458	66	502	73	496	72	304	44	208	30	752	109	749	109	2
4	621	90	547	79	544	79	427	62	613	89	497	72	541	78	534	77	331	48	231	33	806	117	804	117	4
6	667	97	590	86	586	85	464	67	659	96	538	78	581	84	574	83	359	52	254	37	864	125	861	125	6
8	715	104	635	92	629	91	503	73	706	102	581	84	623	90	616	89	389	56	279	40	924	134	921	134	8
10	766	111	682	99	675	98	544	79	757	110	626	91	667	97	660	96	420	61	305	44	987	143	983	143	10
12	818	119	732	106	723	105	586	85	809	117	674	98	714	103	706	102	452	66	333	48	1053	153	1049	152	12
14	873	127	784	114	773	112	631	92	864	125	723	105	762	110	754	109	486	70	362	52	1122	163	1118	162	14
16	930	135	839	122	825	120	678	98	921	134	776	113	812	118	804	117	521	76	392	57	1193	173	1189	172	16
18	990	144	896	130	879	128	727	106	980	142	830	120	864	125	856	124	558	81	424	62	1268	184	1264	183	18
20	1052	153	955	139	936	136	779	113	1043	151	888	129	919	133	910	132	597	87	458	66	1346	195	1342	195	20
22	1117	162	1017	148	996	144	833	121	1107	161	947	137	976	142	967	140	637	92	493	71	1428	207	1423	206	22
24	1184	172	1082	157	1057	153	890	129	1175	170	1010	146	1035	150	1026	149	679	99	529	77	1512	219	1507	219	24
26	1255	182	1150	167	1121	163	949	138	1245	181	1075	156	1097	159	1087	158	723	105	567	82	1601	232	1595	231	26
28	1328	193	1221	177	1188	172	1010	147	1318	191	1143	166	1161	168	1151	167	768	111	607	88	1692	245	1687	245	28
30	1404	204	1294	188	1258	182	1075	156	1394	202	1215	176	1227	178	1218	177	816	118	649	94	1788	259	1782	258	30
32	1482	215	1371	199	1330	193	1142	166	1473	214	1289	187	1296	188	1287	187	865	125	693	101	1887	274	1881	273	32
34	1564	227	1450	210	1405	204	1212	176	1555	226	1366	198	1368	198	1358	197	916	133	738	107	1990	289	1984	288	34
36	1649	239	1533	222	1483	215	1285	186	1640	238	1447	210	1443	209	1432	208	969	140	786	114	2098	304	2091	303	36
38	1737	252	1620	235	1564	227	1361	197	1729	251	1531	222	1520	220	1509	219	1024	148	835	121	2209	320	2202	319	38
40	1829	265	1709	248	1648	239	1440	209	1820	264	1618	235	1600	232	1589	230	1081	157	887	129	2324	337	2317	336	40
42	1924	279	1802	261	1735	252	1522	221	1915	278	1709	248	1683	244	1672	242	1140	165	940	136	2444	354	2437	353	42
44	2022	293	1899	275	1825	265	1608	233	2013	292	1803	262	1769	257	1758	255	1201	174	996	144	2569	373	2561	371	44
46	2124	308	2000	290	1918	278	1697	246	2115	307	1902	276	1858	269	1847	268	1264	183	1054	153	2698	391	2690	390	46
48	2229	323	2104	305	2015	292	1790	260	2221	322	2004	291	1950	283	1939	281	1330	193	1114	162	2831	411	2823	409	48
50	2338	339	2213	321	2115	307	1886	274	2330	338	2110	306	2045	297	2034	295	1397	203	1177	171	2970	431	2962	430	50
52	2451	355	2325	337	2218	322	1987	288	2443	354	2220	322	2144	311	2132	309	1468	213	1241	180	3113	451	3105	450	52
54	2567	372	2442	354	2325	337	2091	303	2559	371	2335	339	2246	326	2234	324	1540	223	1309	190	3262	473	3254	472	54
56	2688	390	2564	372	2436	353	2199	319	2680	389	2454	356	2352	341	2340	339	1615	234	1379	200	3416	495	3408	494	56
58	2813	408	2690	390	2550	370	2311	335	2805	407	2577	374	2461	357	2449	355	1692	245	1451	210	3576	519	3568	517	58
60	2942	427	2821	409	2668	387	2427	352	2933	425	2706	392	2574	373	2562	372	1772	257	1526	221	3741	543	3734	541	60
62	3075	446	2957	429	2790	405	2548	370	3066	445	2839	412	2691	390	2678	388	1854	269	1604	233	3913	567	3905	566	62
64	3213	466	3098	449	2916	423	2674	388	3204	465	2978	432	2811	408	2799	406	1939	281	1684	244	4090	593	4083	592	64
66	3355	487	3246	471	3046	442	2805	407	3345	485	3121	453	2936	426	2923	424	2027	294	1768	256	4274	620	4268	619	66
68	3502	508	3400	493	3180	461	2940	426	3491	506	3271	474	3064	444	3052	443	2117	307	1854	269	4465	648	4461	647	68
70	3654	530	3561	517	3318	481	3081	447	3642	528	3427	497	3197	464	3185	462	2210	321	1943	282	4663	676	4660	676	70

Use Dew pressure for superheat calculations and Bubble pressure for sub-cooling calculations
Red figures under kPa are negative kilopascals gauge and red figures under psi are inches of mercury

Temperature Pressure Data for Common Refrigerants

	R413A				R417A				R427A				R438A (MO99)				R507				R717		R744		
	BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		BUBBLE		DEW		(Ammonia)		(CO²)		
°C	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	°C
-40	-26	8	-45	13	-4	1	-26	8	15	2	-17	5	12	2	-18	3	37	5	37	5	-30	9	903	131	-40
-38	-19	6	-39	11	5	1	-18	5	26	4	-9	3	23	3	-9	1	50	7	50	7	-22	6	979	142	-38
-36	-11	3	-32	10	15	2	-9	3	38	6	1	0	34	5	1	0	64	9	64	9	-13	4	1059	154	-36
-34	-3	1	-25	7	26	4	0	0	51	7	11	2	47	7	11	2	79	11	79	11	-3	1	1144	166	-34
-32	6	1	-17	5	38	5	10	2	65	9	22	3	60	9	22	3	95	14	95	14	7	1	1233	179	-32
-30	16	2	-9	3	50	7	21	3	79	12	34	5	75	11	34	5	112	16	112	16	18	3	1326	192	-30
-28	26	4	0	0	64	9	33	5	95	14	47	7	90	13	47	7	130	19	129	19	30	4	1425	207	-28
-26	37	5	10	1	78	11	45	7	112	16	61	9	106	15	60	9	149	22	149	22	43	6	1528	222	-26
-24	49	7	21	3	93	14	59	9	130	19	76	11	124	18	75	11	169	24	169	24	57	8	1636	237	-24
-22	62	9	32	5	109	16	73	11	149	22	92	13	142	21	91	13	190	28	190	28	72	11	1750	254	-22
-20	75	11	44	6	127	18	89	13	169	24	109	16	162	23	107	16	213	31	213	31	89	13	1868	271	-20
-18	90	13	57	8	145	21	105	15	190	28	127	18	183	26	125	18	237	34	237	34	106	15	1993	289	-18
-16	105	15	71	10	164	24	122	18	213	31	146	21	205	30	144	21	263	38	263	38	125	18	2122	308	-16
-14	121	18	85	12	185	27	141	20	237	34	166	24	228	33	164	24	290	42	290	42	145	21	2258	328	-14
-12	138	20	101	15	207	30	160	23	262	38	188	27	253	37	186	27	318	46	318	46	166	24	2400	348	-12
-10	156	23	118	17	229	33	181	26	289	42	211	31	279	40	209	30	348	51	348	50	189	27	2547	369	-10
-8	175	25	135	20	254	37	203	30	317	46	235	34	307	44	233	34	380	55	379	55	214	31	2701	392	-8
-6	195	28	154	22	279	41	227	33	346	50	261	38	336	49	258	37	413	60	413	60	240	35	2862	415	-6
-4	217	31	174	25	306	44	252	36	378	55	289	42	366	53	285	41	448	65	448	65	267	39	3029	439	-4
-2	239	35	195	28	335	49	278	40	411	60	317	46	398	58	314	46	485	70	484	70	297	43	3203	465	-2
0	263	38	217	32	364	53	305	44	445	65	348	50	432	63	344	50	523	76	523	76	328	48	3384	491	0
2	288	42	241	35	396	57	335	49	481	70	380	55	468	68	376	55	563	82	563	82	361	52	3572	518	2
4	314	46	266	39	429	62	365	53	520	75	414	60	505	73	409	59	606	88	605	88	396	57	3768	546	4
6	342	50	292	42	463	67	398	58	559	81	450	65	544	79	445	64	650	94	649	94	433	63	3971	576	6
8	371	54	320	46	500	72	431	63	601	87	487	71	585	85	482	70	696	101	696	101	472	69	4182	607	8
10	401	58	349	51	537	78	467	68	645	94	527	76	628	91	521	76	745	108	744	108	514	75	4401	638	10
12	433	63	380	55	577	84	505	73	691	100	568	82	673	98	562	81	795	115	795	115	557	81	4628	671	12
14	467	68	412	60	619	90	544	79	739	107	612	89	719	104	604	88	848	123	847	123	603	88	4864	706	14
16	502	73	446	65	662	96	585	85	789	114	657	95	768	111	649	94	903	131	902	131	652	95	5110	741	16
18	539	78	481	70	707	103	628	91	841	122	705	102	819	119	696	101	961	139	960	139	703	102	5364	778	18
20	577	84	518	75	755	109	673	98	895	130	755	110	873	127	746	108	1021	148	1020	148	756	110	5628	816	20
22	617	89	557	81	804	117	720	104	952	138	807	117	928	135	797	116	1083	157	1082	157	812	118	5902	856	22
24	659	96	598	87	856	124	770	112	1011	147	862	125	986	143	851	123	1148	166	1147	166	871	126	6186	897	24
26	703	102	640	93	909	132	821	119	1073	156	919	133	1046	152	907	132	1215	176	1214	176	933	135	6482	940	26
28	748	109	685	99	965	140	875	127	1137	165	979	142	1109	161	966	140	1286	186	1284	186	998	145	6791	985	28
30	796	115	731	106	1023	148	931	135	1203	175	1041	151	1174	170	1027	149	1359	197	1357	197	1066	155	7112	1032	30
32	845	123	780	113	1084	157	989	144	1273	185	1106	160	1242	180	1091	158	1435	208	1433	208	1137	165			32
34	897	130	830	120	1147	166	1050	152	1344	195	1174	170	1312	190	1158	168	1513	220	1512	219	1211	176			34
36	950	138	883	128	1212	176	1114	162	1419	206	1244	180	1385	201	1227	178	1595	231	1594	231	1289	187			36
38	1006	146	938	136	1280	186	1180	171	1496	217	1318	191	1461	212	1299	188	1680	244	1679	243	1370	199			38
40	1064	154	995	144	1350	196	1248	181	1577	229	1394	202	1539	223	1374	199	1768	256	1767	256	1454	211			40
42	1125	163	1055	153	1423	206	1320	191	1660	241	1474	214	1621	235	1453	211	1860	270	1858	269	1542	224			42
44	1187	172	1117	162	1499	217	1394	202	1746	253	1557	226	1705	247	1534	222	1954	283	1953	283	1634	237			44
46	1252	182	1181	171	1577	229	1471	213	1836	266	1643	238	1792	260	1619	235	2053	298	2051	297	1730	251			46
48	1320	191	1248	181	1659	241	1551	225	1928	280	1732	251	1883	273	1706	247	2154	312	2152	312	1829	265			48
50	1390	202	1318	191	1743	253	1634	237	2024	294	1825	265	1976	287	1798	261	2260	328	2258	328	1933	280			50
52	1462	212	1390	202	1830	265	1720	250	2123	308	1922	279	2073	301	1893	274	2369	344	2367	343	2040	296			52
54	1538	223	1465	212	1920	279	1810	263	2226	323	2022	293	2174	315	1991	289	2483	360	2480	360	2152	312			54
56	1616	234	1542	224	2014	292	1903	276	2332	338	2126	308	2277	330	2093	304	2600	377	2598	377	2269	329			56
58	1696	246	1623	235	2110	306	1999	290	2441	354	2234	324	2384	346	2199	319	2722	395	2720	394	2389	347			58
60	1780	258	1706	248	2210	321	2099	304	2554	370	2346	340	2495	362	2309	335	2848	413	2846	413	2514	365			60
62	1866	271	1793	260	2314	336	2203	319	2671	387	2463	357	2609	378	2424	352	2978	432	2976	432	2644	383			62
64	1956	284	1883	273	2421	351	2310	335	2792	405	2584	375	2727	396	2543	369	3114	452	3112	451	2779	403			64
66	2049	297	1976	287	2531	367	2421	351	2916	423	2709	393	2849	413	2666	387	3255	472	3254	472	2918	423			66
68	2144	311	2072	300	2645	384	2537	368	3045	442	2840	412	2975	431	2794	405	3402	493	3401	493	3063	444			68
70	2243	325	2171	315	2763	401	2657	385	3177	461	2975	431	3104	450	2927	425	3555	516	3554	515	3212	466			70

Use Dew pressure for superheat calculations and Bubble pressure for sub-cooling calculations

Red figures under kPa are negative kilopascals gauge and red figures under psi are inches of mercury

Properties of Refrigerants

Refrigerant	R11	R12	R13	R13B1	R14	R22	R23	R113	R114	R115	R123	R134a
Boiling Point at 101 kPa °C	23.8	-29.8	-81.4	-57.7	-127.9	-40.8	-80.1	47.6	3.6	-39.1	27.9	-26.1
Temp. Glide at 101 kPa K	0	0	0	0	0	0	0	0	0	0	0	0
Critical Temperature °C	198	111.8	28.8	67.1	-45.7	96.2	26.3	214.1	145.7	79.9	183.7	101.1
Critical Pressure kPa	4467	4120	3870	3960	3750	4990	4833	3437	3250	3150	3670	4060
Latent Heat of Vapourisation at 101 kPa kj/kg	180.3	165.4	149.7	119.1	136	233.8	238.8	146.8	136.3	126.3	171.6	216.1
Vapour Pressure at 25°C kPa	1.056	651.3	3550	1619.6	3280	1043.7	4732	44	213.4	911.1	91.4	664
Liquid Density at 25°C kg/m^3	1476	1310	1290	1537.82	1320	1193.8	870	1580	1456.3	1284	1462.3	1206.3
Vapour Density at 101 kPa kg/m^3	5.794	6.248	6.857	8.611	7.72	4.645	4.62	7.38	7.737	8.271	6.336	5.213
Ozone Depletion Potential (ODP)	1	1	1	12	0	0.04	0	0.09	0	0.4	0.014	0
Global Warming Potential (GWP) (CO_2=1)	4000	8500	11700	5600	6500	1700	11700	5000	9200	9320	93	1300
Flammability Limit at 25°C	None	None	None	None	None	None	None	None	None	None	None	None

Refrigerant	R141B	R142b	R152a	R290 Propane	R401A	R401B	R402A	R402B	R403B	R404A	R406A	R407B
Boiling Point at 101 kPa °C	32.2	-9.1	-24	-42.1	-33.1	-34.7	-49.2	-47.4	-49.5	-46.5	-32.4	-43.7
Temp. Glide at 101 kPa K	0	0	0	0	6.4	6	1.6 - 2	1.6 - 2	2.6	0.5	9.4	4.4
Critical Temperature °C	204.4	137.2	113.3	125.2	108	106.1	75.5	82.6	90	72.1	114.5	75.8
Critical Pressure kPa	4250	4120	4520	4250	4600	4680	4130	4450	5090	3730	4584	4160
Latent Heat of Vapourisation at 101 kPa kj/kg	224.3	223	337.7	428.1	228.3	229.8	190.8	207.9	185.5	200.3	244.9	201.3
Vapour Pressure at 25°C kPa	78.5	337.7	614.3	924.1	697.8	749.1	1394.1	1277	1274	1236.6	542	1168.6
Liquid Density at 25°C kg/m^3	1234.9	1108.5	899.2	439.7	1195.2	1193.91	1156.28	1160.4	1150.6	1043.9	1085.6	1171.07
Vapour Density at 101 kPa kg/m^3	4.765	4.785	3.315	2.368	4.777	4.734	5.639	5.182	5.682	5.342	4.425	5.512
Ozone Depletion Potential (ODP)	0.1	0	0	0.03	0.032	0.018	0.026	0.027	0	0.041	0	
Global Warming Potential (GWP) (CO2=1)	630	2000	140	3	1120	1230	2380	2080	2640	3850	1700	2300
Flammability Limit at 25°C	Liquid None Vapour in Air by Vol. 5.6/17.7	9.6%	4.8%	2.4%	None	None	None	None	None	None	Worst case of Fractionation flammable	None

Properties of Refrigerants

Refrigerant	R407C KLEA 66	R408A FX10	R409A FX56	R409B FX57	R410A AZ20	R413A ISCEON 49	R500	R502	R503	R507 AZ50	R600a Butane	R717 Ammonia
Boiling Point at 101 kPa °C	-43.6	-43.5	-34.2	-36.6	-51.4	-35	-33.5	-45.4	-88.7	-46.7	-11.8	-33.3
Temp. Glide at 101 kPa K	7.2	0.7	7.1	7.7	0	7.1	0	0	0	0	0	0
Critical Temperature °C	87.3	83.5	107	116	84.9	101.3	105.5	82.2	19.5	70.9	135	133
Critical Pressure kPa	4820	4340	4500	4700	4950	4110	4420	4075	4340	3793	3631	11417
Latent Heat of Vapourisation at 101 kPa kj/kg	250.1	227.2	220.2	220.3	271.6	214.6	201	172	179.4	196.1	355.2	
Vapour Pressure at 25°C kPa	1002.8	1147.9	644	692	1646.9	717.1	770	1160	4290	1286	351.8	
Liquid Density at 25°C kg/m³	1139.22	1062.1	1215.9	1228.4	1083.8	1169.6	1160	1220	1230	1041.6	552.3	
Vapour Density at 101 kPa kg/m³	4.507	4.712	4.91	4.881	4.064	5.272	5.3	4.79	6.03	5.449	4.392	
Ozone Depletion Potential (ODP)	0	0.019	0.04	0.039	0	0	0.605	0.224	0.599	0	0	0
Global Warming Potential (GWP) (CO_2=1)	1370	3060	1530	1510	1300	1510	5210	5590	11700	3900	3	1
Flammability Limit at 25°C	None	None	None	None	None	Worst case of Fractionation flammable	None	None	None	None	1.7%	15%

Variation in Composition of Blended Refrigerants in Case of Leakage

In the following, we make the distinction between:

- Non azeotropic mixtures (having a high temperature glide* typically higher than 3K)
- Near azeotropic mixtures (having a low temperature glide typically lower than 3K)
- Azeotropic mixtures (having a temperature glide equal to zero K)

R404A and R408A are near azeotropic mixtures with a glide lower than 1 K.

The composition of the mixtures does not change when a leak occurs in a homogeneous phase. That is the case at the evaporator outlet (superheated vapour) or at the condenser outlet (subcooled liquid).

By contrast, marked differences of behaviour appear between the different types of mixtures during a leak in the two phase region equilibrium.

For non-azeotropic mixtures, the 'more volatile' components escape in preceding order, altering to a great extent the composition of the mixture remaining in the installation, resulting in change of performance.

For near azeotropic or real azeotropic mixtures, leak rates of all components of the mixture are very close; thus during a leakage, composition of refrigerant remaining in the installation is not affected significantly.

For all blended refrigerants it is stated by some manufacturers that after a leakage of 50% of the initial charge, changes in composition are less than 3% by weight.

Blended refrigerants must always be introduced in the liquid phase in the installation. Introduction in the gas phase, at the compressor suction, may increase the charging time of the installation and may alter performance of the mixture charged.

*For a non-azeotropic mixture the change process liquid vapour occurs over a range of temperatures (glide).

Properties of Refrigerants

General Rules for Handling Fluorocarbon Refrigerants and Nitrogen

Legislation
All purchasers and users of refrigerants should be aware of, and conversant with, the requirements of the Ozone Protection and Synthetic Greenhouse Gas Management Regulations and/or any other state or federal legislation.

Safety Equipment
Goggles or face shields, gloves and safety footwear must be worn when filling cylinders, coupling up storage vessels and/or handling bulk fills so as to prevent eye damage or burns should a coupling give way or a line burst.

Store Cylinders Upright
Store cylinders in a cool, dry place, away from direct sources of heat. A well ventilated area will ensure that no build up of gas can occur should a cylinder leak or relief valve unseat.

Do Not Force Connections
Cylinder connections should fit easily and snugly. Never force them. Use correct tools. Stripped threads can cause leaks and possible loss of refrigerant.

Handle Cylinders Carefully
Cylinders should not be used for 'rollers' or supports. Cuts and abrasions may result. Care in handling cylinders will prolong their life.

Read Labels
Because colour of cylinders cannot be relied upon for positive identification, labels should always be read carefully. Colour blindness might interfere with proper identification. If still in doubt, other methods of identification are available from the manufacturer/supplier.

Visual Examination
Each time a cylinder is returned or delivered for re-charging, it should be carefully examined for evidence of corrosion, cuts, dents, bulges, condition of threads, valves, etc, to ensure suitability for further service. State Codes also provide for examination and testing of cylinders to ensure their continued use.

Never Transfer
Refrigerant cylinders are labelled and identified for a particular refrigerant. Never put a different refrigerant into a cylinder labelled for another refrigerant.

Keep Away from Fire
No part of any cylinder should ever be subjected to direct flame, steam or temperatures exceeding 50°C. If necessary to warm cylinder to promote more rapid discharge, extreme caution should be taken – an easy and safe way is to place bottom part of cylinder in a container of warm or hot water not over 50°C.

Ventilation
Since many materials such as soldering flux, oil, dirt and all refrigerants decompose at the flame temperatures used in soldering, the area in which repair is carried out should be properly ventilated to remove the products of decomposition and combustion of all materials. An adequately ventilated work area is good practice at any time, but especially when an open flame of a leak detector or welding torch is to be used in the presence of 'fluorocarbon' refrigerants.

Check Pressure
The pressure within the cylinder must be greater than in the system to cause the refrigerant to flow into the system. Pressure should be checked before charging.

Main Hazards
Nitrogen is non toxic, inert and inflammable. It comprises 78.09%vol of the air we breathe however; high concentrations in confined spaces may result in unconsciousness without symptoms. Nitrogen is stored at high pressure - 20,000kPa at 15°C.

Storage and Handling
- Protect the cylinders and valves from physical damage, whether empty or full.
- Secure cylinders in an upright position.
- Store below 50°C in clean, well ventilated areas, away from from combustible materials and heat sources.
- Ensure all devices, including fittings and regulators, are free from dust, oil and grease.
- Always open the valve fully to activate the back seat valve which helps to prevent leakage.
- Close valves fully when not in use.
- Check regularly for leaks.
- Do not attempt to transfer contents from one cylinder to another.
- Only regulators, manifolds and ancillary equipment, rated for the appropriate pressure and compatible with the relevant gas, shall be connected to or downstream of these cylinders.

