HVACR Reference

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Revision 10/22/19

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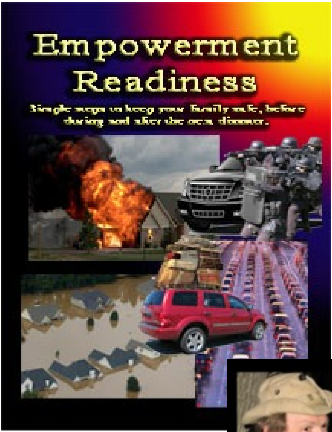
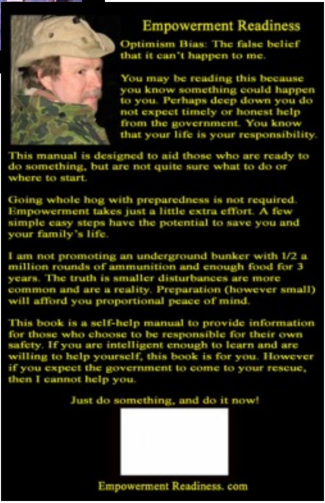


Take control now!

Helpful Videos



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MOTOR

Motor Formulas

1 watt = 3.414 BTU
1 HP = 745.7 Watts

BTUs = (Watt)(3.414)
HP = (Watt)(745.7)

RMS = Peak Volts / Sqrt of 2
or
RMS = Peak Volts / 1.414

Motor Speed

RPM = (Hertz)(120)/ # Poles
# Poles = (7200)(RPM)

2 Poles = 3,600 rpm
4 Poles = 1,800 rpm
6 Poles =1,200 rpm
8 Poles = 900 rpm
16 Poles = 450 rpm

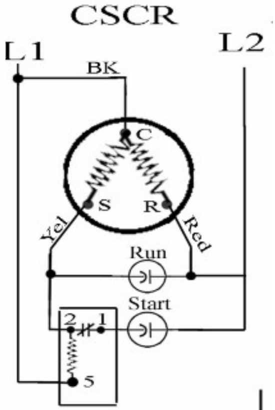
CSCR
Capacitor Start Capacitor Run

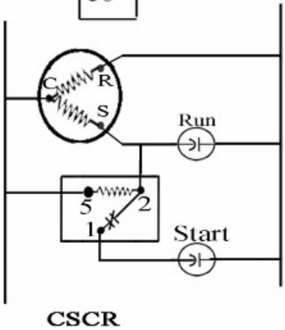
Compressor
Resistance

C to R = Run winding
Lowest resistance

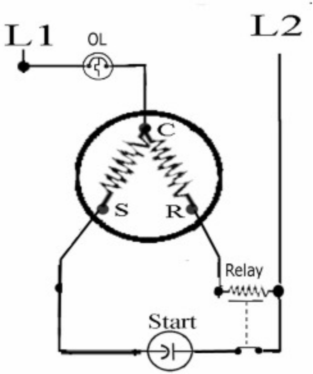
C to S = Start winding
Medium resistance

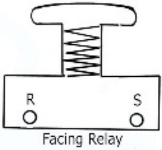
S to R = C to R + C to S
Highest resistance

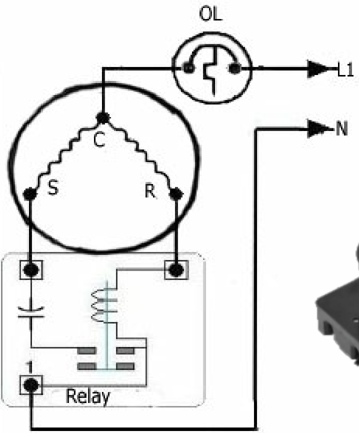




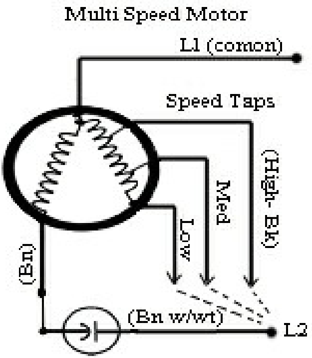
CSIR
Capacitor Start Induction Run







PSC & Motor Speeds
Permanent Split Capacitor



To check Capacitance while running:
Cap.= Cap. Amperage x 2654/ Cap. Volts.
$X_c = 1/(2 \times \pi \times f \times C)$ and $E = I \times X_c$

Multi-Speed Color Codes
Note: For most motors.