Refrigerant Line Sizing

Pipe Sizing Criteria

Pipe sizing choices for refrigeration typically represent a compromise between conflicting objectives. Minimisation of pressure drops in suction and discharge vapour piping is important since these translate directly to losses in system cooling capacity. Such pressure losses also necessitate higher thermodynamic lifts at the compressor with consequent C.O.P. penalties. Pressure losses in liquid lines can result in loss of subcooling, formation of vapour bubbles and potentially erratic and damaging impacts on the smooth functioning of the system. Piping must thus be sized generously enough to limit frictional flow losses, however, sizes must simultaneously be sufficiently small to maintain adequate flow velocities to physically entrain oil droplets in the refrigerant stream.
This reduces the risk of oil trapping and slugging and assures a positive supply of lubricant in the compressor crankcase. Other incentives for pipe size limitation include a minimum refrigerant charge and reduction of first cost. Courtesy of Allied Signal.

R22- Suction Line

Refrigeration Capacity: kW	Evaporating Temperature: °C																			
	4				-7				-18				-29				-40			
	Equivalent Length: Metres																			
	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45
0.88	3/8	3/8	3/8	1/2	3/8	3/8	1/2	1/2	1/2	1/2	5/8	5/8	1/2	5/8	5/8	3/4	5/8	3/4	7/8	7/8
1.76	3/8	1/2	1/2	5/8	1/2	1/2	5/8	5/8	5/8	5/8	3/4	7/8	5/8	3/4	7/8	7/8	3/4	7/8	1 1/8	1 1/8
2.64	1/2	1/2	5/8	5/8	1/2	5/8	5/8	3/4	3/4	3/4	7/8	7/8	3/4	7/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 3/8
3.52	1/2	5/8	5/8	3/4	5/8	5/8	3/4	3/4	3/4	7/8	7/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8
5.28	5/8	3/4	3/4	7/8	3/4	3/4	7/8	7/8	7/8	7/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 3/8	1 1/8	1 3/8	1 5/8	1 5/8
7.03	5/8	3/4	7/8	7/8	3/4	7/8	1/8	1 1/8	7/8	1/8	1 1/8	3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8
8.79	3/4	7/8	7/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 5/8	1 3/8	1 5/8	1 5/8	2 1/8
10.55	3/4	7/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	11/8	1 1/8	1 1/8	1 3/8	1 5/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8
12.3	7/8	7/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 3/8	1 1/8	1 3/8	1 3/8	1 5/8	1 3/8	1 3/8	1 5/8	2 1/8	1 5/8	1 5/8	2 1/8	2 1/8
14.07	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8
15.83	7/8	1 1/8	1 1/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8
17.59	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 3/8	1 3/8	1 5/8	1 3/8	1 5/8	1 5/8	2 1/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8
21.1	1 1/8	1 1/8	1 3/8	1 5/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	3 1/8
26.38	1 1/8	1 3/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 5/8	3 1/8	3 1/8
35.17	1 3/8	1 3/8	1 5/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8
43.96	1 3/8	1 3/8	1 5/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8
52.76	1 3/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 5/8	2 5/8	3 1/8	2 5/8	3 1/8	3 5/8	3 5/8
61.55	1 3/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 5/8	3 1/8	3 5/8	3 5/8
70.34	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 5/8	2 5/8	3 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 1/8	3 1/8	3 5/8	4 1/8
87.93	1 5/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 5/8	3 1/8	3 1/8	2 5/8	3 1/8	3 1/8	3 5/8	3 1/8	3 5/8	4 1/8	5 1/8

Data based on 1.1K maximum pressure drop equivalent.

R22

Refrigeration Capacity: kW	Discharge Line				Liquid Line				Hot Gas Line **			
	Equivalent Length: Metres											
	7.5	15	30	45	7.5	15	30*	45	7.5	15	30	45
0.88	3/8	3/8	3/8	3/8	1/4	1/4	1/4	1/4	3/8	3/8	1/2	1/2
1.32	3/8	3/8	1/2	1/2	1/4	1/4	3/8	3/8	1/2	1/2	1/2	5/8
1.91	3/8	1/2	1/2	1/2	1/4	1/4	3/8	3/8	1/2	1/2	5/8	5/8
2.49	3/8	1/2	1/2	5/8	1/4	3/8	3/8	3/8	1/2	5/8	3/4	3/4
3.52	1/2	1/2	5/8	5/8	3/8	3/8	3/8	1/2	5/8	5/8	3/4	7/8
5.28	1/2	5/8	3/4	3/4	3/8	3/8	1/2	1/2	5/8	3/4	7/8	1 1/8
7.03	5/8	5/8	3/4	7/8	3/8	1/2	1/2	1/2	3/4	7/8	1 1/8	1 1/8
8.79	5/8	3/4	7/8	7/8	3/8	1/2	1/2	5/8	3/4	7/8	1 1/8	1 1/8
10.55	5/8	3/4	7/8	7/8	1/2	1/2	5/8	5/8	7/8	1 1/8	1 1/8	1 1/8
12.3	3/4	3/4	7/8	1 1/8	1/2	1/2	5/8	5/8	7/8	1 1/8	1 1/8	1 3/8
14.07	3/4	7/8	1 1/8	1 1/8	1/2	5/8	5/8	3/4	1 1/8	1 1/8	1 3/8	1 3/8
15.83	3/4	7/8	1 1/8	1 1/8	1/2	5/8	5/8	3/4	1 1/8	1 1/8	1 3/8	1 3/8
17.59	3/4	7/8	1 1/8	1 1/8	1/2	5/8	3/4	3/4	1 1/8	1 1/8	1 3/8	1 3/8
21.1	7/8	1 1/8	1 1/8	1 1/8	5/8	5/8	3/4	3/4	1 1/8	1 3/8	1 3/8	1 5/8
26.38	7/8	1 1/8	1 1/8	1 3/8	5/8	3/4	7/8	7/8	1 1/8	1 3/8	1 5/8	1 5/8
35.17	1 1/8	1 1/8	1 3/8	1 3/8	3/4	3/4	7/8	1 1/8	1 3/8	1 5/8	1 5/8	2 1/8
43.96	1 1/8	1 3/8	1 3/8	1 1/8	3/4	7/8	1 1/8	1 1/8	1 3/8	1 5/8	2 1/8	2 1/8
52.76	1 1/8	1 3/8	1 5/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 5/8	1 5/8	2 1/8	2 1/8
61.55	1 3/8	1 3/8	1 5/8	1 1/8	7/8	7/8	1 1/8	1 1/8	-	-	-	-
70.34	1 3/8	1 5/8	1 1/8	2 1/8	7/8	1 1/8	1 3/8	1 3/8	-	-	-	-
87.93	1 3/8	1 5/8	2 5/8	2 1/8	1 1/8	1 1/8	1 3/8	1 3/8	-	-	-	-

Copper tube sizes are: OD in inches.

ACTROL™

Refrigerant Line Sizing

R410A- Suction Line

Refrigeration Capacity: kW	Evaporating Temperature: deg.C																			
	4				-7				-18				-29				-40			
	Equivalent Length: Meters																			
	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45
0.88	3/8	3/8	3/8	1/2	3/8	3/8	1/2	1/2	3/8	1/2	1/2	5/8	1/2	1/2	5/8	5/8	1/2	5/8	5/8	3/4
1.76	3/8	1/2	1/2	1/2	1/2	1/2	5/8	5/8	1/2	1/2	5/8	3/4	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4
2.64	1/2	1/2	5/8	5/8	1/2	5/8	5/8	3/4	5/8	5/8	3/4	3/4	3/4	3/4	7/8	7/8	7/8	7/8	1 1/8	1 1/8
3.52	1/2	1/2	5/8	5/8	5/8	5/8	3/4	3/4	5/8	3/4	3/4	7/8	3/4	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8
5.28	5/8	5/8	3/4	3/4	5/8	3/4	3/4	7/8	3/4	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8
7.03	5/8	5/8	3/4	7/8	3/4	3/4	7/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8
8.79	3/4	3/4	7/8	7/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8
10.55	3/4	3/4	7/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8
12.3	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8
14.07	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8
15.83	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8
17.59	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8
21.1	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8
26.38	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3
35.17	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3	3	3	4
43.96	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	2 5/8	3	4	4	4	4
52.76	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3	3	3	4	4	4	4	4
61.55	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	3	3	4	4	4	4	4	4	-
70.34	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	2 5/8	3	3	4	4	4	4	4	4	-	-
87.93	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	2 5/8	3	3	4	4	4	4	4	4	-	-	-	-

Data based on 1.1K maximum pressure drop equivalent.

R410A

Refrigeration Capacity: kW	Discharge Line				Liquid line				Hot Gas Line**			
	Equivalent Length: Meters											
	7.5	15	30	45	7.5	15	30	45	7.5	15	30	45
0.88	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	3/8	3/8
1.32	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	3/8	3/8	3/8	1/2
1.91	3/8	3/8	3/8	3/8	1/4	1/4	1/4	3/8	3/8	3/8	1/2	1/2
2.49	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	1/2	5/8	5/8
3.53	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	1/2	1/2	5/8	3/4
5.28	1/2	1/2	1/2	1/2	3/8	3/8	3/8	1/2	5/8	5/8	5/8	3/4
7.03	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	5/8	5/8	3/4	7/8
8.79	1/2	1/2	1/2	5/8	1/2	1/2	1/2	1/2	5/8	3/4	3/4	7/8
10.55	5/8	5/8	5/8	5/8	1/2	1/2	1/2	5/8	3/4	3/4	7/8	1 1/8
12.3	5/8	5/8	5/8	5/8	1/2	5/8	5/8	5/8	3/4	3/4	7/8	1 1/8
14.07	5/8	5/8	5/8	3/4	5/8	5/8	5/8	5/8	3/4	3/4	7/8	1 1/8
15.83	5/8	3/4	3/4	3/4	5/8	5/8	5/8	3/4	3/4	7/8	7/8	1 1/8
17.59	3/4	3/4	3/4	3/4	5/8	5/8	5/8	3/4	7/8	7/8	7/8	1 1/8
21.1	3/4	3/4	3/4	7/8	5/8	3/4	3/4	3/4	7/8	1 1/8	1 1/8	1 3/8
26.38	7/8	7/8	7/8	7/8	3/4	3/4	3/4	7/8	1 1/8	1 3/8	1 3/8	1 3/8
35.17	1 1/8	1 1/8	1 1/8	1 1/8	7/8	7/8	7/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8
43.96	1 1/8	1 1/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8
52.76	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8	1 1/8	1 5/8	1 5/8	1 5/8	2 1/8
61.55	1 3/8	1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8	1 3/8	-	-	-	-
70.34	1 3/8	1 3/8	1 3/8	1 3/8	1 1/8	1 3/8	1 3/8	1 3/8	-	-	-	-
87.93	1 5/8	1 5/8	1 5/8	1 5/8	1 3/8	1 3/8	1 3/8	1 5/8	-	-	-	-

Copper tube sizes are: OD in inches.

* Line sizes are suitable for Condenser to Receiver application.

**For suction temperatures less than -29°C, the next larger line size must be used.

Refrigerant Line Sizing

R134a

Refrigeration Capacity: kW	SUCTION LINE Sizes to Limit Pressure Drop to 1.1K Equivalent									DISCHARGE LINE Sizes for 0.56K Equivalent			LIQUID LINE Sizes for 0.56K Equivalent		
	4°C Evap.			-18°C Evap.			-40°C Evap.								
	Equivalent Length: Metres														
	7.5	15	30	7.5	15	30	7.5	15	30	7.5	15	30	7.5	15	30
0.88	3/8	1/2	1/2	1/2	5/8	3/4	3/4	7/8	1 1/8	3/8	3/8	3/8	3/8	3/8	3/8
1.76	1/2	5/8	5/8	5/8	3/4	7/8	1 1/8	1 1/8	1 3/8	3/8	1/2	1/2	3/8	3/8	3/8
2.64	5/8	5/8	3/4	3/4	7/8	1 1/8	1 1/8	1 3/8	1 5/8	1/2	1/2	5/8	3/8	3/8	3/8
3.52	5/8	3/4	3/4	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1/2	5/8	5/8	3/8	3/8	3/8
5.28	3/4	7/8	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	2 1/8	5/8	5/8	3/4	3/8	3/8	1/2
7.03	3/4	7/8	1 1/8	1 1/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	5/8	3/4	7/8	3/8	3/8	1/2
10.55	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	2 1/8	2 1/8	2 5/8	3/4	7/8	7/8	1/2	1/2	5/8
17.59	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 5/8	3 1/8	7/8	1 1/8	1 1/8	1/2	5/8	3/4
26.38	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 5/8	2 5/8	3 1/8	3 5/8	1 1/8	1 1/8	1 3/8	5/8	3/4	3/4
35.17	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	3 1/8	3 1/8	3 5/8	1 1/8	1 3/8	1 3/8	5/8	3/4	7/8
52.76	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	3 1/8	3 5/8	3 5/8	5 1/8	1 3/8	1 3/8	1 5/8	3/4	7/8	1 1/8
70.34	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	5 1/8	1 3/8	1 5/8	2 1/8	7/8	1 1/8	1 1/8
87.93	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 5/8	4 1/8	5 1/8	5 1/8	1 5/8	2 1/8	2 1/8	7/8	1 1/8	1 1/8
105.5	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	5 1/8	6 1/8	1 5/8	2 1/8	2 1/8	1 1/8	1 1/8	1 3/8
140.7	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	5 1/8	6 1/8	6 1/8	2 1/8	2 5/8	2 5/8	1 1/8	1 3/8	1 3/8

Data based on 49°C condensing. Courtesy of Allied Signal

Copper tubing sizes are: OD in inches.

R404A and R507

Refrigeration Capacity: kW	SUCTION LINE Sizes to Limit Pressure Drop to 1.1K Equivalent									DISCHARGE LINE Sizes for 0.56K Equivalent			LIQUID LINE Sizes for 0.56K Equivalent		
	4°C Evap.			-18°C Evap.			-40°C Evap.								
	Equivalent Length: Metres														
	7.5	15	30	7.5	15	30	7.5	15	30	7.5	15	30	7.5	15	30
0.88	3/8	1/2	1/2	1/2	5/8	3/4	3/4	7/8	1 1/8	3/8	3/8	3/8	3/8	3/8	3/8
1.76	1/2	5/8	5/8	5/8	3/4	7/8	1 1/8	1 1/8	1 3/8	3/8	1/2	1/2	3/8	3/8	3/8
2.64	5/8	5/8	3/4	3/4	7/8	1 1/8	1 1/8	1 3/8	1 5/8	1/2	1/2	5/8	3/8	3/8	3/8
3.52	5/8	3/4	3/4	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1/2	5/8	5/8	3/8	3/8	3/8
5.28	3/4	7/8	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	2 1/8	5/8	5/8	3/4	3/8	3/8	1/2
7.03	3/4	7/8	1 1/8	1 1/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	5/8	3/4	7/8	3/8	3/8	1/2
10.55	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	2 1/8	2 1/8	2 5/8	3/4	7/8	7/8	1/2	1/2	5/8
17.59	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 5/8	3 1/8	7/8	1 1/8	1 1/8	1/2	5/8	3/4
26.38	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 5/8	2 5/8	3 1/8	3 5/8	1 1/8	1 1/8	1 3/8	5/8	3/4	3/4
35.17	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	3 1/8	3 1/8	3 5/8	1 1/8	1 3/8	1 3/8	5/8	3/4	7/8
52.76	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	3 1/8	3 5/8	3 5/8	5 1/8	1 3/8	1 3/8	1 5/8	3/4	7/8	1 1/8
70.34	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	5 1/8	1 3/8	1 5/8	2 1/8	7/8	1 1/8	1 1/8
87.93	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 5/8	4 1/8	5 1/8	5 1/8	1 5/8	2 1/8	2 1/8	7/8	1 1/8	1 1/8
105.5	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	5 1/8	6 1/8	1 5/8	2 1/8	2 1/8	1 1/8	1 1/8	1 3/8
140.7	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	5 1/8	6 1/8	6 1/8	2 1/8	2 5/8	2 5/8	1 1/8	1 3/8	1 3/8

Data based on 49°C condensing. Courtesy of Allied Signal

Copper tubing sizes are: OD in inches.

Equivalent Length of Pipe: Metres - For Valves and fittings

Line Size Outside Dia. Inches	1/2	5/8	7/8	1 1/8	1 3/8	1 5/8	1/2	2 5/8	3 1/8	3 5/8	4 1/8	5 1/8	6 1/8	8 1/8	10 1/8	12 1/8
Globe Valve (Open)	4.3	4.9	6.7	8.5	11	12.8	17.4	21	25.3	30.2	36	42.1	51.2	68.6	85.3	102
Angle Valve (Open)	2.1	2.7	3.7	4.6	5.5	6.4	8.5	10.4	12.8	14.9	17.4	21.3	25.3	35.7	42.7	50.3
Standard Elbow 90°	0.3	0.6	0.6	0.9	1.2	1.2	1.5	2.1	2.4	3	3.7	4.3	4.9	6.1	7.9	9.4
Standard Elbow 45°	0.3	0.3	0.3	0.6	0.6	0.6	0.6	0.9	1.2	1.5	1.8	2.1	2.4	3	4	4.9
Standard Tee (Through Side Out.)	0.9	1.2	1.5	1.8	2.4	2.7	3.7	4.3	5.2	6.1	6.7	8.5	10.4	13.4	17.1	19.8

Values shown are average

Refrigerant Line Design

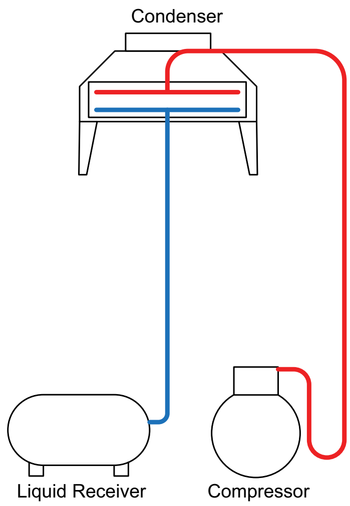
Good refrigeration line design and line sizing is essential to ensure refrigeration systems operate reliably and efficiently.
The designer must satisfy the following:

Discharge Line

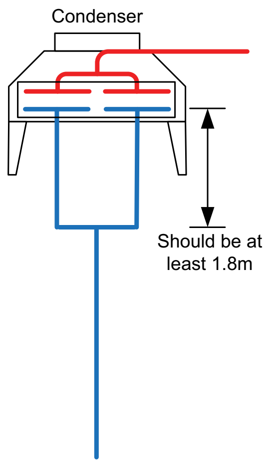
- Minimise pressure losses in the line
- Horizontal lines should be pitched in the direction of flow at 12mm every 3m
- Avoid oil being trapped during times of low load
- Prevent back flow of liquid refrigerant or oil to the compressor at times of low load or shut down.
- Minimise transmission of compressor vibration and dampen vapour pulsations and noise in the line.

Condenser to Receiver Liquid Drain Line

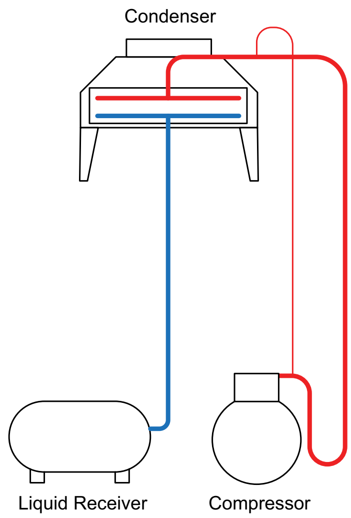
- Allow liquid to freely drain to liquid receiver while providing vapour pressure to equalize in the other direction



Single Riser Discharge Line



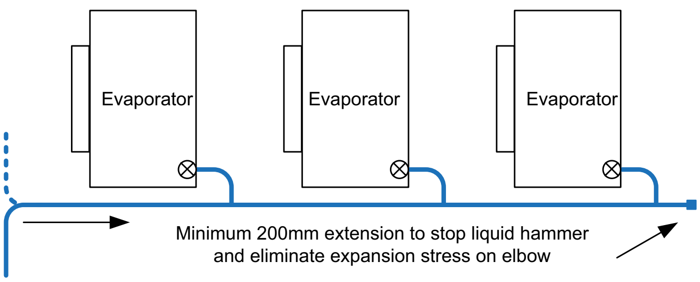
Discharge and Liquid Drain Lines for Double Circuited Condenser



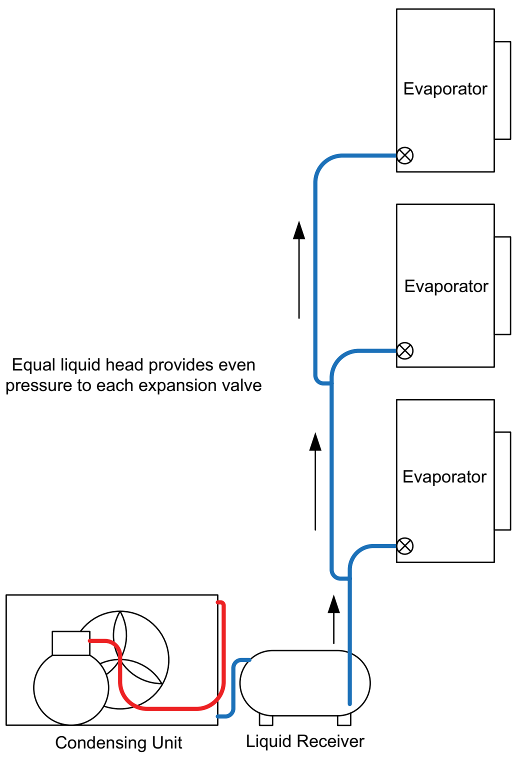
Double Riser Discharge Line

Liquid Line

- Minimise pressure losses in the line to prevent flash gas entering the expansion device
- Minimise heat gain to the liquid refrigerant
- Prevent liquid hammer where multiple evaporators are used



Liquid Line to Horizontal Evaporators



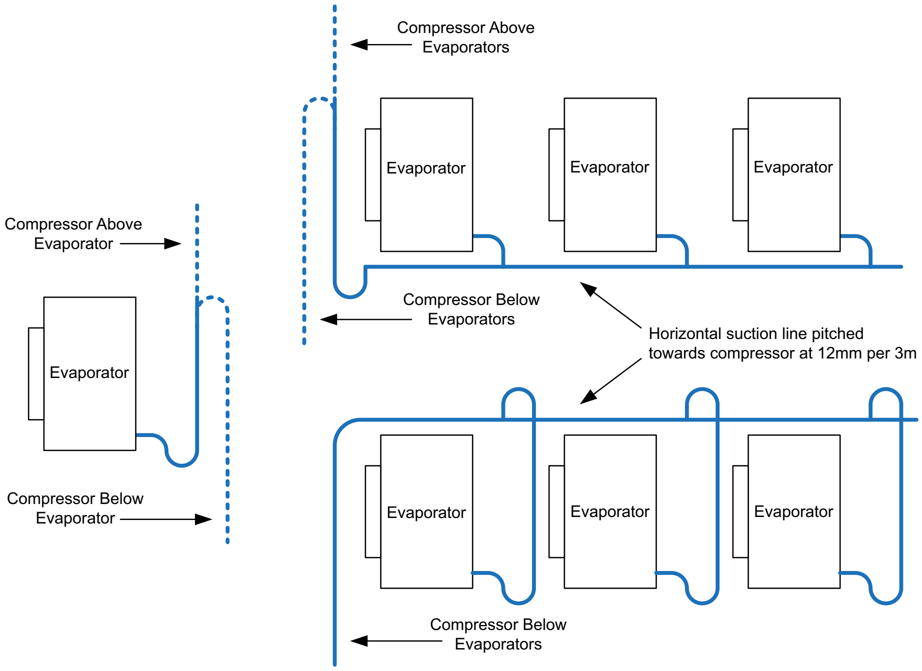
Liquid Line to Vertically Stacked Evaporators

Refrigerant Line Design

Good refrigeration line design and line sizing is essential to ensure refrigeration systems operate reliably and efficiently.
The designer must satisfy the following:

Suction Line

- Minimise pressure losses in the line
- Horizontal lines should be pitched in the direction of flow at 12mm every 3m
- Return the oil to the compressor under all load conditions
- Prevent oil draining from active to inactive evaporators when multiple evaporators are used
- Minimise transmission of compressor vibration and dampen vapour pulsations and noise in the line
- Minimise heat gain into the refrigerant vapour and eliminate condensation on the outer surface of the line



Trapped Riser

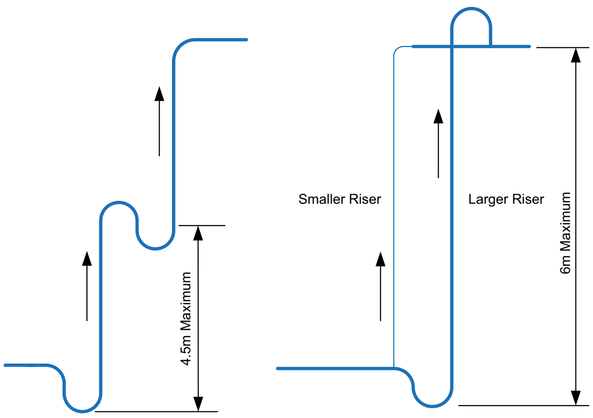
The trapped riser is used in systems with minimal capacity control. The trapped riser is used in vapour lines, both suction and discharge to ensure the oil is carried with the refrigerant vapour up the riser.