Com (L1) = White
High = Black
Med High = Blue
Med = Blue
Low = Red
Low = Yellow
Capacitor = Brown
Capacitor Neutral = Brn/Wt

Motor Amps

HP = (Volts)(Amps)/745.7

Single Phase

Hp	115v	208v	230v
1/6hp	4.4	2.5	2.2
1/4hp	5.5	3.3	2.9
1/3hp	7.2		3.6
1/2hp	9.8	5.6	4.9
3/4hp	13.8	7.9	6.9
1	16	9.2	8
1 1/2hp	20	11.5	10
2hp	24	13.8	12
3	34	19.6	17
5	56	32.2	28
7 1/2hp	80	46	40

Three Phase

Hp	200v	230v	400v
1/2hp	2.3	2	1
3/4hp	3.2	2.8	1.4
1 hp	4.1	3.6	3.4
1 1/2hp	6	5.2	2.6
2hp	7.8	6.8	3.4
3hp	11	9.6	4.8
5hp	17.5	15.2	7.6
7 1/2hp	25.3	22	11
10hp	32.2	32.2	14
15hp	48.3	48.3	21

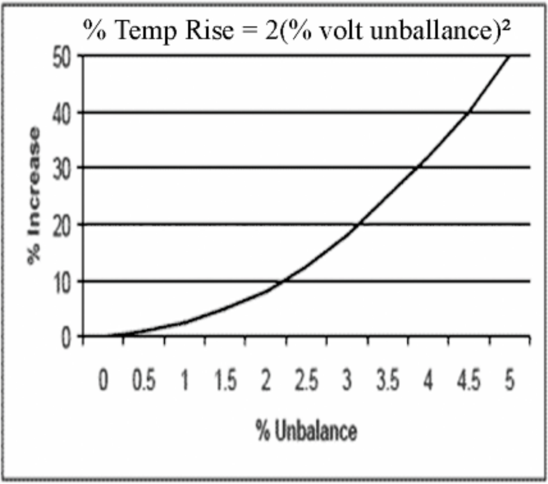
Voltage or Amperage Unbalance

1) Find average: $Avg = \frac{L1 + L2 + L3}{3}$

2) Caluclate deviation for each leg. Use max. deviation (MD) from average.

3) Calculate unbalance:
$$\% \text{ Unbalance} = \frac{MD \times 100}{Avg}$$

Temp Rise w/ Current Unbalance



Three Phase Motor Failure

Single-Phased winding failure is the result of an open in one phase of the power supply to the motor. This will cause one of the three phase winding to burn open.

Overload, thermal deterioration of the insulation in all phases of the stator winding. Typically is caused by the load demand and exceeding the rating of the motor. Under-voltage and over-voltage will result in similar insulation failure.

Voltage Surges insulation failures are often the result of switching power circuits, lightning strikes, capacitor discharges.

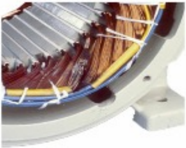
Current Unbalance, thermal deterioration of insulation in one phase of the winding.
Note: A 1% voltage unbalance can cause a 6 - 10% current unbalance.

Shorted types of insulation failures are typically caused by contaminants, abrasion, vibration or voltage surges.

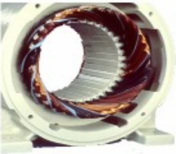
3 Phase Motor Failure

Single-phased

Overload



Voltage Surge



Unballance

Shorted

Earth Fault

Turn to Turn

Phase to Phase

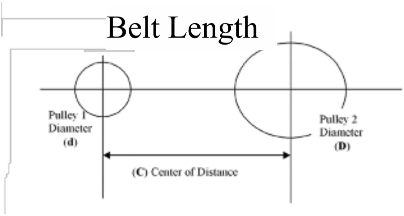
Speed of Sheaves (Pulleys)

$$DR = \frac{(DN)(RN)}{RR} \qquad RR = \frac{(DN)(RN)}{DR}$$

$$DN = \frac{(DR)(RR)}{RN} \qquad RN = \frac{(DR)(RR)}{DN}$$

Where:
DN = Diameter of Driven
DR = Diameter of Driver
RN = RPM of Driven
RR = RPM of Driver