Note: the maximum distance between traps is 4.5 metres.

Double Riser

The double rise is used in systems with a wide range of capacity control. The double riser is also used in vapour lines, both suction and discharge to ensure the oil is carried with the refrigerant vapour.

Note: the maximum distance between traps is 6 meters. The smaller riser is sized at the minimum compressor capacity and the larger riser is sized at the maximum compressor capacity minus the minimum compressor capacity so the combination of the two lines is equal to the maximum compressor capacity.



Trapped Riser

Double Riser

Copper Tube - Safe Working Pressures

Australian Standard AS/NZS 1571 Copper Seamless Tubes for Air-conditioning and Refrigeration

Standard sizes and data for straight copper tubes

Outside Diameter (mm)	Wall Thickness (mm)	Imperial Equivalent O.D. and swg	Nominal Weight (kg/m)	Form	Temper	Safe Working Pressure (kPa) at service temperature				
						50°C	55°C	60°C	65°C	70°C
6.35	0.91	1/4“ x 20	0.139	6m straight	H	12142	11431	10907	10528	10256
9.53	0.91	3/8“ x 20	0.220	6m straight	H	7710	7258	6925	6685	6512
12.70	0.91	1/2“ x 20	0.301	6m straight	1/2H	5653	5322	5078	4901	4774
12.70	1.02	1/2“ x 19	0.335	6m straight	1/2H	6389	6015	5739	5540	5396
15.88	0.91	5/8“ x 20	0.383	6m straight	1/2H	4459	4198	4006	3766	3766
15.88	1.02	5/8“ x 19	0.426	6m straight	1/2H	5031	4737	4519	4362	4249
19.05	0.91	3/4“ x 20	0.464	6m straight	1/2H	3684	3468	3309	3194	3111
19.05	1.02	3/4“ x 19	0.517	6m straight	1/2H	4152	3909	3729	3600	3507
19.05	1.14	3/4“ x 18.5	0.573	6m straight	1/2H	4670	4510	4350	4190	4030
22.23	0.91	7/8“ x 20	0.545	6m straight	1/2H	3137	2953	2818	2720	2649
22.23	1.22	7/8“ x 18	0.720	6m straight	1/2H	4261	4011	3827	3694	3599
22.23	1.63	7/8“ x 16	0.943	6m straight	H	5794	5455	5204	5024	4894
25.40	0.91	1“ x 20	0.626	6m straight	H	2732	2572	2454	2369	2308
25.40	1.22	1“ x 18	0.829	6m straight	H	3705	3488	3328	3212	3129
25.40	1.63	1“ x 16	1.088	6m straight	H	5026	4732	4515	4358	4245
28.57	0.91	1 1/8“ x 20	0.707	6m straight	H	2420	2278	2174	2098	2044
28.57	1.22	1 1/8“ x 18	0.937	6m straight	H	3277	3086	2944	2842	2768
28.57	1.83	1 1/8“ x 15	1.374	6m straight	H	5016	4723	4506	4350	4237
31.75	0.91	1 1/4“ x 20	0.788	6m straight	H	2171	2044	1950	1883	1834
31.75	1.22	1 1/4“ x 18	1.046	6m straight	H	2937	2765	2639	2547	2481
31.75	2.03	1 1/4“ x 14	1.694	6m straight	H	5007	4714	4497	4341	4229
34.92	0.91	1 3/8“ x 20	0.869	6m straight	H	1969	1854	1769	1708	1663
34.92	1.22	1 3/8“ x 18	1.155	6m straight	H	2662	2506	2391	2308	2248
34.92	2.03	1 3/8“ x 14	1.875	6m straight	H	4527	4262	4067	3925	3824
38.10	0.91	1 1/2“ x 20	0.951	6m straight	H	1801	1696	1618	1562	1522
38.10	1.22	1 1/2“ x 18	1.264	6m straight	H	2433	2291	2186	2110	2055
41.27	0.91	1 5/8“ x 20	1.032	6m straight	H	1660	1563	1491	1440	1402
41.27	1.22	1 5/8“ x 18	1.372	6m straight	H	2241	2110	2013	1943	1893
41.27	2.41	1 5/8“ x 12.5	2.630	6m straight	H	4549	4282	4086	3944	3842
44.45	0.91	1 3/4“ x 20	1.113	6m straight	H	1539	1449	1383	1335	1300
44.45	1.22	1 3/4“ x 18	1.481	6m straight	H	2077	1955	1866	1801	1754
50.80	0.91	2“ x 20	1.275	6m straight	H	1344	1265	1207	1165	1135
50.80	1.22	2“ x 18	1.699	6m straight	H	1812	1705	1627	1571	1530
50.80	1.63	2“ x 16	2.251	6m straight	H	2438	2296	2190	2114	2060
53.97	0.91	2 1/8“ x 20	1.356	6m straight	H	1264	1190	1135	1096	1067
53.97	1.22	2 1/8“ x 18	1.807	6m straight	H	1703	1603	1530	1477	1438
53.97	1.63	2 1/8“ x 16	2.396	6m straight	H	2291	2157	2058	1987	1935
66.68	1.22	2 5/8“ x 18	2.243	6m straight	H	1373	1293	1233	1190	1160
66.68	1.63	2 5/8“ x 16	2.978	6m straight	H	1845	1737	1657	1599	1558
76.20	1.63	3“ x 16	3.414	6m straight	H	1610	1515	1446	1396	1360
101.60	1.63	4“ x 16	4.577	6m straight	H	1201	1131	1079	1042	1015

Denotes R410A rated tube. Courtesy of Crane Enfield Metals Pty Ltd

Copper Tube - Safe Working Pressures

Australian Standard AS/NZS 1571 Copper

Seamless Tubes for Air-conditioning and Refrigeration

Standard sizes and data for straight copper tubes

Outside Diameter (mm)	Wall Thickness (mm)	Imperial Equivalent O.D. and swg	Nominal Weight (kg/m)	Form	Temper	Safe Working Pressure (kPa) at service temperature				
						50oC	55oC	60oC	65oC	70oC
4.76	0.56	3^1/6 " x 24	0.066	30m Coil	0	9711	9142	8723	8420	8202
4.76	0.71	3^1/6 " x 22	0.081	30m Coil	0	12715	11971	11422	11025	10739
4.76	0.91	3^1/6 " x 20	0.098	30m Coil	0	17041	16043	15308	14776	14393
6.35	0.56	^{1}/4 " x 24	0.091	30m Coil	0	7069	6656	6350	6130	5971
6.35	0.71	^{1}/4 " x 22	0.112	30m Coil	0	9175	8638	8242	7955	7749
6.35	0.91	^{1}/4 " x 20	0.139	30m Coil	0	12142	11431	10907	10528	10256
6.35	1.22	^{1}/4 " x 18	0.176	30m Coil	0	17143	16140	15400	14864	14480
7.94	0.56	5^1/6 " x 24	0.116	30m Coil	0	5558	5232	4993	4819	4694
7.94	0.71	5^1/6 " x 22	0.144	30m Coil	0	7177	6757	6447	6223	6062
7.94	0.91	5^1/6 " x 20	0.180	30m Coil	0	9431	8879	8472	8177	7966
9.53	0.56	^{3}/8 " x 24	0.141	18m Coil	0	4579	4311	4113	3970	3867
9.53	0.71	^{3}/8 " x 22	0.176	18m Coil	0	5893	5548	5294	5110	4978
9.53	0.91	^{3}/8 " x 20	0.220	18m Coil	0	7710	7258	6925	6685	6512
12.70	0.56	^{1}/2 " x 24	0.191	18m Coil	0	3389	3190	3044	2938	2862
12.70	0.71	^{1}/2 " x 22	0.239	18m Coil	0	4344	4090	3903	3767	3669
12.70	0.81	^{1}/2 " x 21	0.270	18m Coil	0	4994	4701	4486	4330	4218
12.70	0.91	^{1}/2 " x 20	0.301	18m Coil	0	5653	5322	5078	4901	4774
15.88	0.56	^{5}/8 " x 24	0.241	18m Coil	0	2688	2530	2414	2331	2270
15.88	0.71	^{5}/8 " x 22	0.303	18m Coil	0	3438	3237	3088	2981	2904
15.88	0.81	^{5}/8 " x 21	0.343	18m Coil	0	3945	3715	3544	3421	3332
15.88	0.91	^{5}/8 " x 20	0.383	18m Coil	0	4459	4198	4006	3866	3766
15.88	1.02	^{5}/8 " x 19	0.426	18m Coil	0	5031	4737	4519	4362	4249
19.05	0.71	^{3}/4 " x 22	0.366	18m Coil	0	2846	2679	2557	2468	2404
19.05	0.91	^{3}/4 " x 20	0.464	18m Coil	0	3684	3468	3309	3194	3111
19.05	1.14	^{3}/4 " x 18.5	0.573	18m Coil	0	4670	4510	4350	4190	4030
22.23	0.91	^{7}/8 " x 20	0.545	18m Coil	0	3137	2953	2818	2720	2649

Pair Coil Specifications

Outside Diameter (mm)	Wall Thickness (mm)	Imperial Equivalent O.D. and swg	Nominal Weight (kg/m)	Form	Temper	Safe Working Pressure (kPa) at service temperature				
						50oC	55oC	60oC	65oC	70oC
6.35 9.52	0.81 0.81	^{1}/4 " x 21 ^{3}/8 " x 21	0.126 0.198	20m Coil	0	10635 6800	10012 6402	9553 6108	9221 5896	8982 5743
6.35 12.70	0.81 0.81	^{1}/4 " x 21 ^{1}/2 " x 21	0.126 0.270			10635 4994	10012 4701	9553 4486	9221 4330	8982 4218
6.35 15.88	0.81 1.02	^{1}/4 " x 21 ^{5}/8 " x 19	0.126 0.426			10635 5031	10012 4737	9553 4519	9221 4362	8982 4249
9.52 15.88	0.81 1.02	^{3}/8 " x 21 ^{5}/8 " x 19	0.198 0.426			6800 5031	6402 4737	6108 4519	5896 4362	5743 4249
9.52 19.05	0.81 1.22	^{3}/8 " x 21 ^{3}/4 " x 18	0.198 0.611			6800 5015	6402 4722	6108 4505	5896 4349	5743 4236
12.70 19.05	0.81 1.22	^{1}/2 " x 21 ^{3}/4 " x 18	0.270 0.611			4994 5015	4701 4722	4486 4505	4330 4349	4218 4236

Interpolation of allowable design stress as defined by table D7 of AS4041 for below temps.

Temperature (oC)	50.0	55.0	60.0	65.0	70.0	75.0
SD (MPa)	41.0	38.6	36.83	35.55	4.63	34.0

Denotes R410A rated tube

Working Pressures

Safe working pressures for copper tube are calculated on the basis of annealed temper tube with the maximum allowable outside diameter and minimum wall thickness, thus allowing for softening of the tube due to brazing or heating. All safe working pressures are based on the following formula: $P_{SW} = \frac{2000 \times S_D \times t_m}{D - tm}$

Where:

P_{SW} = safe working pressure (MPa)
S_D = maximum allowable design stress for annealed copper (MPa)
t_m = minimum wall thickness of tube (mm)
D = outside diameter or tube (mm)

Courtesy of Crane Enfield Metals Pty Ltd

ACTROL

Capillary Tube - Conversion Chart

This Conversion Chart is designed to enable users of capillary tubing to use the standard sizes which are readily available through refrigeration wholesalers. While many original equipment manufacturers and condensing unit manufacturers recommend specific lengths and diameters of capillary tubing for their units, these tube sizes are not always readily available, except on special order.
This chart enables the user to translate the recommended length into that of a tube diameter that can be readily obtained. In using the chart, it is recommended that conversions be made using factors falling in the shaded area. In addition, it is highly recommended that the minimum length of capillary used be 1 metre.

To Use Chart:
1. Located ‘Recommended Cap. Tube ID’ in left hand column.
2. Read across and find conversion factor under ‘Possible Capillary Tube ID’ sizes.
3. Multiply the given length of the recommended tube by the conversion factor of the possible tube.
4. The resultant length of tube will give the same flow characteristics as the original recommended tube.

Example: Recommended capillary tube 2 metres of 1.02mm. Locate 1.02mm in left hand column and reading across gives the following conversion factors: For 0.91mm ID Tubing - Factor 0.62. For 1.1mm ID tubing - Factor 1.55. Multiply the recommended capillary tube length of 2 metres by the conversion factors, which give the following results: 1.24m of 0.91mm ID and 3.1m of 1.1mm ID. Either of these capillary tubes will give the same results as the original.

Recommended Tube ID		Possible Tube ID – mm (inches)											
mm	Inches	0.66 (0.026)	0.8 (0.031)	0.91 (0.036)	1.1 (0.044)	1.27 (0.05)	1.4 (0.055)	1.5 (0.059)	1.62 (0.064)	1.78 (0.07)	1.9 (0.075)	2.04 (0.08)	2.3 (0.09)
0.61	0.024	1.44											
0.64	0.025	1.2											
0.66	0.026	1	2.24										
0.71	0.028	0.72	1.59										
0.76	0.03	0.52	1.16										
0.8	0.031	0.45	1	2									
0.81	0.032		0.86	1.75									
0.84	0.033		0.75	1.54									
0.86	0.034		0.65	1.35									
0.89	0.035		0.58	1.16									
0.91	0.036		0.5	1									
0.94	0.037		0.45	0.9	2.22								
0.97	0.038		0.39	0.8	1.92								
0.99	0.039		0.35	0.71	1.75								
1.02	0.04		0.31	0.62	1.55								
1.04	0.041		0.28	0.56	1.38	2.5							
1.07	0.042		0.25	0.5	1.24	2.23							
1.09	0.043		0.23	0.45	1.11	1.98							
1.1	0.044		0.2	0.39	1	1.79							
1.14	0.045			0.35	0.9	1.6							
1.17	0.046			0.32	0.82	1.47	2.27						
1.19	0.047				0.74	1.31	2.06						
1.22	0.048				0.67	1.2	1.87						
1.24	0.049				0.61	1.09	1.69						
1.27	0.05				0.56	1	1.56	2.14					
1.3	0.051				0.51	0.93	1.44	1.96					
1.32	0.052				0.47	0.85	1.32	1.78					
1.35	0.053				0.43	0.78	1.2	1.64					
1.37	0.054				0.39	0.7	1.09	1.52	2.18				
1.4	0.055				0.36	0.64	1	1.38	2				
1.42	0.056					0.6	0.94	1.27	1.85				
1.45	0.057					0.55	0.87	1.17	1.72				
1.47	0.058					0.51	0.8	1.07	1.56				
1.5	0.059					0.47	0.73	1	1.44	2.18			
1.52	0.06					0.43	0.67	0.93	1.33	2.04			
1.62	0.064					0.32	0.5	0.69	1	1.5	2.07		
1.78	0.07						0.33	0.46	0.67	1	1.37	1.84	
1.9	0.075								0.48	0.73	1	1.37	
2.04	0.08									0.54	0.74	1	1.71
2.16	0.085										0.57	0.76	1.29
2.3	0.09										0.43	0.62	1
2.41	0.095											0.46	0.79
2.54	0.1												0.62
2.67	0.105												0.49

Pressure Regulating Valve Selection Guide

General Definition
A device for regulating the flow of refrigerant, whether liquid or vapour in refrigeration and air conditioning systems. This Selection Guide briefly describes the main types, their common names and application.
It should be remembered that due to the wide variety of control systems in use, one type of regulator/valve may perform several functions, and when coupled with other types of control valves (Solenoid Valves, Check Valves etc.) their application may be extended. Therefore only the more common applications are detailed below.

Capacity Regulator
Also known as: Hot Gas By-Pass Regulator/Valve, Discharge By-Pass Regulator/Valve, Discharge Pressure Regulator/Valve. Often abbreviated to HGBP Regulator/Valve. Description: Used to control the compressor capacity and prevent suction pressure from falling to objectionably low levels. May be used in systems with one or more evaporators where compressor itself has no capacity regulation or can extend compressor capacity reduction below the last step of cylinder unloading.

Application: By-Pass to Suction Line – piped so that discharge gas is admitted to the suction line to flow against the direction of the suction gas. To prevent overheating of the compressor, a liquid injection valve is sometimes required for de-superheating.
By-Pass to Evaporator Inlet – usually fitted between the TX valve and the refrigerant distributor. The advantage of this method is that the artificial load imposed on the evaporator causes the TX valve to respond to the increase in superheat, thus eliminating the need for the liquid injection valve. This type of system must be equipped with a Venturi-Flo Refrigerant Distributor (i.e. no restrictor orifice). It is recommended that a solenoid valve be installed ahead of the by-pass regulator permitting the system to operate on an automatic pump-down cycle and also guarding against leakage during the 'off-cycle'.
Also used for: By-Pass Control Valve for air-cooled condensers.

Crankcase Pressure Regulating Valve
Also known as: Hold Back Valve, Suction Pressure Regulator, Starting Regulator, Outlet Regulator, Downstream Regulator. Often abbreviated to CPRV.

Description: A valve which regulates the suction pressure to a pre-determined maximum in order to prevent the compressor motor overloading, which may be due to any or all of the following: High load on start up, high suction pressure at termination of defrosting cycle, surges in suction pressure, prolonged operation at excessive suction pressures, low voltage and high suction pressure conditions.

Application: Installed in the suction line ahead of the compressor, the valve establishes the maximum pressure at the compressor inlet, thus providing overload protection for the compressor motor. May be used with one or more evaporators, either direct expansion or flooded evaporator designs. Also used for: High to low side by-pass, by-pass control for air cooled condensers.

Evaporator Pressure Regulating Valve
Also known as: Back Pressure Regulator / Valve, Constant Pressure Valve*, Upstream Regulator, Inlet Pressure Regulator, Suction Line Regulator. Often Abbreviated to: EPR or EPRV.
*Sometimes referred to as a Constant Pressure Regulator, but should not be confused with the same 'general' term applied to an automatic expansion valve.

Description: Used to maintain a constant evaporating pressure and hence a constant evaporator temperature plus protection against too low an evaporating pressure since the regulator closes when the pressure in the evaporator falls below the setting.

Application: Installed in the suction line near the evaporator outlet. Available in two main types: Direct operated and pilot operated.
Pilot operated regulators may be integral types, or remote pilot actuated either by pressure or temperature.
Also used for: Freeze-up or frost protection , maintaining evaporator pressure during a defrost, providing a safety or pressure relief function.

Condenser Pressure Regulator For Water Cooled Condensers
Also known as: Pressure Controlled Water Valve, Temperature Controlled Water Valve.

Description: The water valve is used for regulating the quantity of water in refrigeration systems with water cooled condensers. Use of the water valve results in modulating regulation of the condensing pressure so that it is kept almost constant during operation.

Condenser Pressure Regulator For Air Cooled Condensers
Also known as: Head Pressure Control Valve.

Description: To maintain a constant and sufficiently high condensing pressure in air cooled condensers at low ambient temperatures. The valve must maintain liquid subcooling and prevent liquid line flash-gas and also provide adequate pressure at the inlet side of the TX valve to obtain sufficient pressure drop across the valve port.

Application: Dependent on the type of control circuit employed or recommended by the air cooled condenser manufacturer, the control may be either a single three-way modulating type valve or two separate valves to achieve the same function.

Thermostatic Injection Valve
Also known as: Liquid Injection Valve.

Description: Used to prevent compressor overheating and high discharge temperatures when: An R717 compressor operates either at low suction pressures or at high condensing temperatures. A compressor operates both at low suction pressures and at high condensing temperatures, especially with R22. A compressor operates with By-pass to suction line hot gas by-pass.

Application: Liquid injected into a gas to be de-superheated should be injected in a manner which provides homogeneous mixing of the liquid and superheated gas. Preferred method is to pipe the hot gas and liquid injection into a Tee to permit good mixing before it enters the suction line. A good mix with the suction gas may be gained by injecting the liquid/hot gas mixture into the suction line at approximately a 45° angle against the flow of suction gas to the compressor.

Air Cooled Condenser Selection

The selection of an air cooled condenser is based on the heat rejection capacity at the condenser rather than net refrigeration effect at the evaporator because the refrigerant gas absorbs additional energy in the compressor. This additional energy, the heat of compression, varies appreciably with the operating conditions of the system and with compressor design, whether open or suction cooled hermetic type.

Some compressor manufacturers publish heat rejection figures as part of their compressor ratings. Since heat rejection varies with compressor designs, it is recommended that the compressor manufacturer's data be used whenever available in selecting an air cooled condenser. If the compressor manufacturer does not publish heat rejection ratings, factors from Table A and B may be used to estimate total heat rejection (THR).

Heat Rejection Factors

Open Compressors

TABLE A

Evap. Temp. °C	Condensing Temperature °C						
	30	35	40	45	50	55	60
-35	1.37	1.4	1.44	1.5	*	*	*
-30	1.32	1.36	1.4	1.44	1.5	*	*
-25	1.28	1.31	1.35	1.39	1.44	1.49	*
-20	1.24	1.27	1.31	1.35	1.39	1.44	1.49
-15	1.21	1.24	1.28	1.31	1.35	1.39	1.44
-10	1.18	1.21	1.24	1.27	1.31	1.35	1.39
-5	1.15	1.18	1.21	1.24	1.28	1.31	1.35
0	1.12	1.15	1.18	1.2	1.24	1.27	1.31
5	1.1	1.13	1.15	1.17	1.2	1.24	1.27
10	1.08	1.11	1.13	1.15	1.18	1.2	1.24

Suction Cooled Hermetic Compressors

TABLE B

Evap. Temp. °C	Condensing Temperature °C						
	30	35	40	45	50	55	60
-35	1.56	1.6	1.65	1.71	*	*	*
-30	1.49	1.52	1.56	1.62	1.68	*	*
-25	1.43	1.46	1.49	1.54	1.6	1.68	*
-20	1.37	1.4	1.45	1.48	1.54	1.6	1.65
-15	1.32	1.35	1.39	1.43	1.47	1.53	1.58
-10	1.28	1.31	1.33	1.37	1.42	1.47	1.52
-5	1.24	1.26	1.29	1.33	1.37	1.41	1.46
0	1.2	1.22	1.25	1.28	1.32	1.36	1.41
5	1.16	1.19	1.22	1.24	1.27	1.31	1.35
10	1.13	1.15	1.18	1.21	1.24	1.26	1.29

*Outside of normal limits for single stage compression application.

Condenser Capacity (THR) = Compressor Capacity x Heat Rejection Factor

Selection Example:

Given:
- Compressor Capacity 38600 Watts
- Evaporating Temperature 5°C
- Refrigerant R22
- Ambient Air 35°C
- Maximum Condensing Temperature 50°C
- Suction Cooled Hermetic Compressor

Procedure
- Assuming the compressor manufacturers heat rejection data is not available, determine the heat rejection factor for the specified conditions using Table B (Suction Cooled Hermetic Compressors) = 1.27

- Multiply the compressor capacity by the heat rejection factor to estimate the required condenser capacity
(Total Heat Rejection, THR) 38600 x 1.27 = 49022 Watts THR

- Divide required THR by the specified temperature difference (KTD) between condensing temperature and the ambient air,
50° – 35°C = 15 K TD. $\frac{\text{49022 Watts}}{\text{15 K TD}}$ THR = 3268 Watts / K TD

- Select condenser from manufacturers capacity tables, based on R22 and 1K temperature difference. Select a model that has this capacity,
if the model selected is oversized the condenser will balance the compressor heat rejection at less than the maximum condensing temperature of 50°C.

Motor Types
L'Unite Hermetique

SINGLE PHASE MOTORS WITH START WINDING

P.T.C.S.I.R During start-up, the start winding is fed through the P.T.C. which changes the resistance of the P.T.C. with the change in temperature.

ELECTRICAL COMPONENTS:
- 1 P.T.C.
- 1 External overload protector fitted on the compressor.
- 1 Earth connection

R.S.I.R. During start-up, the start winding is energised through an electromagnetic relay.

ELECTRICAL COMPONENTS:
- 1 Electromagnetic relay
- 1 External overload protector fitted on the compressor
- 1 Earth connection

C.S.I.R. During start-up, the start winding is energised through an electromagnetic relay and a start capacitor.

ELECTRICAL COMPONENTS:
- 1 Electromagnetic relay
- 1 External overload protector fitted on the compressor
- 1 Start capacitor
- 1 Earth connection

SINGLE PHASE MOTORS WITH PERMANENT SPLIT CAPACITOR

P.T.C.S.R During start-up, the start winding is fed through the P.T.C. which changes the resistance of the P.T.C. with the change in temperature.

ELECTRICAL COMPONENTS:
- 1 P.T.C.
- 1 External overload protector fitted on the compressor
- 1 Run capacitor
- 1 Earth connection

P.S.C. The start winding of such a motor remains in circuit through a permanent split capacitor.

ELECTRICAL COMPONENTS:
- 1 External overload protector fitted on the compressor
- 1 Run capacitor
- 1 Earth connection

C.S.R. During start-up, the start winding is energised through an electromagnetic potential relay and a start capacitor. This winding remains in circuit and is supplied through a permanent split capacitor.

ELECTRICAL COMPONENTS:
- 1 External overload protector fitted on the compressor
- 1 Electrical box containing:
- 1 Electromagnetic potential relay
- 1 Start capacitor fitted with a discharge pressure
- 1 Terminal block
- 1 Earth connection
- 1 External run capacitor with fixing bracket

Coolroom Design Data

Product Load

Product placed in a refrigerated room at a temperature higher than the storage temperature will lose heat until it reaches the storage temperature. The product load will be affected by one or more of the following factors:

- Specific Heat
- Latent Heat of Fusion
- Heat of Respiration

Specific Heat is the amount of heat required to change the temperature of 1kg of product 1K. It has two values, one above freezing, the other below freezing due to the change in state which occurs.
Latent Heat of Fusion is the amount of heat removal required to freeze 1kg of product. It should be noted that the latent heat has a definite relationship to the water content of a product. Most food products have a freezing temperature in the range of -3°C to -0.5°C. If the exact freezing temperature is unknown, it may be assumed to be -2°C.

Heat of Respiration is the amount of heat given off by products such as fresh fruits and vegetables during storage. Since the products are alive, they continually undergo a change in which energy is released in the form of heat. The amount of heat liberated varies with the type and temperature of the product.

Miscellaneous- All electrical energy dissipated by lights, motors, heaters etc. located in the refrigerated area must be included in the heat load. An item often overlooked is the fan motor on a unit cooler.
Heat equivalents of electric motors vary as to size of motor.

Balancing the System

For the general purpose coolroom, holding meats, vegetables and dairy products, it is common procedure to balance the low side to the condensing unit at a 6K to 7K temperature difference; that is, they are balanced to maintain a temperature difference between the refrigerant in the coil and the air of 6K to 7K. It has been learned by experience that, if this is done, one may expect to maintain in a cooler 80% to 85% relative humidity, which is a good range for general storage.

A coil which is selected for a wide temperature difference will maintain a lower relative humidity in service, whereas one which is selected for too close temperature difference will produce relative humidities which are higher than required for practical operation and surface sliming may result on stored meat products during winter periods when loads are reduced and compressor running time falls off. Heat may have to be added to the room for about 6 hours/day compressor operation. On straight vegetable coolers where higher humidities are desired, the coil should be selected to balance the compressor at a 4K to 6K temperature difference, as such will produce an average relative humidity of 90% within the refrigerated space. The same recommendation applies to florists' display rooms and in both cases, the maintenance of a high relative humidity in long term storage is beneficial whereas some exception with reference to meat products is noted above.

On low temperature units, if one stops to consider that the amount of dehumidification is in proportion to the temperature difference, it is obvious that the closer the temperature difference, the less frost accumulation. It is strongly recommended that coils for low temperature work be selected to balance the condensing unit at a 6K temperature difference or less.

Selection of T.X. Valves

The selection and installation of thermostatic expansion (T.X.) valves is of utmost importance for best coil performance. Valve capacity must be at least equal to the coil load rating and never more than twice that value. Any valve which is substantially oversized will tend to be erratic in operation and this will penalise both coil performance and rated capacity output. Liquid line strainers should always be installed ahead of all T.X. valves.

T.X. valves are nominally rated with R22 refrigerant at 4°C evaporator temperature, 5.6K superheat and 690 kPa (100 psi) differential (pressure at valve inlet minus pressure at valve outlet). For capacities at other differentials or when used with other refrigerants, the valve manufacturer's ratings must be consulted and closely followed in reference to Capacity Correction Factors.

Although it is frequently assumed that when thermostatic expansion valves are used in low temperature applications, some increased capacity results due to a higher pressure differential, this is not always true because of variations in valve design. It is always advisable under wide range conditions to secure the valve manufacturer's recommendations.

As a further precautionary note, the power element charges of all T.X. valves must be properly selected for operating temperature ranges and the type of refrigerant used in the system.

T.X. valves should be located as close as possible to evaporator inlet and bulbs attached or inserted at a point where refrigerant will not trap in the suction line. Keep bulbs away from tees in common suction lines so that one valve will not affect any other valve.

Externally equalised valves should be used on all multicircuited evaporators. In general, internally equalised valves are applied with single circuited coils.

Coolroom Design Data

Storage Requirements of Perishable Products

Product	Storage Temp. °C	Relative Humidity %	Specific Heat kj / kg • K		Latent Heat kj / kg	Approx. Freezing Point °C	Approx. Storage Life	Water Content %
			Above Freezing	Below Freezing				
Fruits and Melons								
Apples	-1 to 4	90 to 95	3.65	1.89	280	-1.1	3 to 8 months	84
Apricots	0	90 to 95	3.68	1.9	284	-1.1	1 to 2 weeks	85
Avocados – Green	7 to 10	85 to 90	3.01	1.65	217	-0.3	2 to 4 weeks	65
Bananas	13	85 to 95	3.35	1.78	250	-0.8	2 to 3 weeks	75
Blackberries	0	90 to 100	3.68	1.9	284	-0.8	2 to 3 days	85
Blueberries	0	90 to 100	3.58	1.86	274	-1.6	2 weeks	82
Cantaloupe (Rock Melon)	2 to 4	90	3.92	1.99	307	-1.2	5 to 15 days	92
Casaba Melons	7 to 10	85 to 95	3.95	2	310	-1.1	4 to 6 weeks	93
Cherries	-1 to 0	95	3.51	1.84	267	-1.8	2 to 3 weeks	80
Coconuts	0 to 2	80 to 85	2.41	1.43	157	-0.9	1 to 2 months	47
Cranberries	2 to 4	90 to 95	3.75	1.93	290	-0.9	2 to 4 months	87
Currents	-0.5 to 0	90 to 95	3.68	1.9	284	-1	10 to 14 days	85
Dates – Cured	-18 or 0	75 or less	1.5	1.09	67	-16	6 to 12 monthly	20
Dew Berries	0	90 to 95	3.68	1.9	284	-1.3	3 days	85
Figs – Dried	0 to 4	50 to 60	1.61	1.12	95	-	9 to 12 months	23
Figs– Fresh	-1 to 0	85 to 90	3.45	1.81	260	-2.4	7 to 10 days	78
Frozen Fruits	-23 to –18	90 to 95	-	-	-	-	6 to 12 months	-
Gooseberries	0	90 to 95	3.82	1.95	297	-1.1	1 to 2 weeks	89
Grapefruit	14 to 16	85 to 90	3.82	1.95	297	-1.1	4 to 6 weeks	89
Grapes	-1 to 0	95 to 100	3.58	1.86	274	-2	3 to 6 months	82
Honeydew Melons	7 to 10	90	3.95	2	310	-0.9	3 to 4 weeks	93
Lemons	15 to 18	85 to 90	3.82	1.95	297	-1.4	1 to 6 months	89
Limes	9 to 10	85 to 90	3.72	1.92	287	-1.6	6 to 8 weeks	86
Mangoes	13	85 to 90	3.55	1.85	270	-0.9	2 weeks	81
Nectarines	0	90	3.58	1.86	274	-0.9	1 to 2 weeks	82
Olives – Fresh	7 to 10	85 to 90	3.35	1.78	250	-1.4	4 to 6 weeks	75
Oranges	5	85 to 90	3.75	1.93	290	-0.8	3 to 12 weeks	87
Orange Juice	-1 to 2		3.82	1.95	297		3 to 6 weeks	89
Papaw	13	90	3.88	1.98	304	-0.8	1 to 3 weeks	91
Peaches	0	90 to 95	3.82	1.95	297	-0.9	2 to 3 weeks	89
Pears	-1.6 to 0	90 to 95	3.61	1.88	277	-1.6	2 to 6 months	83
Persian Melons	7 to 10	90 to 95	3.95	2	310	-0.8	2 weeks	93
Persimmons	-1	90	3.45	1.81	260	-2.2	3 to 4 months	78
Pineapples	20	85 to 90	3.68	1.9	284	-1	1 to 4 weeks	85
Plums	-0.5 to 0	90 to 95	3.72	1.92	287	-0.8	1 to 4 weeks	86
Pomegranates	0	90	3.58	1.86	274	-3	2 to 4 months	82
Prunes – Fresh	-1 to 0	90 to 95	3.72	1.92	287	-0.8	2 to 4 weeks	86
Prunes – Dried	0 to 4	55 to 60	2.56	1.19	108	-	5 to 8 months	28
Quinces	-1 to 0	90	3.68	1.9	284	-2	2 to 3 months	85
Raspberries	0	90 to 100	3.55	1.85	270	-1.1	2 to 3 days	81
Strawberries	0	90 to 100	3.85	1.97	300	-0.8	5 to 7 days	90
Tangerines	0	90 to 95	3.75	1.93	290	-1.1	2 to 4 weeks	87
Watermelons	5 to 10	85 to 90	3.95	2	310	-0.4	2 to 3 weeks	93

Coolroom Design Data

Storage Requirements of Perishable Products

Product	Storage Temp. °C	Relative Humidity %	Specific Heat kj / kg • K		Latent Heat kj / kg	Approx. Freezing Point °C	Approx. Storage Life	Water Content %
			Above Freezing	Below Freezing				
Vegetables								
Artichokes – Globe	0	95 to 100	3.65	1.89	280	-1.2	2 weeks	84
Artichokes – Jerusalem	0	90 to 95	3.47	1.84	267	-2.5	5 months	80
Asparagus	0 to 2	95 to 100	3.95	2	310	-0.6	2 to 3 weeks	93
Beans – Green	7 to 10	95 to 100	3.82	1.95	297	-0.7	7 to 10 days	89
Beetroot – Bunch	0	95 to 100				-0.4	1 to 2 weeks	
Beetroot – Topped	0	95 to 100	3.78	1.94	294	-0.9	2 to 5 months	88
Broccoli	0	95 to 100	3.85	1.97	300	-0.6	10 to 14 days	90
Brussels Sprouts	0	95 to 100	3.68	1.9	284	-0.8	3 to 5 weeks	85
Cabbage	0	98 to 100	3.92	1.99	307	-0.9	1 to 4 months	92
Carrots – Topped, Immature	0	98 to 100	3.78	1.94	294	-1.4	4 to 6 weeks	88
Carrots – Topped, Mature	0	98 to 100	3.78	1.94	294	-1.4	4 to 5 months	88
Cauliflower	0	95 to 100	3.92	1.99	307	-0.8	2 to 4 weeks	92
Celery	0	95 to 100	3.98	2.02	314	-0.5	1 to 2 months	94
Corn – Sweet	0	95 to 98	3.31	1.76	247	-0.6	4 to 8 days	74
Cucumbers	10	95 to 100	4.05	2.04	320	-0.5	10 to 14 days	96
Eggplant	7 to 10	90 to 95	3.95	2	310	-0.8	7 days	93
Endive (Escarole)	0	90 to 100	3.95	2	310	-0.1	2 to 3 weeks	93
Frozen Vegetables	-23 to -18						6 to 12 months	
Garlic – Dry	0	65 to 70	2.88	1.6	203	-0.8	6 to 7 months	61
Horseradish	0	95 to 100	3.35	1.78	250	-1.8	10 to 12 months	75
Kale	0	95	3.75	1.93	290	-0.5	3 to 4 weeks	87
Kohlrabi	0	90 to 100	3.85	1.97	300	-1	2 to 4 weeks	90
Leeks – Green	0	95	3.68	1.9	284	-0.7	1 to 3 months	85
Lettuce – Head	0	95 to 100	4.02	2.03	317	-0.2	2 to 3 weeks	95
Mushrooms	0	95	3.88	1.98	304	-0.9	3 to 4 days	91
Onions – Dry	0	65 to 70	3.78	1.94	294	-0.8	1 to 8 months	88
Parsley	0	95 to 100	3.68	1.9	284	-1.1	1 to 2 months	85
Parsnips	0	98 to 100	3.48	1.83	264	-0.9	2 to 6 months	79
Peas – Green	0	95 to 98	3.31	1.76	247	-0.6	1 to 2 weeks	74
Peas – Dried	10	70	1.24	0.99			6 to 8 months	12
Peppers – Sweet	7 to 13	90 to 95	3.92	1.99	307	-0.7	2 to 3 weeks	92
Peppers – Dry, Chilli	0 to 10	60 to 70	1.24	0.99			6 months	12
Potatoes – Culinary	7	90 to 95	3.45	1.81	260	-0.7		78
Potatoes – Sweet	13 to 16	85 to 90	3.15	1.7	230	-1.3	4 to 6 months	69
Pumpkins	13	85 to 90	3.88	1.98	304	-0.8	2 to 3 months	91
Radishes – Topped	0	90 to 95	4.02	2.03	317	-0.7	3 to 4 weeks	95
Rhubarb	0	95	4.02	2.03	317	-0.9	2 to 4 weeks	95
Rutabaga	0	90 to 95	3.82	1.95	297	-1.1	2 to 4 months	89
Silverbeet (Spinach)	0	95 to 98	3.95	2	310	-0.3	1 to 2 weeks	93
Squash – Button	7	95 to 100	3.98	2.02	314	-0.5	1 to 3 weeks	94
Squash – Hard Shell	13	85 to 90	3.68	1.9	284	-0.8	1 to 3 months	85
Tomatoes – Firm, Ripe	5 to 7	90 to 95	3.98	2.02	313	-0.5	4 to 7 days	94
Tomatoes– Mature, Green	13	90 to 95	3.95	2	310	-0.6	1 to 2 weeks	93
Turnips	0	95	3.92	1.99	307	-1.1	4 to 5 months	92
Yams	16	85 to 90	3.31	1.76	247		3 to 6 months	74

Coolroom Design Data

Storage Requirements of Perishable Products

Product	Storage Temp. °C	Relative Humidity %	Specific Heat kj / kg • K		Latent Heat kj / kg	Approx. Freezing Point °C	Approx. Storage Life	Water Content %
			Above Freezing	Below Freezing				
Meat - Fish - Shellfish								
Bacon – Medium Fat	3 to 5	80 to 85	1.47	1.07	63		2 to 3 weeks	19
– Frozen	-23 to -18	90 to 95					2 to 4 months	
Beef – Fresh, Average	0 to 1	88 to 92	2.9 to 3.4	1.6 to 1.8	206 to 257	-2.2 to -2.7	1 to 6 weeks	62 to 77
– Liver	0	90	3.18	1.71	233	-1.7	5 days	70
– Veal	0 to 1	90	3.05	1.66	220		1 to 7 days	66
– Frozen	-23 to -18	90 to 95					6 to 12 months	
Ham – 74% Lean	0 to 1	80 to 85	2.71	1.54	187	-1.7	3 to 5 days	56
– Light Cure	3 to 5	80 to 85	2.74	1.55	190		1 to 2 weeks	57
– Country Cure	10 to 15	65 to 70	2.24	1.36	140		3 to 5 months	42
– Frozen	-23 to -18	90 to 95					6 to 8 months	
Lamb – Fresh, Average	0 to 1	85 to 90	2.8 to 3.2	1.6 to 1.7	200 to 233	-2.2 to -1.7	5 to 12 days	60 to 70
– Frozen	-23 to -18	90 to 95					8 to 12 months	
Pork – Fresh, Average	0 to 1	85 to 90	1.9 to 2.3	1.2 to 1.4	107 to 147	-2.2 to -2.7	3 to 7 days	32 to 44
– Frozen	-23 to -18	90 to 95					4 to 8 months	
– Sausage	0 to 1	85	2.11	1.31	127		1 to 7 days	38
Poultry – Fresh, Average	-2 to 0	85 to 90	3.31	1.76	247	-2.8	1 week	74
– Frozen	-23 to -18	90 to 95					8 to 12 months	
Rabbits – Fresh	0 to 1	90 to 95	3.11	1.69	227		1 to 5 days	68
Fish – Fresh, Average	-1 to 1	95 to 100	2.91 to 3.55	1.61 to 1.85	207 to 270	-2.2	5 to 14 days	62 to 81
– Frozen	-29 to -18	90 to 95					6 to 12 months	
Scallops – Meat	0 to 1	95 to 100	3.51	1.84	267	-2.2	12 days	80
Shrimp	-1 to 1	95 to 100	3.38	1.79	254	-2.2	12 to 14 days	76
Oysters, Clams – Meat and Liquid	0 to 2	100	3.75	1.93	290	-2.2	5 to 8 days	87
Oysters – In Shell	5 to 10	95 to 100	3.51	1.84	267	-2.8	5 days	80
Shellfish – Frozen	-29 to -18	90 to 95					3 to 8 months	
Miscellaneous								
Beer – Bottles & Cans	2 to 4	65 or less	3.85	1.97	300	-2.2	3 to 6 months	90
Bread – Frozen	-18		1.99	1.27	106 to 123	-9 to -7	3 to 13 weeks	32 to 37
Butter	0 to 4	75 to 85	1.37	1.04	53	-20 to -0.6	1 month	16
Butter – Frozen	-23	70 to 85					12 Months	
Cheese – Cheddar	0 to 1	65	2.07	1.3	123	-13	12 months	37
– Cheddar	4.4	65	2.07	1.3	123	-13	6 months	37
Chocolate – Milk	-18 to 1	40	0.87	0.85	3.3		6 to 12 months	1
Coffee – Green	2 to 3	80 to 85	1.17 to 1.34	0.96 to 1.03	33 to 50		2 to 4 months	10 to 15
Eggs – Whole	-2 to 0	80 to 85	3.05	1.66	220	-2.2	5 to 6 months	66
– Whole	10 to 13	70 to 75	3.05	1.66	220	-2.2	2 to 3 weeks	66
– Frozen, Whole	-18 or less		3.31	1.76	247		1 year plus	74
Furs and Fabrics	1 to 4	45 to 55					Several years	
Honey	Below 10		1.4	1.05	57		1 year plus	17
Hops	-2 to 0	50 to 60					Several months	
Milk–Whole, Pasteurised	0 to 1		3.75	1.93	290	-0.6		87
Nuts	0 to 10	65 to 75	0.94 to 1.04	0.88 to 0.91	10 to 20		8 to 12 months	3 to 6
Oleomargerine	2	60 to 70	1.37	1.04	53		1 year plus	16
Popcorn – Unpopped	0 to 4	85	1.17	0.96	33		4 to 6 weeks	10