Belt Length



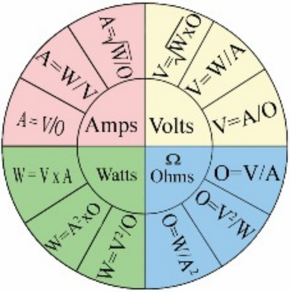
L = Pitch Length of belt
C = Center of Distance
D = Diameter of Lg. Pulley
d = Diameter of Sm. Pulley

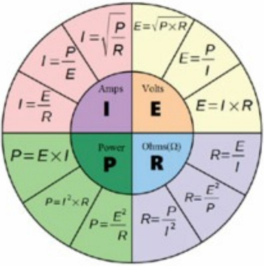
$$L = \frac{(D + d)\,Pi}{2} + 2C$$

Blank

ELECTRIC

Ohm's Law





Watts = (Volts)(Amps)
= (Amps^2)(Ohms)
= Volts^2 / Ohms

Volts = Watts / Amps
= (Amps)(Ohms)
= √ (Watts)(Ohms)

Amps = Watts / Volts
= Volts / Ohms
= √ Watts / Ohms

Ohms = Volts / Amps
= Volts^2 / Watts
= Watts / Amps^2

P = (E)(I)
= (I^2)(R)
= E^2 / R

E = P / I
= (I)(R)
= √ (P)(R)

I = P / R
= E / R
= √ P / R

R = E / I
= E^2 / P
= P / I^2

Cap Volt	Cap Amps											
	2	3	4	5	6	7	8	9	10	11	12	13
315	17	25	34	42	51	59	68	76	85	93	101	109
320	17	25	33	41	50	58	66	75	83	91	99	108
325	16	24	33	41	49	57	65	73	82	90	98	106
330	16	24	32	40	48	56	64	72	80	88	96	104
335	16	24	32	40	48	55	63	71	79	87	95	103
340	16	23	31	39	47	55	62	70	78	86	94	101
345	15	23	31	38	46	54	62	69	77	85	92	100
350	15	23	30	38	45	43	61	68	76	83	91	99
355	15	22	30	37	45	52	60	67	75	82	90	97
360	15	22	29	37	44	52	59	66	74	81	88	96
365	15	22	29	36	44	51	58	65	73	80	87	94
370	14	22	29	36	43	50	57	65	72	79	86	93
375	14	21	28	35	42	50	57	64	71	78	85	92
380	14	21	28	35	42	49	56	63	70	77	84	91
385	14	21	28	34	41	48	55	62	69	76	83	90
390	14	20	27	34	41	48	54	61	68	75	82	88
395	13	20	27	34	40	47	54	60	67	74	81	87
400	13	20	27	33	40	46	53	60	66	73	80	86
405	13	20	26	33	39	46	52	59	65	72	79	85
410	13	19	26	32	39	45	52	58	65	71	78	84
415	13	19	26	32	38	45	51	58	64	70	77	83
420	13	19	25	32	38	44	51	57	63	69	76	82
425	12	19	25	31	37	44	50	56	62	69	75	81
430	12	19	25	31	37	43	49	56	62	68	74	80
435	12	18	24	30	37	43	49	55	61	67	73	79
440	12	18	24	30	36	42	48	54	60	66	72	78
445	12	18	24	30	36	42	48	64	60	66	72	77

Read Capacitor amps and volts.

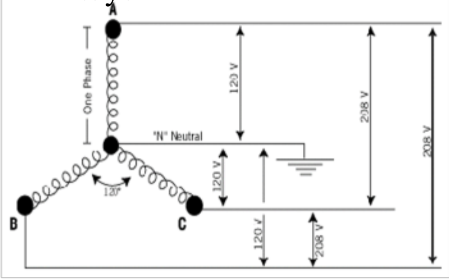
Find Capacitor size.

To check Capacitance while running:

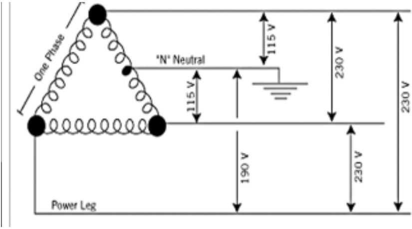
Cap.= Cap. Amperage x 2654/ Cap. Volts.