Coolroom Design Data

Heat of Respiration: Watts / Tonne

Product	Storage Temperature : °C				
	0	5	10	15	20
Fruits and Melons					
Apples	6 – 10	13 – 20		35 – 80	45 – 95
Apricots	16 – 17	19 – 27	33 – 56	63 – 102	87 – 155
Avocados – Green		53 – 80		160 – 415	195 – 915
Blackberries	47 – 68	85 – 136	155 – 281	209 – 432	388 – 582
Blueberries	7 – 31	27 – 36		101 – 183	154 – 259
Cantaloupe (Rock Melon)		26 – 30	46	100 – 114	132 – 192
Cherries – Sweet	12 – 16	28 – 42		74 – 133	83 – 95
Cranberries		12 – 14			33 – 54
Figs – Fresh		33 – 39	66 – 68	146 – 188	169 – 282
Gooseberries	20 – 26	36 – 40		65 – 96	
Grapefruit				38	52
Grapes	4 – 6	8 – 16		26 – 31	
Honeydew Melons			24	35 – 47	59 – 71
Lemons				47	67
Limes			8 – 17	17 – 31	20 – 55
Mangoes				133	223 – 449
Olives – Fresh				65 – 116	114 – 145
Oranges	5 – 13	10 – 19		35 – 60	60 – 90
Papaw		11 – 16		40 – 60	
Peaches	12 – 19	19 – 27		98 – 126	176 – 304
Pears	8 – 15	18 – 39	23 – 59	76 – 155	101 – 231
Persimmons		18		35 – 42	59 – 71
Pineapples		4 – 6		35 – 50	65 – 105
Plums	6 – 9	12 – 27	27 – 34	35 – 37	53 – 77
Raspberries	52 – 74	92 – 114	82 – 165	244 – 301	340 – 727
Strawberries	36 – 52	49 – 98	146 – 281	211 – 274	303 – 581
Watermelons			22		51 – 74

Coolroom Design Data

Heat of Respiration: Watts / Tonne

Product	Storage Temperature : °C				
	0	5	10	15	20
Vegetables					
Artichokes – Globe	67 – 133	95 – 178	162 – 292	229 – 430	404 – 692
Asparagus	81 – 238	162 – 404	318 – 904	472 – 971	809 – 1484
Beans – Green		101 – 104	162 – 173	252 – 276	351 – 386
Beetroot – Topped	16 – 21	27 – 28	35 – 40	50 – 69	
Broccoli	55 – 64	102 – 475		515 – 1008	825 – 1011
Brussels Sprouts	46 – 71	96 – 144	187 – 251	283 – 317	267 – 564
Cabbage - White	15 – 40	22 – 64	36 – 98	58 – 170	
Carrots – Topped	46	58	93	117	209
Cauliflower	53	61	100	137	238
Celery	20	30		100	170
Corn – Sweet	126	230	332	483	855
Cucumbers			68 – 86	71 – 98	92 – 143
Garlic – Dry	9 – 32	18 – 29	27 – 29	33 – 81	30 – 54
Horseradish	24	32	78	97	132
Kohlrabi	30	49	93	146	
Leeks – Green	28 – 49	58 – 86	159 – 202	245 – 347	
Lettuce – Head	27 – 50	40 – 59	81 – 119	114 – 121	178
Mushrooms	83 – 130	210			782 – 939
Onions – Dry	9	10	21	33	50
Parsley	98 – 137	196 – 252	389 – 487	427 – 662	582 – 757
Parsnips	34 – 46	26 – 52	61 – 78	96 – 127	
Peas – Green	90 – 139	163 – 227		530 – 600	728 – 1072
Peppers – Sweet			43	68	130
Potatoes – Immature		35	42 – 62	42 – 92	54 – 134
– Mature		18 – 20	20 – 30	20 – 35	20 – 47
Radishes – Topped	16 – 18	23 – 24	45	82 – 97	142 – 146
Rhubarb – Topped	24 – 39	33 – 54		92 – 135	119 – 169
Rutabaga	6 – 8	14 – 15		32 – 47	
Silverbeet (Spinach)		136	328	531	682
Tomatoes – Coloured and Ripe		16		65 – 75	65 – 115
– Mature, Green		13 – 22		43 – 75	75 – 110
Turnips – Roots	26	28 – 30		64 – 71	71 – 74

Coolroom Design Data

Heat Load Tables

2°C Coolrooms

Based on:

- 35°C Ambient Temperature
- 75mm Polystyrene Insulation
- Product Specific Heat: 3.4 kj/kg K
- Product Pull Down Time: 24 hours
- 16 hours/day Compressor Operation
- Heavy Usage = Average Air Changes x 2

External Dimensions : m		Volume m^3	Heat Load – Watts					
			Product Load Per Day (Product Entering at 12°C)					
Height = 2.4			150 kg		350 kg		700 kg	
Length	Width		Average Usage	Heavy Usage	Average Usage	Heavy Usage	Average Usage	Heavy Usage
1.8	1.2	3.9	930	1280	1070	1420		
1.8	1.8	6.13	1120	1560	1260	1690		
1.8	2.4	8.35	1300	1800	1440	2010		
1.8	3	10.58	1470	2100	1610	2240		
2.4	2.4	11.39	1510	2150	1650	2290	1890	2530
2.4	3	14.43	1710	2420	1840	2550	2080	2800
2.4	3.6	17.47	1900	2660	2030	2800	2270	3040
2.4	4.2	20.5			2220	3040	2460	3280
3	3	18.28			2060	2850	2310	3090
3	3.6	22.12			2280	3130	2520	3370
3	4.2	25.97			2490	3390	2730	3630
3.6	3.6	26.78			2520	3440	2760	3680
3.6	4.2	31.44			2750	3730	3060	4040
4.2	4.2	36.91			3070	4120	3310	4370

-18°C Freezers

Based on:

- 35°C Ambient Temperature
- 150mm Polystyrene Insulation
- Heavy Usage = Average Air Changes x 2
- Product Specific Heat above freezing: 3.3 kj/kg K
- Product Specific Heat below freezing: 1.5 kj/kg K
- Product Latent Heat: 247 kj/kg
- Product pull down time: 24 hours
- 18 hours/day compressor operation

External Dimensions : m		Volume m^3	Storage Only – No Product Freezing	Heat Load - Watts		
Height = 2.4				Product Freezing Load Per Day (Product Entering at 5°C)		
Length	Width			150 kg	350 kg	700 kg
1.8	1.2	2.84	740	1480	2550	
1.8	1.8	4.72	930	1660	2730	
1.8	2.4	6.61	1100	1820	2900	
1.8	3	8.51	1250	2040	3050	
2.4	2.4	9.26	1300	2080	3090	4910
2.4	3	11.91	1490	2260	3260	5090
2.4	3.6	14.55	1670	2430	3430	5260
2.4	4.2	17.2	1840	2590	3600	5420
3	3	15.31	1710	2460	3470	5290
3	3.6	18.71	1910	2650	3660	5480
3	4.2	22.11	2170	2840	3840	5670
3.6	3.6	22.87	2200	2870	3870	5700
3.6	4.2	27.03	2420	3080	4150	5910
4.2	4.2	31.94	2650	3310	4380	6140

We recommend that the above information be used as a guide only and that each particular application be referred to Actrol for selection advice.

Superheat

A vapour is superheated whenever its temperature is higher than the saturation temperature corresponding to its pressure. The amount of the superheat equals the amount of temperature increase above the saturation temperature at the existing pressure.

For example, a refrigeration evaporator is operating with Refrigerant 134a at 236 kPa suction pressure (See Figure 1). The Refrigerant 134a saturation temperature at 236 kPa is 4°C. As long as any liquid exists at this pressure, the refrigerant temperature will remain 4°C as it evaporates or boils off in the evaporator.

As the refrigerant moves along in the coil, the liquid boils off into a vapour, causing the amount of liquid present to decrease. All of the liquid is finally evaporated at point B because it has absorbed sufficient heat from the surrounding atmosphere to change the refrigerant liquid to a vapour. The refrigerant gas continues along the coil and remains at the same pressure (236 kPa) however, its temperature increases due to continued absorption of heat from the surrounding atmosphere. When the refrigerant gas reaches the end of the evaporator (Point C), its temperature is 10°C. This refrigerant gas is now superheated and the amount of superheat is 6°C or 6K (10° – 4°). The degree to which the refrigerant gas is superheated depends on the amount of refrigerant being fed to the evaporator by the T.X. valve and the heat load to which the evaporator is exposed.

Adjustment of Superheat

The function of a T.X. valve is to control the superheat of the suction gas leaving the evaporator in accordance with the valve setting. A T.X. valve which is performing this function within reasonable limits can be said to be operating in a satisfactory manner.

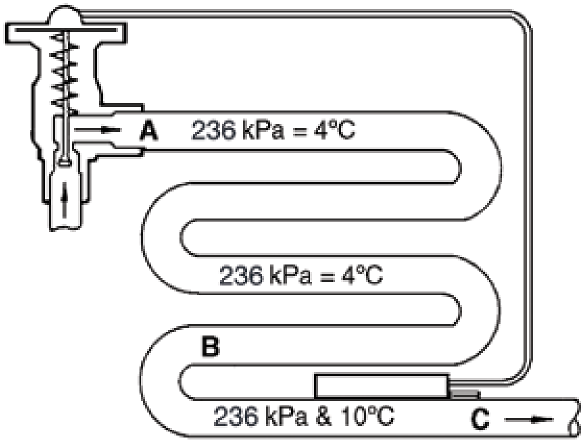
Good superheat control is the criterion of T.X. valve performance. It is important that this function be measured as accurately as possible, or in the absence of accuracy, to be aware of the magnitude and direction of whatever error is present.

Superheat has been previously defined as the temperature increase of the refrigerant gas above the saturation temperature at the existing pressure. Based on this definition, the pressure and temperature of the refrigerant suction gas passing the T.X. valve remote bulb are required for an accurate determination of superheat.

Thus, when measuring superheat, the recommended practice is to install a calibrated pressure gauge in a gauge connection at the evaporator outlet. In the absence of a gauge connection, a tee installed in the T.X. valve external equaliser line can be used just as effectively.

A refrigeration type pocket thermometer with appropriate bulb clamp may be used, or more effective is the use of a service type potentiometer (electric thermometer) with thermocouples (leads and probes).

The temperature element from your temperature meter should be clamped to the suction line at the point of remote bulb location and must be insulated against the ambient. Temperature elements of this type, as well as thermometers, will give an average reading of suction line and ambient if not insulated. Assuming an accurate gauge and temperature meter, this method will provide sufficiently accurate superheat readings



Thermostatic Expansion Valve with internal equaliser on evaporator with no pressure drop

for all practical purposes.
On installations where a gauge connection is not available and the valve is internally equalised there are two alternate methods possible. Both of these methods are approximations only and their use is definitely not recommended. The first of these is the two temperature method which utilises the difference in temperature between the evaporator inlet and outlet as the superheat. This method is in error by the temperature equivalent of the pressure drop between the two points of temperature.

Where the pressure drop between the evaporator inlet and outlet is 7 kPa or less, the two temperature method will yield fairly accurate results. However, evaporator pressure drop is usually an unknown and will vary with the load. For this reason, the two temperature method cannot be relied on for absolute superheat readings. It should be noted that the error in the two temperature method is negative and always indicates a superheat lower than the actual figure.

The other method commonly used to check superheat involves taking the temperature at the evaporator outlet and utilising the compressor suction pressure as the evaporator saturation pressure. The error here is obviously due to the pressure drop in the suction line between the evaporator outlet and the compressor suction gauge.

On self-contained equipment, the pressure drop and resulting error are usually small. However, on large built-up systems or systems with long runs of suction line, considerable discrepancies will usually result.

Since estimates of suction line pressure drop are usually not accurate enough to give a true picture of the superheat, this method cannot be relied on for absolute values. It should be noted that the error in this instance will always be positive and the superheat resulting will be higher than the actual value.

Restating, the only method of checking superheat that will yield an absolute value involves a pressure and temperature reading at the evaporator outlet.

Other methods employed will yield a fictitious superheat that can prove misleading when used to analyse T.X. valve performance. By realising the limitations of these approximate methods and the direction of the error, it is often possible to determine that the cause of a trouble call is due to the use of improper methods of instrumentation rather than any malfunction of the valve.

Trouble Shooting Tips - A list of Do's and Don'ts for Commercial Refrigeration

Do	Don't
• Check suction gas superheat at the compressor. High superheats cause high discharge temperatures and shorten compressor life. • Check expansion valve superheat using the temperature pressure method (refer to Page 388). Set to equipment manufacturer's specification. • Replace filter-driers or drier cores when opening the system for service. • Maintain test instruments in workable calibrated condition. • Use an accurate liquid line moisture indicator to ensure system dryness. • Read and observe installation and safety instructions included with a product. • Familiarise yourself with the operation of a control before attempting to make adjustments or repairs. • Remember that a thermostatic expansion valve is not a temperature or pressure control.	• Select solenoid valves by line size or port size. Select based on valve capacity. • Rely on sight or touch for temperature measurements. Use an accurate thermometer. • Be a 'parts changer'. Analyse the problem and determine the cause of failure before making adjustments or repairs. • Attempt to re-use driers or drier blocks once they have been removed from the system. • Energise a solenoid coil with it removed from a valve. It will burn out in a matter of minutes.

Silver Brazing and High Purity Nitrogen

High purity nitrogen must be injected through pipe-work when silver soldering to stop the formation of copper oxide inside the pipe-work.
In order for brazing alloys to melt and flow properly, 620°C to 790°C is required. Copper will react with the oxygen in air at these temperatures to form a scale of copper oxide on the inner walls of tubing, pipe and fittings. The scale is broken off into flakes by the turbulence of flowing liquid refrigerant. The flakes quickly break up into a fine powder which blocks filter driers, strainers and capillary tubes. If the air in the line being brazed is replaced with an inert gas such as high purity nitrogen, the formation of copper oxide can be eliminated.
The line should be purged thoroughly and a slow steady flow of nitrogen maintained by means of a pressure reducing valve.
Always use the correct pressure reducing valves for the protection of the user as high purity nitrogen is stored at very high pressures.

Evaporator and System Superheat

Superheat varies within the system depending on where it is measured. The superheat that the thermal expansion valve is controlling is the evaporator superheat. This is measured at the outlet of the evaporator. The refrigerant gains superheat as it travels through the evaporator, basically starting at 0K as it enters the evaporator and reaching its maximum at the outlet as the refrigerant travels through the evaporator absorbing heat.
System superheat refers to the superheat entering the suction of the compressor. Compressor manufacturers usually like to see a minimum 20°C of superheat at the compressor inlet to ensure that no liquid refrigerant enters the compressor.

Liquid Flooding

Liquid flooding also known as flood back is the term used to describe the condition when liquid refrigerant reaches the compressor. This occurs when the amount of liquid refrigerant fed into the evaporator is more than can be evaporated. There are a number of causes of liquid flooding including:

- TXV oversized for the application
- TXV misadjusted (superheat too low)
- TXV bulb not properly attached
- System overcharged with refrigerant
- Insufficient air flow through the evaporator
- Dirty evaporator or air filters
- Evaporator fan or fans not operating

Migration

Migration is the term used to describe when refrigerant moves some place in the system where it is not supposed to be, such as when liquid migrates to the compressor sump. This phenomenon occurs because refrigerant will always migrate to the coldest part of a system.
As an example, in a split air conditioning system with the compressor/ condenser outside, the liquid refrigerant from the evaporator will migrate to the compressor during the winter months due to the compressor being colder than the indoor (evaporator) temperature. If migration is not prevented the liquid refrigerant in the sump will cause liquid slugging when the compressor starts up.

Migration can be eliminated by the use of either a crank case heater or a pump down cycle.

A crank case heater elevates the crank case temperature above that of the evaporator.

A pump down cycle will store the refrigerant in the liquid receiver and or condenser so it cannot migrate to the compressor.

Sub-cooling

Sub-cooling is the condition where the liquid refrigerant is colder than the minimum temperature (saturation temperature) required to keep it from boiling and, hence, change from a liquid to a gas/vapour phase.
The amount of sub-cooling, at a given condition, is the difference between saturation temperature and the actual liquid refrigerant temperature. Sub-cooling is desirable for several reasons. Sub-cooling increases the efficiency of the system since the amount of heat removed per kg of refrigerant circulated is greater. In other words, you pump less refrigerant through the system to maintain the refrigerated temperature you want, This reduces the amount of time the compressor must run to maintain the temperature.

Sub-cooling is also beneficial because it prevents the liquid refrigerant from changing to a gas / vapour before it gets to the evaporator. Pressure drops in the liquid line piping and vertical risers can reduce the refrigerant pressure to the point where it will boil or "flash" in the liquid line. This change of phase is caused by the refrigerant absorbing heat before it reaches the evaporator. Inadequate sub-cooling prevents the expansion valve from properly metering liquid refrigerant into the evaporator resulting in poor system performance.

Refrigeration Terminology

Temperature
Indicates level of heat energy
Centigrade Scale °C (Celsius)
Absolute Temperature °K (Kelvin) = °C + 273°

Measurement
The quantity of heat energy is measured in kilojoules (kj). The heat required to raise or lower the temperature of 1kg of water 1K is 4.19 kilojoules. (kJ/sec = kw)

States of Matter
Solid, liquid and gas

Change of State
The change from one state of matter to another by the addition or the removal of heat at constant temperature. Change of state can also be referred to as change of phase.

Sensible Heat
Heat added to or subtracted from a substance without a change of state (only a change in temperature).

Specific Heat
The amount of sensible heat required to raise the temperature of 1kg of a substance 1K or the ratio of the heat capacity of the substance to that of water. (kj/kg K)

Latent Heat
Quantity of heat added or removed from a unit weight of a substance during change of state or phase at constant temperature.(kJ/kg.K)
1. Latent Heat of Fusion: Melting of a solid or freezing of a liquid.
2. Latent Heat of Evaporation: Change from a liquid to a gas.
3. Latent Heat of Condensation: Change from a gas to a liquid.

Total Heat (Enthalpy) Heat Capacity
The sum total of sensible and latent heat quantities. kJ/kg.K, usually referenced to -40° at which point the Total Heat (Enthalpy) is taken as 0 kJ/kg.K with negative values below -40°. When all heat has been extracted from a substance, it is said to be at Absolute Zero 0°K (Kelvin).

Note: Enthalpy referenced to 0°C for air.

Pressure
Expressed in Pascals (Pa) or Kilopascals (kPa) Gauge or absolute.
1. Atmospheric Pressure: At sea level is 101.325 kPa absolute (deduct approx. 3.447 kPa or 25.4mm of mercury for every 304.8 metres increase in elevation above sea level).
2. Gauge Pressure: = Calibrated Gauge to read zero at atmospheric pressure.
3. Absolute Pressure: = true or total pressure. Therefore if the pressure is geater than the atmospheric pressure the atmospheric pressure must be added to the gauge pressure. But if the pressure is less than atmospheric pressure the atmospheric pressure must be subtracted from the gauge pressure.
4. Vacuum: Pressures below atmospheric pressure are measured in millimetres of mercury (vacuum) (50.8 millimetres of mercury can be equal to 6.89 kPa). A perfect vacuum (0 kPa) being equal to 25.4 millimetres of mercury (mmHg) or 760mm, at sea level. Measurements are sometimes expressed in microns (1,000,000 microns in a metre).
5. Vapour Pressure: Equilibrium Pressure between a liquid and its saturated vapour. As long as vapour and liquid are both present there will be only one vapour pressure for each level of temperature.
6. Gas Pressure: In the absence of liquid the pressure of a gas is proportional to Absolute gas temperature and to gas density (perfect gas laws).

Saturated Vapour and Liquid
When gas and liquid exist in equilibrium there will be only one vapour pressure for each level of temperature.
1. Subcooled Liquid: If additional heat is removed from saturated liquid in the absence of vapour, its temperature is reduced at constant pressure and it becomes subcooled.
2. Superheated Gas: If additional heat is added to saturated vapour in the absence of liquid, it becomes superheated vapour or gas.

ACTROL™

Refrigeration Terminology

Bubble Point (Saturated Liquid Temperature)

The temperature (for a given pressure) at which the liquid of a refrigerant blend (any 400 or 500 series refrigerant) begins to evaporate or boil. This is similar to the saturated liquid temperature of a single component refrigerant.

Dew Point (Saturated Vapor Temperature)

The temperature (for a given pressure) at which the vapour of a given refrigerant blend (any 400 or 500 series refrigerant) begins to condense or liquefy. This is similar to the saturated vapour temperature of a single component refrigerant.

Fractionation

Fractionation is the change in composition of a refrigerant blend (any 400 or 500 series refrigerant) when it changes phase from liquid to vapour (evaporating) or from vapour to liquid (condensing). This behaviour in blends explains the permanent changes to refrigerant composition due to vapour charging or leaks in a refrigerant system causing the blend to deviate outside the tolerances of the designed composition.

Glide

The difference in temperature between the evaporator inlet and outlet due to fractionation of the blend.
Theoretically, this can be calculated by finding the difference between the dew and bubble temperatures at constant pressure. Actual measurements may differ slightly depending on the state of the liquid refrigerant at either end of the evaporator (or condenser). Pressure losses through the evaporator may also affect glide.

Normal Boiling Point (NBP)

The temperature at which a given refrigerant begins to boil while at atmospheric pressure (101.325kPa absolute).

Abbreviations

AB - alkyl benzene
GWP - global warming potential
MO - mineral oil
ODP - ozone depletion potential
OEM - original equipment manufacturer
POE - Polyolester
PAG - polyalkylene glycol

Fundamentals of Dehydrating a Refrigeration System

Moisture in a Refrigeration System

A single drop of moisture may look harmless, but to a refrigeration system it is extremely damaging. Moisture enters a system easily but can be difficult to remove. Moisture causes two main problems within a refrigeration system, freeze up and acid production. Moisture will be picked up by the refrigerant and transported through the refrigerant line in a fine mist from which ice crystals form at the point of expansion (expansion valve). Ice crystals stop or retard the flow of refrigerant causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant flow, the ice melts and passes through the expansion valve and once more builds a formation of ice crystals. The result is intermittent cooling. Moisture when mixed with refrigeration oils will produce acid which will damage components including the electric windings of compressors. The Polyolester oils used with HFC refrigerants are manufactured from water and acid using a reversible process. If moisture enters the refrigeration system it will mix with the Polyolester oil to produce acid.

Effects of Pressure and Temperature on the Boiling Point of Water

The pressure exerted on the earth at sea level is 101.325kPa absolute pressure. This is called atmospheric pressure. Any pressure measured above atmospheric pressure is referred to as gauge pressure and pressure below is referred to as vacuum. Water will boil when the vapour pressure is equal to the atmospheric pressure surrounding the water. At atmospheric pressure of 101.325kPa absolute pressure a gauge will read 0kPa gauge pressure; at this pressure water will boil at 100°C. The boiling point of water rises as pressure increases and falls as pressure decreases. Australia's highest mountain is Mt. Kosciusko with its summit at 2228 metres above sea level where water will boil at 92.6°C.

Boiling Temperature of Water at Altitude

Temperature [°C]	Altitude [m]
82.82	5000
93.38	2000
96.73	1000
98.38	500
100	0

Boiling Temperature of Water in a Vacuum

Temperature [°C]	KiloPascal [kPa]	Micron [millitorr]
100 1 atmosphere	101.325 1 atmosphere	760000 1 atmosphere
96.1	84.66	535000
90	70.064	525526
80	47.339	355092
70	31.157	233680
60	19.91	149352
50	12.327	92456
40	7.349	55118
30	4.233	31750
26.7	3.385	25400
24.4	3.047	22860
22.2	2.709	20320
20.6	2.371	17780
17.8	2.033	15240
15	1.696	12700
11.7	1.351	10160
7.2	1.013	7620
0	0.606	4572
-6.1	0.337	2540
-14.4	0.168	1270
-31.1	0.033	254
-37.2	0.016	127
-51.1	0.003	25
-56.7	0.001	13
-67.8	0.0003	2.54

Fundamentals of Dehydrating a Refrigeration System

Removing Moisture from a Refrigeration System

There are two ways to remove moisture from a refrigeration system,

1. Employ a high vacuum pump to reduce the pressure and therefore the boiling point of water.
2. Install a high quality liquid line filter drier to entrap the moisture as it enters the filter drier.

It is recommended that both these methods be employed together to remove moisture from a refrigeration system as a vacuum pump alone will not remove the moisture entrapped within the oil. The only way to remove the moisture entrapped within Polyolester oil is to circulate the refrigerant oil mixture through a good quality filter drier.

Vacuum Pumps

Two stage vacuum pumps are recommended for refrigeration and air conditioning technicians as the second chamber allows the pump to achieve a higher vacuum. In a two stage vacuum pump the exhaust from the first pumping stage is discharged into the intake of the second pumping stage, rather than to atmospheric pressure. The second stage begins pumping at a lower pressure and therefore pulls a higher vacuum on the system than the first stage is capable of on its own. Two stage vacuum pumps are capable of achieving vacuums as low at 20 microns for a prolonged period of time in field conditions. A gas ballast or vented exhaust feature is a valving arrangement which permits relatively dry air from the atmosphere to enter the second stage of the pump. This air reduces compression in the final stage, which helps to prevent the moisture from condensing into a liquid and mixing with the vacuum pump oil.

Moisture in the vacuum pump oil will increase the time taken to achieve a vacuum and reduce the ultimate vacuum achieved. It is therefore essential to change the vacuum pump oil on a regular basis, please refer to the pump manufacturers recommendations.

Factors affecting the speed at which a vacuum pump can dehydrate a refrigeration or Air Conditioning system

Several factors influence the pumping speed of a high vacuum pump and thus the time required to remove the moisture from a refrigeration system. Some of the most important are the cubic capacity of the refrigeration system itself; the amount of moisture contained within the system; the ambient temperature; internal and external restrictions and the size of the vacuum pump. The refrigeration or air conditioning system manufacturer determines the internal system cubic capacity and Mother Nature the ambient temperature so the only factors under the control of the service technician are the external restrictions between the system and the vacuum pump. Laboratory tests show the pumping time can be significantly reduced by the use of large diameter hoses. For optimum pumping speed keep the access lines as short in length and large in diameter as possible.

This chart provides a reasonable idea of the minimum vacuum pump capacity required for various sized refrigeration or air conditioning systems. Larger pumps can easily be used on smaller systems.

System Size	Suggested High Vacuum Pump Size
Up to 30kW	35 l/min
Up to 75kW	85 l/min
Up to 123kW	140 l/min
Up to 246kW	280 l/min
Up to 370kW	425 l/min

How vacuum can be measured

A compound gauge is not accurate enough to measure a high vacuum. An electronic vacuum meter or dedicated vacuum gauge is recommended to determine the actual vacuum in the refrigeration or Air Conditioning system. When reading the vacuum created in a refrigeration or Air Conditioning system, the vacuum pump should be isolated with a good vacuum valve or gauge manifold and time allowed for the vacuum pressure to equalize before taking a final reading. If the pressure does not equalize, it is an indication of a leak. If the vacuum equalizes at a pressure which is too high, it is an indication of moisture within the system and more pumping time is required.

Removing moisture using a liquid line filter drier

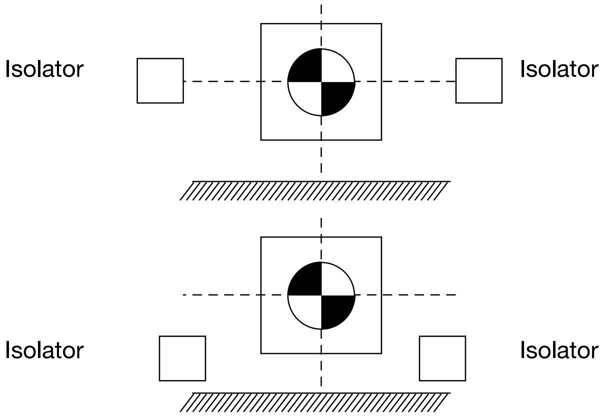
High quality filter driers are essential in all refrigeration and air conditioning systems especially systems containing Polyolester oil. A vacuum alone will not remove all the moisture from Polyolester oils. A high quality liquid line filter drier will entrap moisture as it is carried through the system by the refrigerant. When selecting a liquid line filter drier be sure to follow the appropriate "field replacement" size recommendations which are based on the refrigeration capacity of the system to ensure the cubic capacity of the filter drier is sufficient to entrap all the moisture. Whenever a system has been opened or moisture is suspected to be present the liquid line filter drier should be replaced.

Noise and Vibration

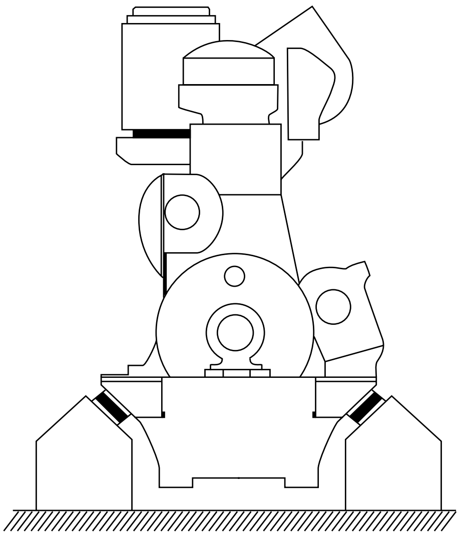
Selection Principles:

Temperature
Extremes of temperature can affect the service life of rubber isolators. Generally, operating temperature should not exceed 60ºC but occasional temperatures of up to 80ºC can be accommodated.

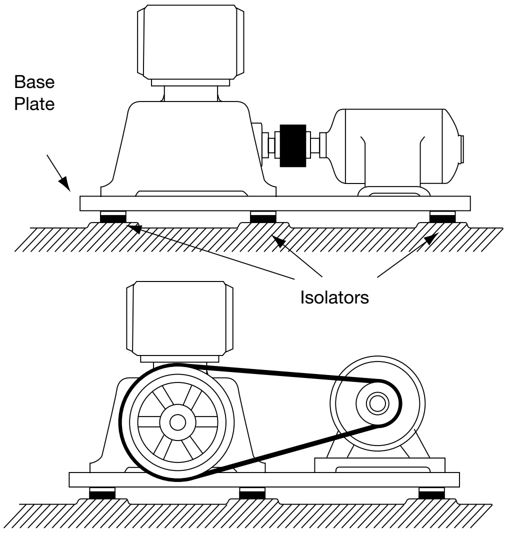
Protection
While most rubber compounds deteriorate if in constant contact with oil or grease, experience has shown that small amounts of oil will not cause a reduction in the mechanical properties of elastomers. It is advisable where oil or grease is prevalent to install isolators so that contact is avoided.



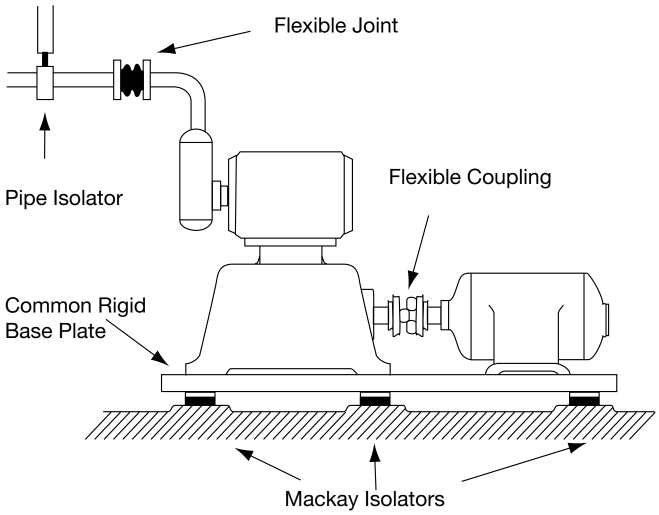
Mount Positioning
The stability of a resiliently supported mechanism is greatest when the isolators are in a horizontal plane passing through the centre of gravity of the mechanism or where the isolators are placed far away from the centre of gravity. Most machines, because of their design, require mounting below the centre of gravity which tends towards instability. For this reason, a small percentage of the isolators efficiency must be sacrificed for the sake of mechanical stability.



Stability
To maintain stability and relative positions between the drive and belt driven units, install both on a common rigid baseplate and then resiliently support the baseplate.



Flexible Couplings
The efficiency of a resilient isolator under a mechanism can be seriously impaired by the rigidity of the connecting members, such as water and steam pipes, conduit etc. For best performance, it is essential all connecting members be joined as flexibly as possible using Mackay flexible couplings and flexible joints.



Selection
The main consideration is to select the isolator to carry the load as shown in the load rating charts, giving preference to the top end of the ratings, and then choosing the one to suit your specific fitting requirements. Mackay isolators have each been engineered to specific requirements of deflections under working conditions and providing the disturbing or forced frequencies above 15Hz, selection is simple.

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ACTROL

Noise and Vibration

Low Frequency Selection

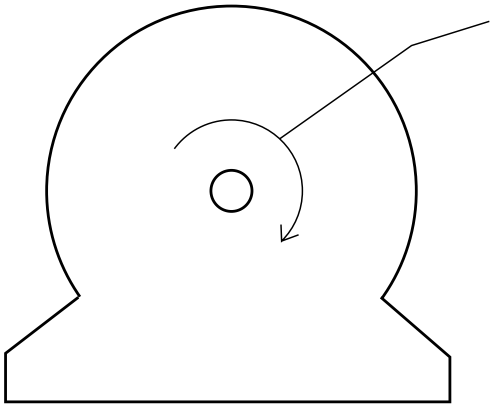
When frequencies under 15Hz are encountered or when there are HEAVY impact loads imposed on the isolator, consult with Mackay's technical division for advice. For normal purposes, the disturbing frequency can be considered as the revolutions per second of the offending item:

i.e. $\frac{\text{R.P.M}}{60}$

Multi-cylinder Engines

In multi-cylinder engines it is usually the number of working impulses per revolution which constitutes the disturbing frequency.

e.g. Two cylinder engine direct drive operating at 2500 r.p.m. = Disturbing Frequency of 83 Hz.b

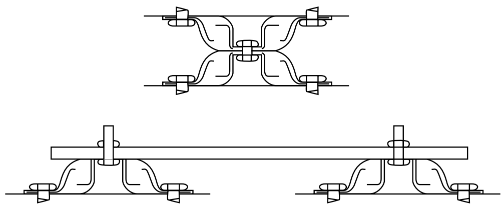


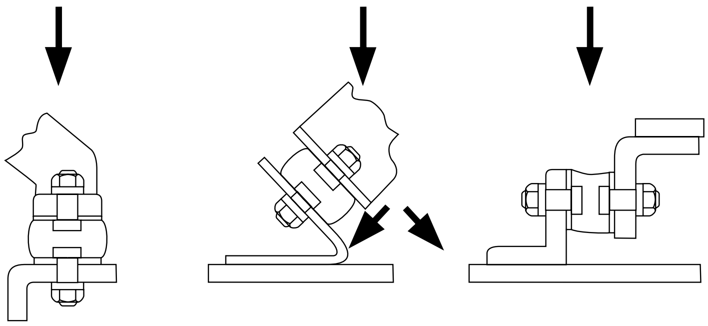
$= \frac{\text{RPM}}{60}$ Hz

$\frac{2500}{60} \times 2 = 83\text{Hz}$

Series and Parallel Assemblies

The isolation efficiency of low disturbing frequencies can be increased by using two isolators in series. This effectively doubles the deflection obtained with one isolator of the same load carrying capacity - by placing them in parallel, you double the load rating at the same deflection.





Calculating Deflections

If the isolator selected has a higher load carrying rating than required, the deflection of your actual loading can be calculated approximately by using this formula:

$$\frac{\text{Rated Deflection x Actual Load}}{\text{Rated Load}}$$

and then referring to the graph illustrated on the next page, the isolation efficiency can be ascertained (should always exceed 70% under normal operating conditions).

Disturbing Frequencies and Deflections

The graph illustrates the percentage of vibration isolation that is possible to obtain for simple linear vibration in a resiliently mounted assembly with various combinations of static deflection and disturbing frequencies.

The area (shaded) below the resonance line indicates the region of magnification of the vibration that occurs when the ratio of he disturbing frequency to the natural frequency of the mounted assembly is less than the square root of 2. The area above the resonance line shows the percentage of the vibratory forces that are prevented from reaching the supporting structure when correct isolators are selected. For example; with a disturbing frequency of 5Hz and a deflection of 30mm you will obtain an isolating efficiency of 50%, while with a deflection of 3mm your vibration will magnify by a factor of 1.5.

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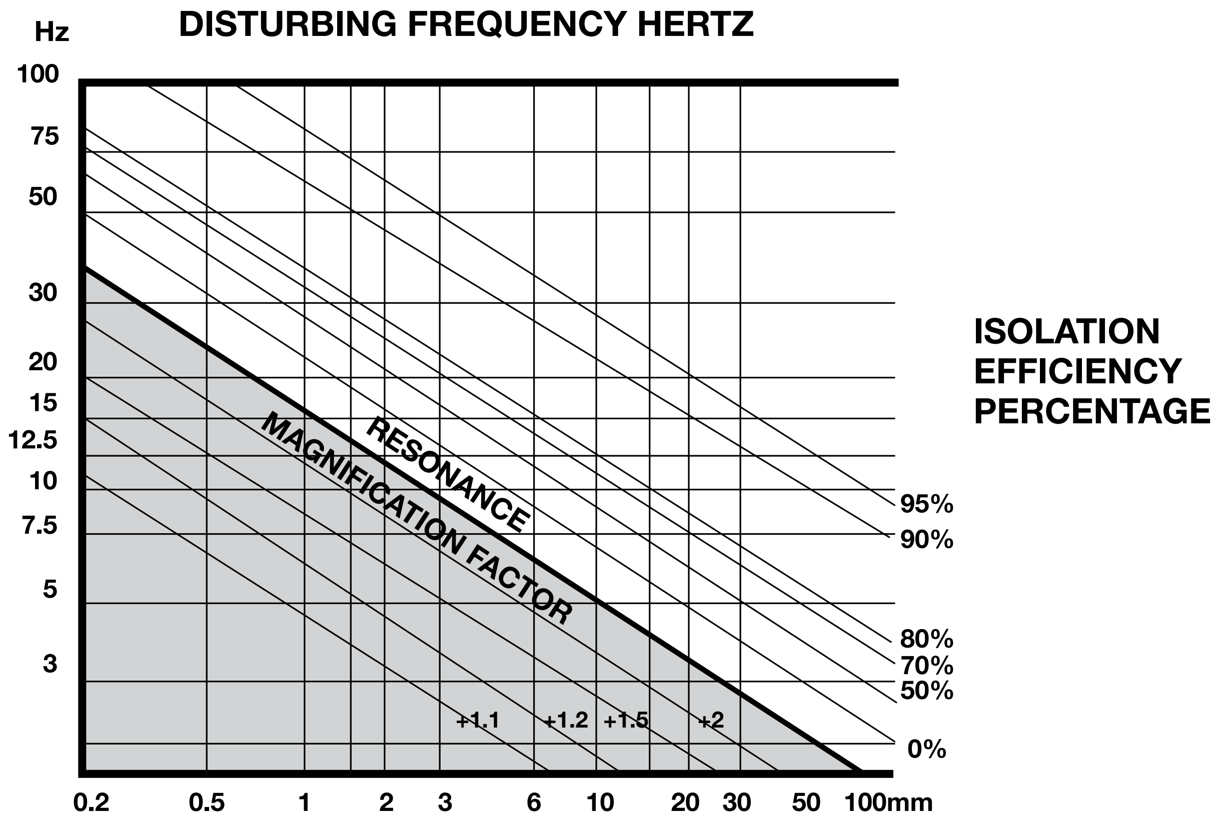


To assist you in selecting the correct isolator from the Mackay range we have listed the isolation efficiency that should be used under normal conditions of operation. The isolation efficiency at any given deflection and disturbing frequencies can be obtained by using the simple graph above.

Suggested Isolation Efficiency Guide			
	Factories, Schools, Dept. Stores Isolation Efficiency		Hospitals, Theatres, Libraries Isolation Efficiency
Air Handling Units		80%	94%
Axial Flow Fans	Up to 8kW 8kW to 38kW More than 38kW	70% 75% 80%	90% 94% 96%
Centrifugal Compressors		94%	99.5%
Centrifugal Fans	Up to 4kW 4kW to 18kW More than 18kW	70% 80% 90%	94% 96% 98%
Fan Coil Units	Hung Supported	80% 90%	90% 96%
Pipes	Hung	70%	90%
Pumps	Up to 2 kW 2kW to 4kW More than 4kW	70% 80% 90%	94% 96% 98%
Reciprocating Compressors	Up to 8kW 8kW to 38kW More than 38kW	70% 80% 90%	94% 96% 98%
Unit Air Conditioners	Hung Supported	80% 90%	90% 96%

Courtesy of Mackay Consolidated Industries Pty Ltd

Noise and Vibration

Sound, Noise and Refrigeration Equipment

Sound is vital in everyday life for communication, safety and enjoyment. Noise is usually defined as unwanted sound, and this includes noise from mechanical plant such as refrigeration equipment, air conditioners, pumps and various other items of equipment.

The type and location of equipment can influence the noise impact and annoyance to owners, adjacent properties and neighbours.

This brochure is a guide to some of the DO's and DON'T's and helps explain the noise impact of refrigeration equipment installations. This brochure is a guide only and advice should be sought from a qualified acoustic consultant for more detailed advice and assessments.

Noise Limits and Regulations

The acceptable or allowable noise limits from refrigeration and other equipment from one property to a neighbouring property is generally enforced by local councils or police based on State or Territory legislation. The Reference List at the end of this brochure is a starting point for identifying the appropriate noise legislation for each State and Territory.

The guideline limits may depend on the zoning of the surrounding area, whether the noise is intermittent or tonal, time of day etc. A typical requirement is that the equipment noise should not exceed the background noise by more than 5 dBA. In most cases nuisance and annoyance may be avoided if a noise goal of 35 to 40 dBA at the boundary is achieved.

Item	Typical Sound Pressure Level (dBA)	Subjective Evaluation
Threshold of Pain	130	Intolerable
Heavy Rock Concert / Grinding on Steel / Ambulance Sirens / Chainsaw	110 - 120	Extremely Noisy
Loud Car Horn / Jackhammer / Construction Site with Pnematic Hammering	90 - 100	Very Noisy
Curbside of a Busy Street / Loud Radio or TV / Lawn Mower / Electric Drill	70 -80	Loud
Normal Conversation / Department Store / General Office	50 - 60	Moderate to Quiet
Inside a Private Office / Inside a Quiet House	30 - 40	Quiet to Very Quiet
Unoccupied Recording Studio / Quiet Day in the Country	20	Almost Silent
Threshold of Hearing	0	Completely Silent

Measurement of Sound - the dBA

The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure which the ear responds to is ten million times greater than the softest. In order to simplify and reduce such a large range, a logarithmic scale, called the decibel, or dBA is used.

The human ear also responds differently to the frequency of sound. For example, the human ear is more sensitive at mid frequencies (500 to 1000 Hz), and less sensitive at very high and very low frequencies, hence, sound level meters incorporate a filter which approximately corresponds to that of human hearing. This filter is the 'A-Weighted' filter.

So the 'dBA' or 'dB(A)' is the A-Weighted sound level in decibels. This is the most commonly used measurement parameter for sound.

Sound Pressure Level (SPL) and Sound Power Level (SWL)

Refrigeration equipment and items of plant sometimes have a label displaying the total Sound Power Level (referred to as SWL or Lw), or the Sound Pressure Level (referred to as SPL or Lp), in dBA. If the equipment does not have a label indicating the noise level then the supplier should be able to provide this data.

The SPL or SWL indicate how noisy the equipment is, the lower the number, the quieter the equipment.

The SWL is a measure of how much acoustic power is produced by the equipment. The SPL is the resulting noise level from the operation of the equipment. The SPL depends on the location of the sound source, how many reflecting surfaces are nearby (how reverberant the space is) and the distance between the equipment and the receiver.

The SWL is an intrinsic property of the equipment where as the SPL depends on the SWL and the environment. For example, the SWL maybe thought of as the Watts of a light bulb, while the SPL is similar to the overall brightness - it depends on the environment (e.g. size of room, colour of walls) as well as the power of the light bulb.

Generally, the SPL is lower than the SWL. In a 'Free Field' with no reflecting surfaces such as walls nearby, the SPL is approximately 8 dBA lower than the SWL at one metre from the equipment (assuming source is on a hard surface).

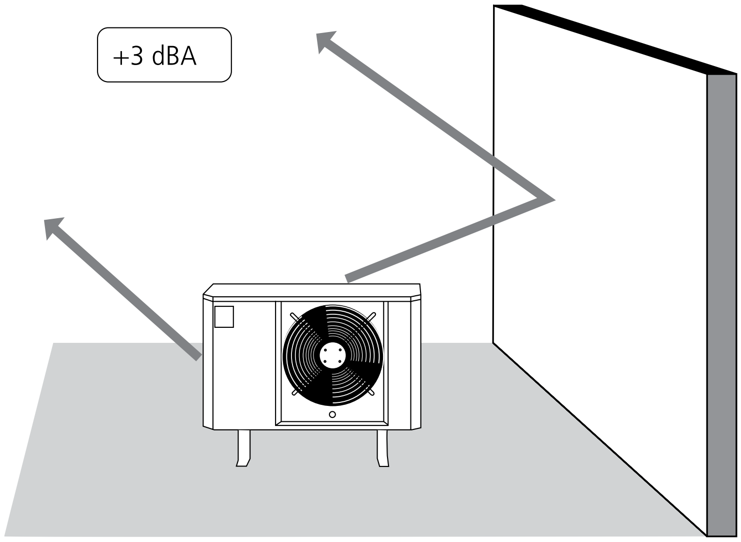
Reduction of Sound Pressure Level (SPL)									
Distance (m)	1	2	3	4	5	6	7	8	10
Reduction (dBA)	8	14	17	20	22	23	25	26	28

Noise and Vibration

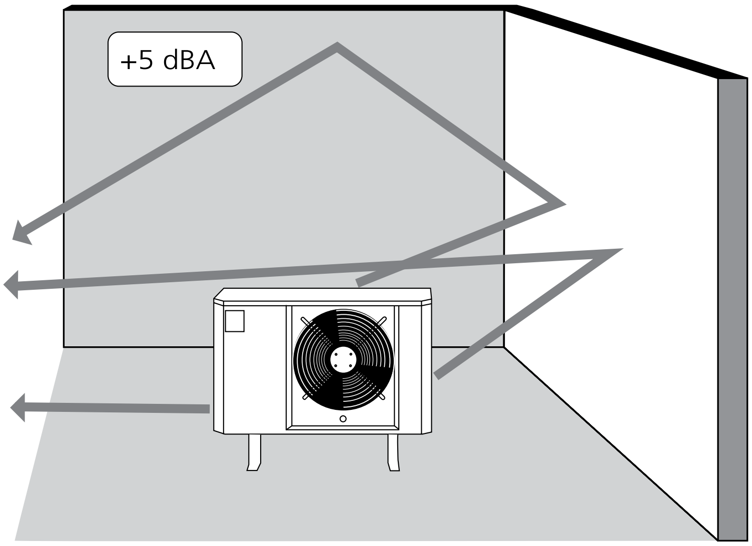
Sound Pressure Level and Reflective Surfaces

Reflective surfaces such as walls or a ceiling near the noise source can increase the resulting Sound Pressure Level (SPL). The following diagrams illustrate the effect of reflective surfaces.

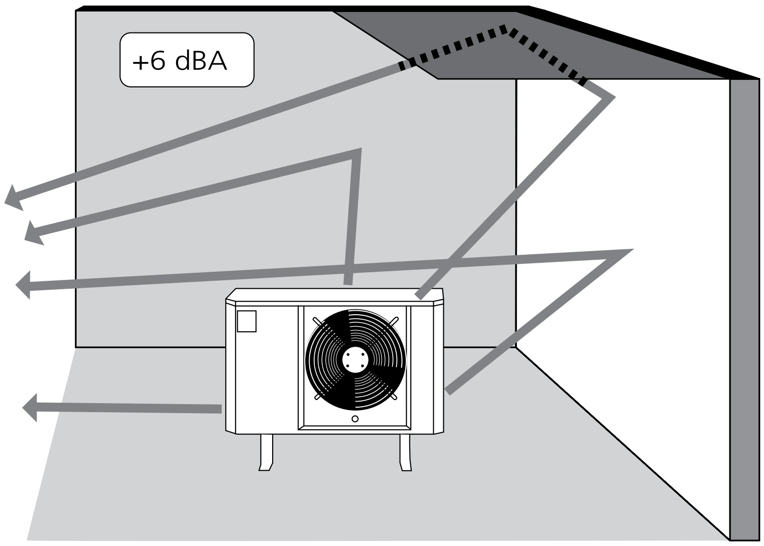
+3 dBA if unit is within 3 metres of 1 wall/ceiling



+5 dBA if unit is within 3 metres of 2 walls/ceiling



+6 dBA if unit is within 3 metres of 3 walls/ceiling



Noise and Vibration

Addition of dB Levels

The decibel scale is a logarithmic scale so 2 + 2 does not equal 4. A doubling of the sound pressure levels results in an increase of 3 dBA. The following table shows the result of adding two SPL's or SWL's together. The first column shows the difference between the two SPL's and the second column shows resulting dBA increase - the level that should be added to the higher of the two SPL's to obtain your result.

Example: Two units both at 50 dBA. The difference is zero, so 3 dBA is added to the noisier unit (either one in this case) to give an overall noise level of 53 dBA.

Example: One unit is 50 dBA, the other is 46 dBA. The difference is 4 dBA - the table says you should add 1.5 dBA to the noiser unit - so the overall level is 51.5 dBA.

As you can see, because the addition of dBA levels is logarithmic, the level may not increase very much but it is always controlled by the noisier item of equipment - the best approach is to use the quietest equipment possible to begin with!

Difference between SPL's (dB)	Result - amount to add to the higher SPL
0	3
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1
7	0.8
8	0.6
9	0.5
10	0.4

Vibration

Vibration from plant and equipment may result in regenerated noise and you could end up with more noise than you expected. In addition, the vibration may adversely affect the owner / user of the equipment.
The vibration from the equipment may be transmitted through various support structures and end up in a lightweight structure which could radiate noise.

The following provides some guidance with regard to vibration control:

- Use at least 1 layer of waffle pad, not less than 8mm thick, under equipment in all areas
- Ensure that the waffle pad is not bypassed by a rigid connection. The units should be sitting on the waffle pad under their own weight, not bolted to the structure through the pad. If the unit must be bolted then ensure that a rubber isolating washer and sleeve is used.
- Install equipment on a concrete slab at ground level if possible
- Install equipment on a platform above lightweight structures if possible
- Do not locate equipment above particularly sensitive spaces (e.g. bedrooms or private offices in commercial situations), also try to keep the equipment as far away as possible from all adjacent receivers.
- When units are installed on a lightweight structure or over (or near) a sensitive area, the use of waffle rubber may not be sufficient - consider a double thickness of rubber pads or the use of springs. It is best to obtain professional advice in this situation as the extent of vibration isolation required depends on a number of factors such as the rpm of the equipment, the weight of the equipment, the structure construction etc.

Noise and Vibration

Barriers

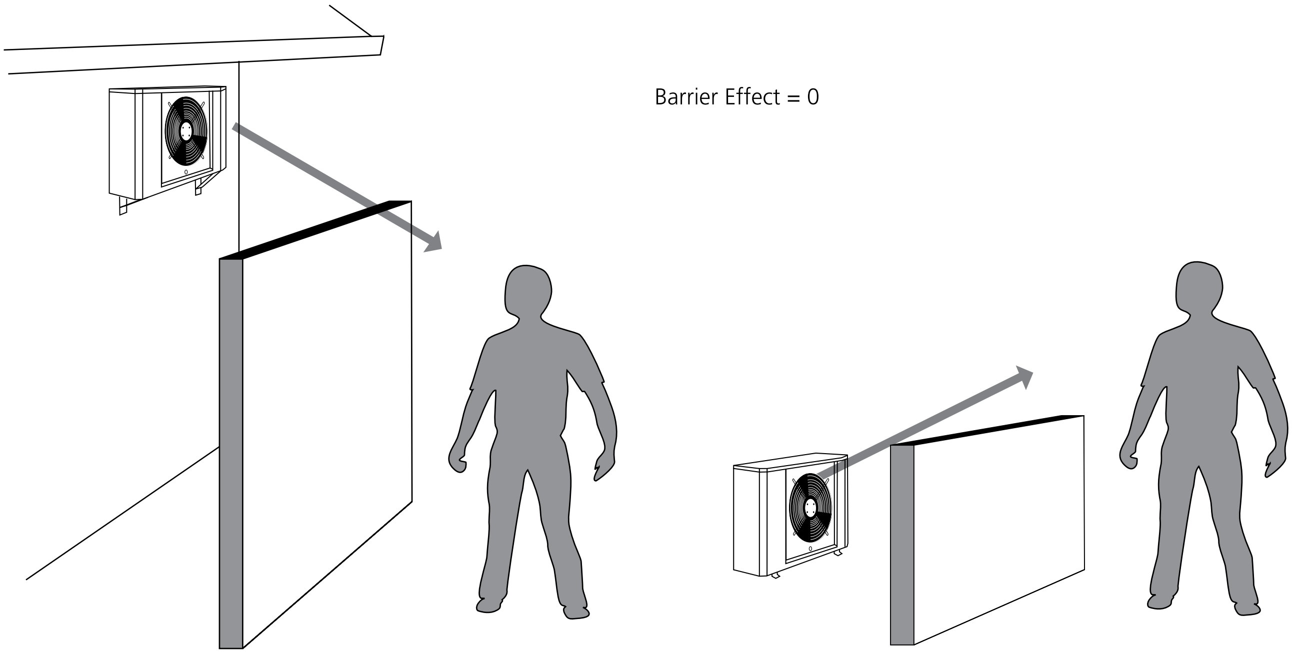
Barriers can be an effective method for reducing noise, however, the barrier must be a solid material with no gaps or penetrations. The material should have a surface density of not less than 5 kg/m.

Effective Barriers

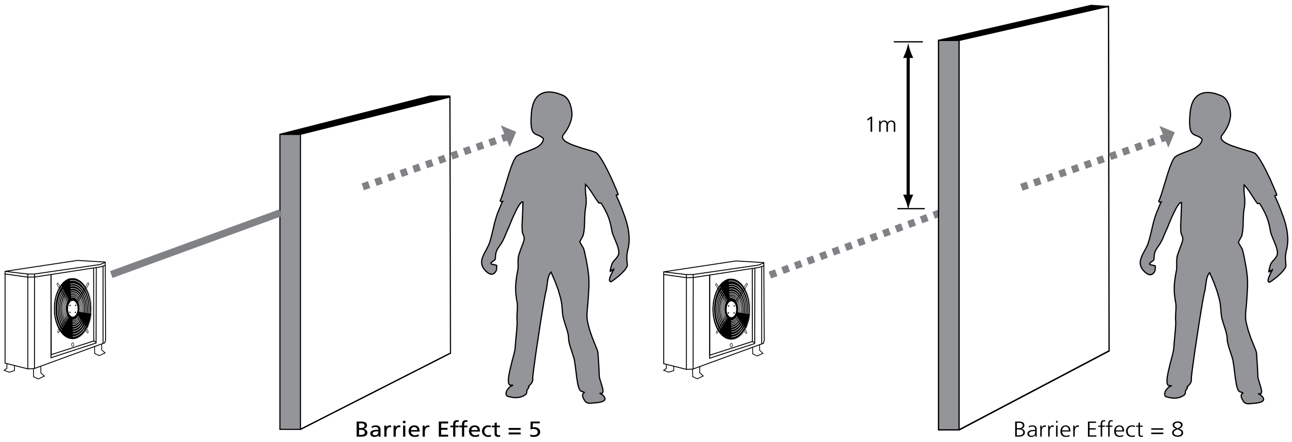
- Solid timber fence (e.g. double lapped fence)
- Solid masonry fence (brick, concrete block, aerated concrete)
- Solid colourbond, sheetmetal, or corrugated iron fence
- Other solid material (e.g. plywood, cement sheet, particleboard)

Ineffective Barriers

- Trees, bushes or shrubs
- Fences with holes in them (e.g. missing planks, decorative openings, picket fences, lattices etc.)



A barrier, even an effective barrier, can only work if it screens the noise source from the receiver. If the barrier is too short and the receiver can see the noise source, then the Barrier Effect is insignificant. If the barrier screens the line of sight so the receiver cannot see the noise source then the Barrier Effect is approximately 5 dBA. If the barrier is very high (e.g. higher than 1m above the line of sight) then the Barrier Effect is 8 dBA.



Noise and Vibration

A Guide to Calculating Noise Levels

Step 1 - SWL of Unit
Enter the sound Power Level (SWL) of the proposed equipment at the top of the table.

Step 2 - Distance Factor
Determine the shortest distance between the location of the proposed unit and the receiver position (e.g. neighbour). For simplicity the distance between the unit and the boundary may be acceptable. Circle the corresponding Distance Factor in Column 1.

Step 3 - Barrier Effect
Determine the type of barrier - if any between the proposed unit and the receiver position. Check the section on ‘Barriers’ to determine the situation you have. Remember that an ‘Ineffective Barrier’ is one where there is no barrier or the barrier or fence has holes in it which allows the noise to pass through it (e.g. picket fences, missing planks, decorative openings etc.). Circle the corresponding Barrier Factor in Column 2.

Step 4 - Reflection Factor
Determine the number of reflective surfaces that are within 3 metres of the proposed unit, such as walls and large eaves (do not include the ground). Circle the corresponding Reflection Factor in Column 3.

Step 5 - Resultant Noise Level
Determine the estimated Resultant Noise Level by:

Sound Power Level (SWL) of Proposed Unit - dBA [ ] dBA

Column 1	
Shortest straight line distance from Unit to Receiver position: m	Distance factor
1	8
2	14
3	17
4	20
5	22
6	23
7	25
8	26
10	28

Column 2	
Barrier	Barrier Effect
Ineffective Barrier	0
Effective Barrier	
Line of sight to unit not blocked	0
Blocks line of sight to unit	5
High barrier blocks line of sight of unit by more than 1m	8

Column 3	
Reflection	Reflection Factor
No reflecting surfaces within 3m	0
One reflecting surface within 3m (one wall)	3
Two reflecting surfaces within 3m (two walls)	5
Three reflecting surfaces within 3m (two walls and large eaves)	6
	6

[ ] SWL - [ ] Distance factor - [ ] Barrier Effect + [ ] Reflection Factor

= Resultant Sound Pressure Level (SPL) [ ]

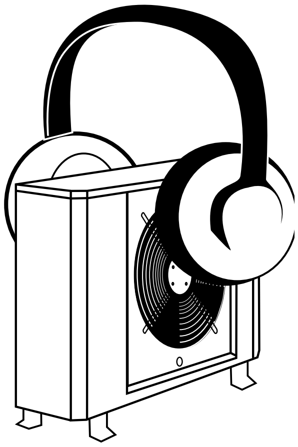
Noise and Vibration

Do's and Don'ts

As you can see from the Guide to Calculating Noise Levels, one of the most important factors is the Sound Power Level (SWL) of the proposed unit.

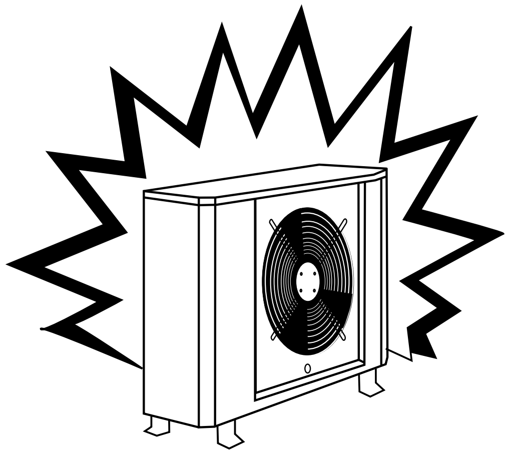
DO

Use the quietest unit to begin with - it may be the difference between an acceptable or unacceptable noise level for a given location.



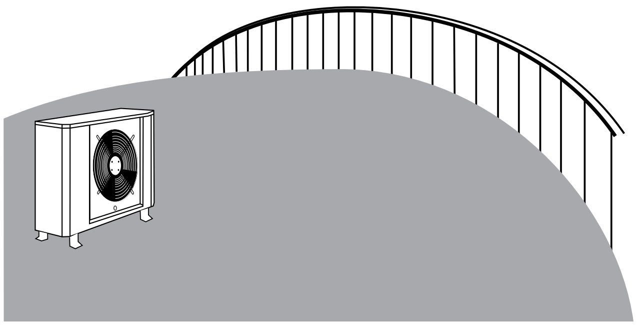
DON'T

Don't necessarily use the cheapest unit - it may be the noisiest - check the SWL.



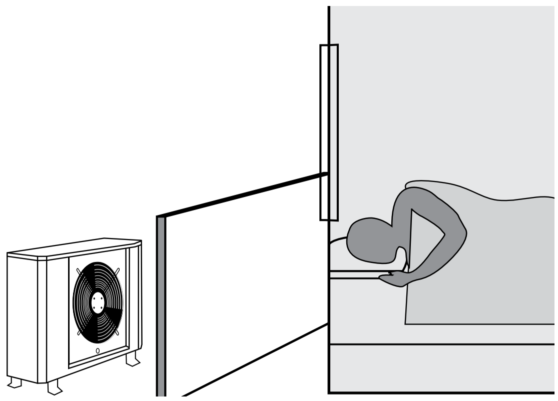
DO

Install the unit as far from the boundary as possible - the further it is from neighbours, the lower the noise level. Place the unit facing the back fence or the furthest fence if possible.



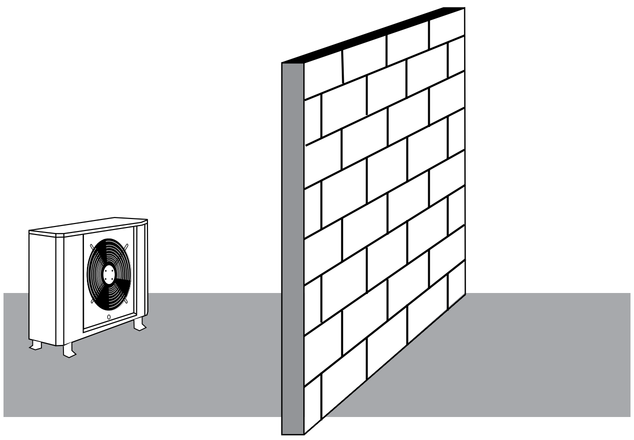
DON'T

Don't install the unit near a boundary, especially if it is near a window or worst of all - near a bedroom window!



DO

Make sure that any fences or barriers are Effective Barriers, with no holes, gaps or missing planks.



DON'T

Don't assume any tree or bush is an Effective Barrier - it is not and it won't provide any protection from the noise.

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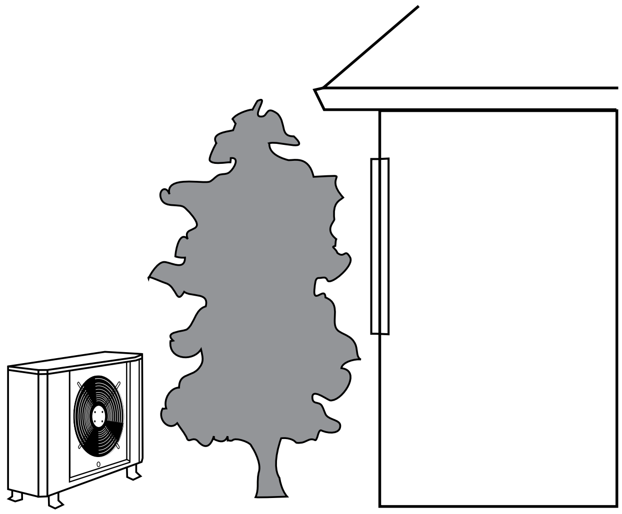
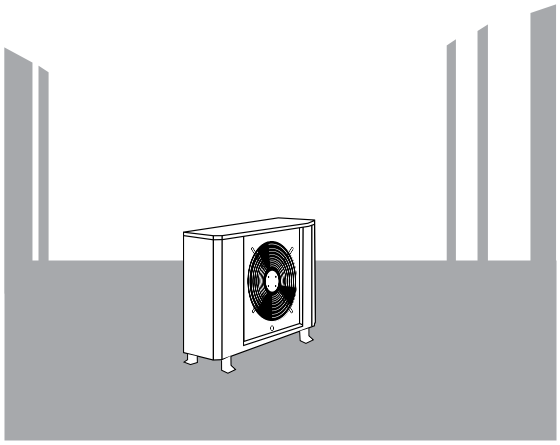
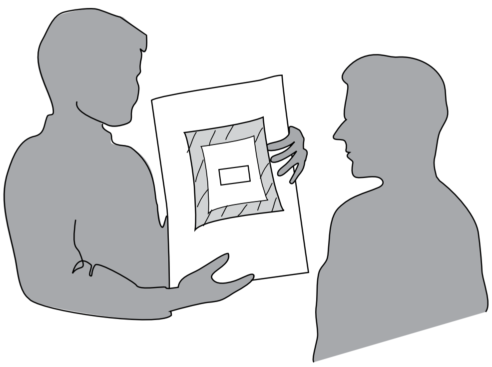


Noise and Vibration

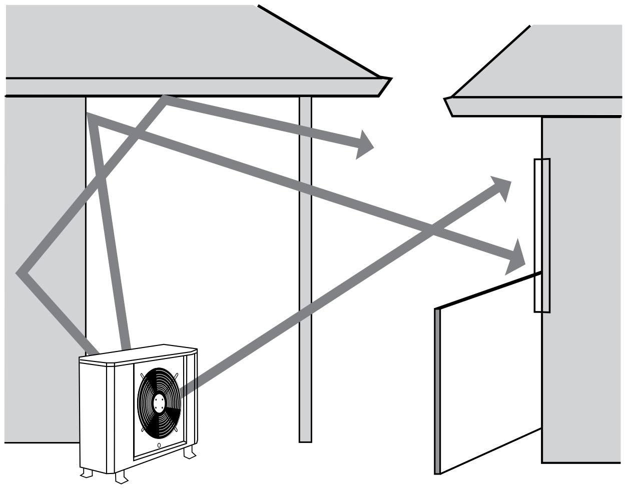
DO
Try and locate the unit away from any reflecting surfaces.



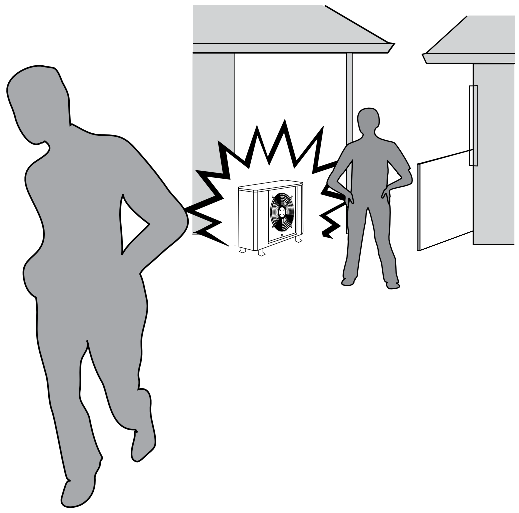
DO
Ask for acoustic advice from a professional qualified acoustic consultant. Even if the expected noise level is too high a consultant will be able to design an enclosure or advise on how to reduce the noise level.



DON'T
Don't place the unit near corners or in very reverberant spaces such as carports or alcoves.



DON'T
Don't assume the problem will go away - it won't. Act now before it is a problem and you will have a happy client, not an ongoing and possibly expensive complaint.



State Acts, Regulations and Guidelines

The following Acts, Regulations and Guidelines are applicable for the respective States and Territories, but may not be limited to these.

If a detailed assessment is required or the expected noise level is excessive, you should consult a qualified Acoustic Consultant.

New South Wales:
Protection of the Environment Operations (Noise Control) Regulations 2000 (Section 52)
Noise Control (Miscellaneous Articles) Regulation 1995

Victoria:
Environment Protection (Residential Noise) Regulations 1997

Queensland:
Environment Protection (Noise) Policy 1997
Environment Protection Act 1994
Environment Protection Regulation 1998

South Australia:
Environment Protection (Machine Noise) Policy 1994
Environment Protection Act 1995

Western Australia:
Environment Protection (Noise) Regulations 1997
Environment Protection Act 1986
Noise Abatement (Noise Labeling of Equipment) Regulations (No. 2) 1985

Tasmania:
Environment Protection (Noise) Amendment Regulations 2000, Statutory Rules 2000, No. 186

Australian Capital Territory:
Environment Protection Policy 1998 (Noise)
Environment Protection Act 2000

Field Service Instructions for Reversing Valves

These Field Service Instructions will aid recognition of a malfunctioning Heat Pump System equipped with a reversing valve

Field Problems Simplified

Heat pump equipment usually includes a reversing valve (added to a refrigerating system to create an "all season" heat pump) which is easily identified and blamed for many failures of the system. Valves have been needlessly replaced without correcting the original trouble in the system, principally due to inadequate testing and erroneous quick decisions.
A tabulated chart follows these instructions on Valve troubles which are so listed to be quickly analysed by "Touch" testing for "possible causes" with suggested "corrections", to simplify testing procedures and cut testing time.

Operation of the Valve

The Solenoid Coil on the 3-WAY PILOT VALVE forces the needles of the pilot valve to OPEN and CLOSE two port openings at the INSTANT of reversing operations for the 4-WAY MAIN VALVE.

Operating Sequence

1. An ENERGISED COIL (in the heating phase) forces two opposing pilot valve needles, "back needle" and "plunger needle", separated with stainless steel pins, to simultaneously CLOSE the "back" port and to KEEP OPEN the "front" port.

Notes:

(a) The "outlet" port is the center bleeder tube (called "common capillary") which is brazed into the suction line tube and is a common bleed path for each outside port ("front" and "back" capillaries).
(b) The "inlet" tubes, called "back" and "front capillary" and each from its pilot port, are operating paths to the opposite end chambers of the main valve cylinder. These paths conduct the gas which bleeds through a monel screen from "bleeder holes" located in each piston as gas pressure changes occur within the end chambers.

2. Gas flows out of the RIGHT end chamber, decreasing in pressure there. High pressure gas from the system immediately builds up within the LEFT end chamber since no path is open for escape which was first closed by the needle valve at the pilot "back port".
Note: At the end of each stroke, one of the operating gas paths is closed to the pilot valve.

3. Difference in pressures between the two end chambers aids the "slide bracket" assembly to move instantly to the RIGHT by the pistons from the pressure differential of the system.

Note:

In reversing operation, the "slide" port straddles one or the other of two openings (in section views "E" and "C" tubing schematically piped through the illustrated circled figures 3 and 4 respectively) as directed. The "suction tube" between "E" and "C" is always OPEN to the low pressure side of the system.

4. While in and during the operating phase of heating, both end chambers EQUALISE in pressure until the "solenoid coil" is DE-ENERGISED (into cooling or deicing phase) when the opposite operation in reversing takes place within the PILOT and MAIN VALVES.

Notes:

(a) During the transfer period, there is sufficient by-pass to prevent overloading the compressor due to an excessive head pressure.
(b) The valve reverses against running pressures with no mechanical or impact noises from the "slide", "slide bracket" or pistons; however, there is an instant of hissing gas as pressures equalise in both end chambers.

System troubles that affect the reversing valve

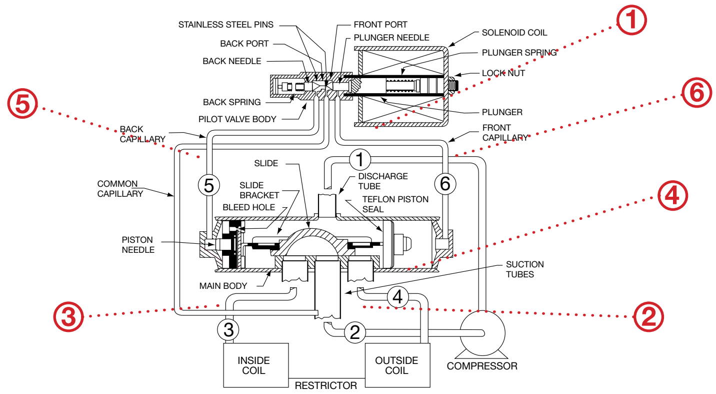
Any trouble in a heat pump, which will materially affect the normal operating pressures, may prevent the valve from shifting properly.
For example, (1) a leak in the system resulting in a loss of charge, (2) a compressor which is not pumping properly, (3) a leaking check valve, (4) defective electrical system or (5) mechanical damage to the valve itself, each will indicate an apparent malfunction of the valve.
Make the following checks on the system and its components before attempting to diagnose any valve trouble by making the "Touch Test" method of analysis.

1. Make a physical inspection of the valve and solenoid coil for dents, deep cratches and cracks.

2. Check the electrical system. This is readily done by having the electrical system in operation so that the solenoid coil is energised.
In this condition, remove the lock nut to free the solenoid coil. Slide it partly off the stem and notice a magnetic force attempting to hold the coil in its normal position. By moving the coil farther off the stem, a clicking noise will indicate the return of the "plinger" to its non-energised position. When returning the coil to its normal position on the stem, another clicking noise indicates that the "plunger" responded to the energised coil. If these conditions have not been satisfied, other components of the electrical system are to be checked for possible trouble.

3. Check the heat pump refrigeration system for proper operation as recommended by the manufacturer of the equipment. After all of the previous inspections and checks have been made and determined correct, then perform the "Touch Test" on the reversing valve according to chart on the following page. This test is simply performed by feeling the temperature relationships of the six (6) tubes on the valve and compare the temperature differences. Refer to the chart after the comparative temperatures have been determined for the "possible cause" and suggested "corrective action" to be taken.

Touch Test Chart



Valve Operating Condition	Disch. Tube Compr. 1	Suction Tube to Compr. 2	Tube to Inside Coil 3	Tube to Outside Coil 4	LEFT Pilot Back Capill. Tube 5	Right Pilot Back Capill. Tube 6	Possible Causes	Corrections
Normal Operation of Valve								
Normal Cooling	Hot	Cool	Cool as (2)	Hot at (1)	*TVB	*TVB		
Normal Heating			Hot as (1)	Cool at (2)				
Malfunction of Valve								
Valve will not shift from Cool to Heat	Check electrical circuit and coil						No voltage to coil	Repair electrical circuit
							Defective coil	Replace coil
	Check refrigeration charge						Low charge	Repair leak, recharge system
							Pressure differential too high	Recheck system.
	Hot	Cool	Cool as (2)	Hot as (1)	*TVB	Hot	Pilot valve OK. Dirt in one bleeder hole	De-energise solenoid, raise head pressure, re-energise solenoid to break dirt loose. If unsuccessful, remove valve, wash out. Check on air before installing. If no movement, replace valve, add strainer to discharge tube, mount valve horizontally
							Piston cup leak	Stop unit. After pressures equalise, restart with solenoid energized. If valve shifts, re-attempt with compressor running. If still no shift, replace valve
						*TVB	Clogged pilot tubes	Raise head pressure, operate solenoid to free. If still no shift, replace valve
					Hot	Hot	Both ports of pilot open. (Back seat port did not close)	Raise head pressure, operate solenoid to free partially clogged port. If still no shift, replace valve
	Warm			Warm as (1)	*TVB	Warm	Defective Compressor	
Start to shift but does not complete reversal	Hot	Warm	Warm	Hot	*TVB	Hot	Not enough pressure differential at start of stroke or not enough flow to maintain pressure differential	Check unit for correct operating pressures and charge. Raise head pressure. If no shift, use valve with smaller ports
							Body damage	Replace valve
					Hot		Both ports of Pilot open	Raise head pressure, operate solenoid. If no shift, replace valve
		Hot	Hot	Hot	*TVB		Body damage	Replace valve
							Valve hung up at mid-stroke. Pumping volume of compressor not sufficient to maintain reversal	Raise head pressure, operate solenoid. If no shift, use valve with smaller ports.
					Hot		Both ports of Pilot open	Raise head pressure, operate solenoid. If no shift, replace valve.
Apparent leak in heating	Hot	Cool	Hot as (1)	Cool as (2)	*TVB	*WVB	Piston needle on end of slide leaking	Operate valve several times then recheck. If excessive lek, replace valve.
					*WVB		Pilot needle and piston needle leaking	Operate valve several times then recheck. If excessive leak, replace valve.
Will not shift from heat to cool	Hot	Cool	Hot as (1)	Cool as (2)	*TVB	*TVB	Pressure differential too high	Stop unit. Will reverse during equalization period. Recheck system.
							Clogged Pilot tube	Raise head pressure, operate solenoid to free dirt. If still no shift, replace valve.
					Hot		Dirt in bleeder hole	Raise head pressure, operate solenoid. Remove valve and wash out. Check on air before reinstalling if no movement, replace valve. Add strainer to discharge tube. Mount valve horizontally.
							Piston cup leak	Stop unit, after pressures equalise, restart with solenoid de-energised. If valve shifts, re-attempt with compressor running. If it still will not reverse while running, replace valve.
						Hot	Defective Pilot	Replace Valve
	Warm		Warm as (1)		Warm	*TVB	Defective Compressor	

NOTES: *Temperature of Valve Body. **Warmer than Valve Body.

VALVE OPERATED SATISFACTORILY PRIOR TO COMPRESSOR MOTOR BURN OUT - caused by dirt and small greasy particles inside the valve.

To CORRECT: Remove valve, thoroughly wash it out. Check on air before reinstalling, or replace valve. Add strainer and filter-dryer to discharge tube between valve and compressor.

Air Filter Selection & Service Guide

Introduction

This guide provides practical information to building owners, managers and consultants with the selection and application of air filters in commercial, retail, institutional and industrial buildings. In addition, it will assist OH&S administrators meet work place safety laws by ensuring air cleaning standards are maintained within their facilities.

The level of air cleaning required in a building will vary depending on the occupants and/or process needs. Schools, office buildings and shopping centres protect occupants, retail goods and architectural features. Of most concern to building owners today is OH&S risk minimisation. Atmospheric contaminants are identified in OHS Regulation 2001 as a health hazard so ensuring appropriate filtration standards are applied is critical. Finally, maintaining clean air handling plant and heat exchangers will ensure ongoing energy costs are kept to a minimum.

Effects of airborne particles

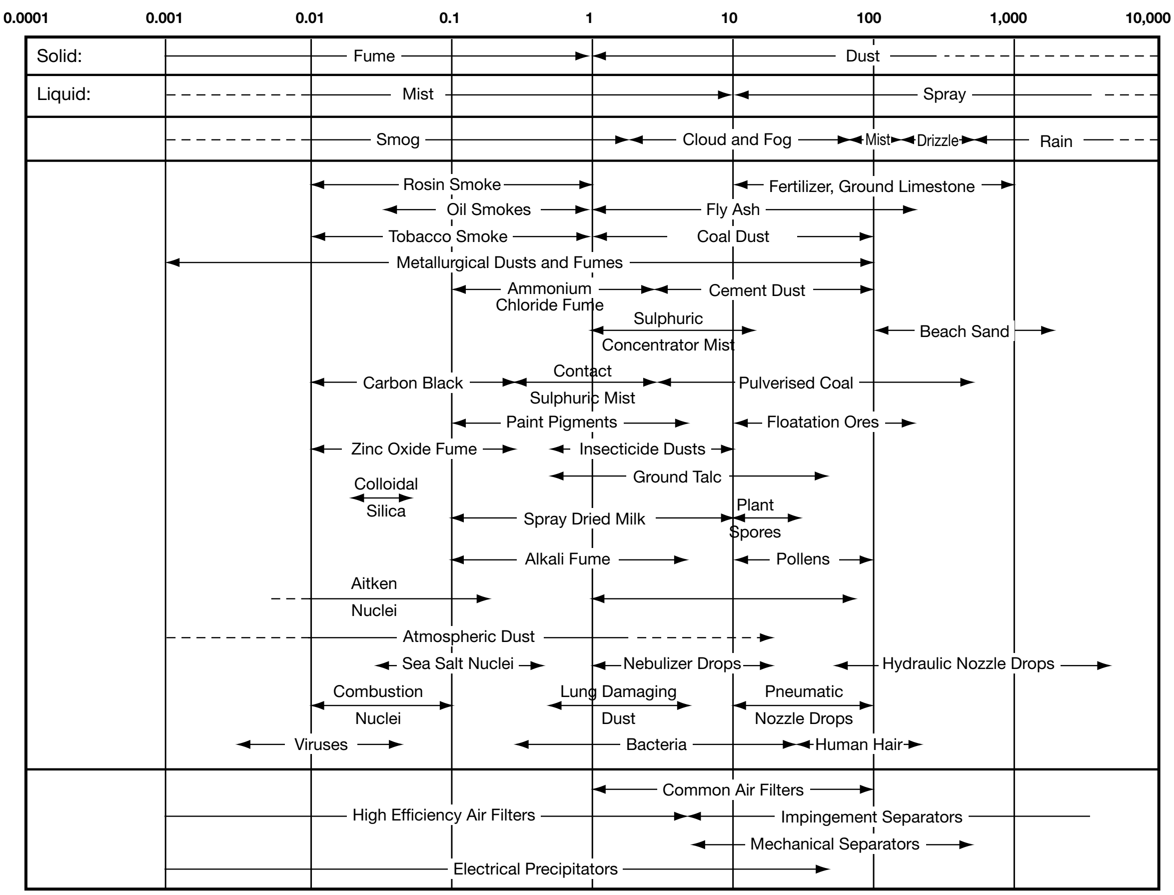
Health effects resulting from poor indoor air quality vary with individual cases, however minimising the levels of airborne particulates will minimise the risk to health. Some well known ailments exacerbated by poor air quality include itchy and watery eyes, sneezing, itchy throat, wheezing, asthma, as well as the spread of infections such as influenza, colds, measles and mumps. Reducing the number of airborne particles through the use of high efficiency air filtration will minimise this risk.

Poor air filtration will also affect the ventilation system itself. High levels of dust contamination will lead to increased duct cleaning costs, increase the risk of corrosion and accelerate refurbishment costs to architectural features. Poor air filtration also reduces heat exchanger efficiency resulting in higher energy inputs and therefore greater operating costs.

What's in the Air?

Solid particles of soot, carbon matter, ashes, earth, sand and silica materials, fibres, road dirt and other animal, vegetable and mineral substances. Mould spores, bacteria, viruses, pollens and Volatile Organic Compounds may also be present. Some of these substances are known carcinogens and asthma triggers.2

LOGARITHMIC SCALE OF PARTICLE DIAMETRES
IN MICRONS



1 This guide does not deal with the removal of odours and gaseous substances or high volume product dust from industrial processes, which require specialised equipment.
2 The Australian Institute of Refrigeration Air-Conditioning & Heating – Air Filters Application Manual.

Information courtesy of AREMA

Air Filter Selection & Service Guide

Air Filter Standards

As a general guide, Australian Standards are useful information tools that provide minimum performance standards. Care should be taken when applying minimum standards that may not adequately service the air quality needs of the building.

Relevant Australian standards and specifications commonly referred to are:

- AS1324 (Air Filters for use in general ventilation and air-conditioning)
- AS1668 (The use of mechanical ventilation and air-conditioning in buildings), and
- AS3666 (Air Handling and Water Systems of Buildings)

Filter Classification - Performance Ratings

The following performance table is commonly used internationally. It classifies the filter by efficiency from test results carried out in an appropriate air filter-testing laboratory. The following table is found in AS1324 Part 1.2001

For most air-handling and air conditioning applications, testing with Test Dusts No.1 and No.4 is to be used to define the performance of an air filter. These test requirements are consistent with tests carried out to US and European standards ASHRAE 52.1 and EN779.

The benefit of using No.1 dust is to determine the efficiency of the air filter to catch particles of submicrometre nature. The benefit of No.4 dust is to evaluate the arrestance and likely service life of an air filter. ASHRAE 52.2 Removal Efficiency by Particle Size standard provides a useful method of evaluating filtering applications given the particle size of the contaminant.

Air Filter Selection Chart

Filter Class	Average Arrestance AS1324.2 Dust No.4 ASHRAE 52.1 Eurovent 4/5 EN779 Gravimetric	Average Efficiency AS1324.2 Dust No.1 ASHRAE 52.1 Eurovent 4/5 EN779 Atmospheric	Maximum Final Resistance Pa
G1	A < 65		250
G2	65 ≤ A < 80		
G3	80 ≤ A < 90		
G4	90 ≤ A		
F5		40 ≤ E < 60	450
F6		60 ≤ E < 80	
F7		80 ≤ E < 90	
F8		90 ≤ E < 95	
F9		90 ≤ E	

*Note: Filters which are tested with a minimum efficiency of less than 20% shall only be rated as G type arrestance filters.

Air-handling systems with airflow rates equal to or greater than 1500l/s require air filtration with the following efficiencies:
- Test dust No. 1: 20% (minimum) @ 250Pa.
- Test dust No. 1: 20% to 40% (average) @ 250Pa.

AS1324 Filter Types
- Type 1 - Dry, eg. Woven or non-woven fabrics, which when unused feel dry.
- Type 2 - Viscous impingement, eg. Woven or non-woven oil or gel coated fabrics, including metalviscous filters.
- Type 3 - Electrostatic precipitators AS1324 Filter Classes
- Class A - Fully disposable (entire cell replaced, including frame)
- Class B - Reusable media (reusable frame)
- Class C - Reusable media and frame (after cleaning)
- Class D - Self-renewable (in respect of media advancement and cleaning)
  Example: Supply Type 1, Class B multi pocket bag filter.

Labelling

It is a requirement of AS1324 that all air filters are labelled with a filter performance rating together with the manufacturers/distributors details.

Testing

In order to ensure compliance to the filter performance rating of any product AS1324 recommended that all products are tested at least every five years and that the air filter media used be tested at least every year. No laboratory test older than five years should be accepted as proof of filter performance rating.

Filter Selection

The following table is the AREMA recommended filter classification for building grades to match Property Council of Australia 1999 Benchmarks Handbook. The table sets the benchmark air cleaning standard.

BOMA Grade*	A.R.E.M.A. Min. recommended filter classification
Premium	F7
A	
B	F6
C	F5
D	G4

* Property Council of Australia Benchmarks Handbook

Air Filter Selection & Service Guide

Information courtesy of AREMA

Filter Selection Steps

When selecting air filters using the above classification table, you should also consider:

- Air flow capacity of system
- Clean and final resistance of your filter system
- Arrestance dust holding capacity
- Filter life
- Comparison of filters should be made at the same final pressure drop ie 250, 375 or 450 pascals.

Other important considerations when selecting your air filter system include:

- Use of prefilters to extend final filter life
- Optimising the surface are of the filter system
- Access for filter replacement and routine service
- Suitability of filter materials and construction for conditions encountered

Installation

Filter banks should be sealed between filters and frames to prevent leakage and should be suitably stiffened to prevent flexing.

When filters are installed in a slide access, filter and service doors need to be sealed to prevent air leakage and fitted with sash clamp type catches.

General: Provide a permanent notice fixed to the wall identifying the filter type and performance rating.

Plinth: Where possible, provide a 100mm high plinth below the filter bank.

Manometers

Provide a measure of differential pressure across each filter bank. Differential pressure gauge unit - 100mm dial type diaphragm gauge including pipework, termination and fittings necessary for correct operation and maintenance.

Gauge scale - Mark in suitable divisions with full-scale deflection no more than twice the maximum dirty filter condition. Locate gauge outside unit casing in a readily readable location.

Maintenance

Servicing

- Ensure suitable and safe access is provided for air filter inspection & replacement
- All food preparation areas should be located away from filter service points
- Air conditioning plant located at height require Work Cover approved ladders, platforms and harness points.
- Only licensed companies with a registered waste water treatment facility are to service washable filters. A copy of the Trade Waste Agreement should be kept on file to mitigate off site liability under the Environment Operations Act 1997.

Cleaning

Before start-up, ensure that the installation is clean, and inspect filter banks and plenums to ensure integrity of the installation.

Temporary pre-filters

Remove temporary media at completion of commissioning.

Operation and maintenance manual

Each different filter bank should have an operation and maintenance manual which includes information on performance ratings, replacement filter part numbers and sizes.

Washing of Filters on Site

The Clean Waters Act (Part 4) prohibits anyone from washing a filter in a manner that could pollute a waterway. Filters can only be washed by someone who holds a licence to operate an approved washing facility. Many filter service companies are licenced and will remove the filters from site and wash them in their premises.

Electrical IP Ratings

The IP rating system is used to indicate the ingress protection level of electrical equipment against the intrusion of foreign bodies such as fingers, tools, dust and moisture.

The IP rating consists of two numbers, the first indicates protection from solid objects and the second protection from water.

Description of first number	1st Number
No special protection	0
Protection from objects > 50mm	1
Protection from objects < 80mm in length and 12mm diameter	2
Protection from objects > 2.5mm	3
Protection from objects > 1mm	4
Protection from an amount of dust that would interfere with the operation of the equipment	5
Protection from all dust	6
Description of second number	**2nd Number**
No special protection	0
Protection from vertically dripping water	1
Protection from dripping water when tilted up to 15°	2
Protection from sprayed water	3
Protection from splashed water	4
Protection from water projected from a nozzle	5
Protection against heavy seas or powerful jets of water	6
Protection against temporary immersion	7
Protection against complete continuous submersion in water of 1 metre depth for 15 minutes	8

E.g. An electrical component with an IP rating of IP56 has protection from an amount of dust that would interfere with the operation of the equipment and protection against heavy seas or powerful jets of water.

Selection of ***Cool Room/Freezer Equipment***

When requesting quotations for coolroom equiment, please supply the following information to assist Actrol Technical Staff to advise on the selection of suitable equipment for your particular application. Tick boxes where applicable. All * highlighted fields must be filled in before we can proceed.

*Date: ________ / ________ / ________

*Client: ______________________ *Phone No: ______________________

*Contact Name: ______________________ *Fax No: ______________________

Address: ______________________ Email: ______________________

Account No: ______________________

Product Details

*Product Type: ______________________ eg. Beef, Vegetables...

*Weight of Product Entering Room per Day ____________ kg Weight per 24 Hours

*Temperature of Entering Product ____________ °C

*Room Storage Temperature ____________ °C *Room Design Temperature*

Approximate Room Relative Humidity ____________ %RH *Usually Dictated by Product*

Product Pull Down Time Required ____________ Hours *Usually 24 Hours*

Room Location, Dimensions and Construction City/town ______________________

State ______________________

*Width ________ *Length ________ *Height ________ Internal ☐ External ☐

Construction Insulation Thickness and Type

*Walls ________ mm Polyurethane Polystyrene ☐

*Ceiling ________ mm

Floor *Concrete ________ mm *Insulation ________ mm Floor Heating ☐ None ☐

*Solid Door/s ________ Width ________ mm Height ________ mm

*Glass Door/s ________ Width ________ mm Height ________ mm

Door Useage Heavy ☐ Average ☐ Long ☐ Glazing Type ☐ Double ☐ Triple ☐

Miscelaneous Loads

Number of Occupants ________ Hours/Day ________ Lighting ________ Watts

Forklift Yes ☐ No ☐ *Standard lighting 10 Watts per m²*

Forklift Type Electric ☐ Internal Combustion ☐ Hours per Day ________

Ventilation Yes ☐ No ☐ *Any outside air added to the room*

Other Loads ______________________

Selection of ***Cool Room/Freezer Equipment***

Other Information

*Power Supply 240V 1PH 50Hz ☐ 415V 3PH 50Hz ☐ *Preferred Refrigerant ____________________

Equivalent Line Length

	Horizontal	Vertical
Liquid	______ m	______ m
Suction Line	______ m	
Discharge Line	______ m	

Any additional data available ____

Equipment Preferences

Conventional	☐	Packaged	☐	Remote	☐
Punchbowl	☐	Buffalo	☐	Cabero	☐

Other ____________________

Other ____________________

Actrol can only base equipment selections on the information supplied above and are not responsible if this information is incorrect, changed without notice or if assumptions need to be made due to lack of information.

*Form Completed By: ____________________ *Client's Signature: ____________________

These forms can also be found:
http://www.actrol.com.au/Services/Services-Applications-Engineering/