	Diamater		Ohm	Amp		
AWG	mils	inch	/1000'	THHN	RUW	max@ 20(
OO	364.8	0.3648	0.07793	135	145	283
0	324.9	0.3249	0.09827	120	125	245
1	289.3	0.2893	0.1239	100	110	211
2	257.6	0.2576	0.1563	90	95	181
3	229.4	0.2294	0.197	75	85	158
4	204.3	0.2043	0.2485	65	70	135
6	162	0.162	0.3951	60	55	101
8	128.5	0.1285	0.6282	40	40	73
10	101.9	0.1019	0.9989	25	30	55
12	80.8	0.08081	1.588	12	20	41
14	64.1	0.06408	2.525		15	32
16	50.8	0.0508	4.016		12	22
18	40.3	0.0403	6.39		10	16
20	32.0	0.03196	10.15		7	11
22	25.4	0.02535	16.14		5	7
24	20.1	0.0201	25.67		2.1	3.5
26	15.9	0.01594	40.81		1.3	2.2
28	12.6	0.01264	64.90		0.83	1.4
30	10.0	0.01003	103.20		0.52	0.86
32	8.0	0.00795	164.10		0.32	0.53
34	6.3	0.006305	260.90			0.33
36	5.0	0.005	414.80			0.21
38	4.0	0.003965	659.60			0.13
40	3.1	0.003145	1049.00			0.09

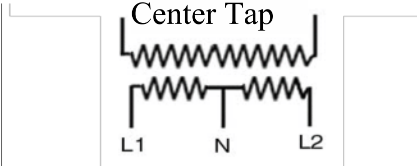
Wye



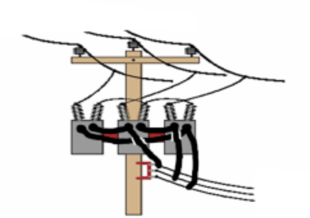
Delta

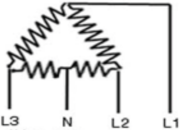


Center Tap

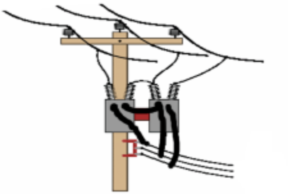


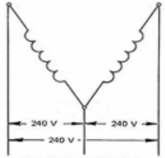
Delta



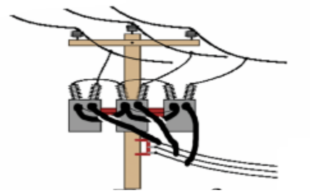


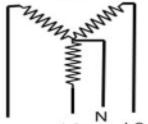
Open Delta



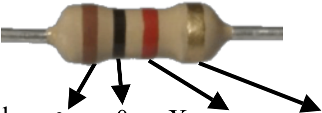


Wye





Resistor Color Code



Black	0	0	X	1	Tolerance
Brown	1	1	X	10	Gold 5%
Red	2	2	X	100	Silver 10%
Orange	3	3	X	1,000	None 20%
Yellow	4	4	X	10,000	
Green	5	5	X	100,000	
Blue	6	6	X	1,000,000	
Violet	7	7	X	10,000,000	
Gray	8	8	X	100,000,000	
White	9	9	X	---	

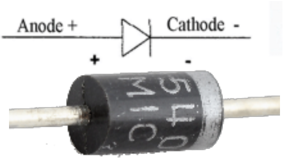
Abbreviations

Meg = 1,000,000
Kilo = 1,000
Milli = .001
Micro = .000,001
Nano = .000,000,001
Pico = .000,000,000,001

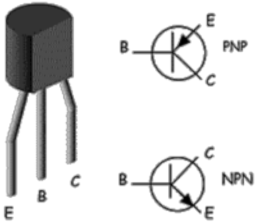
i.e. 1 K ohm = Rd.- Bk. - Bn.

Capacitor

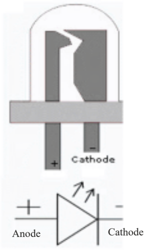
Diode

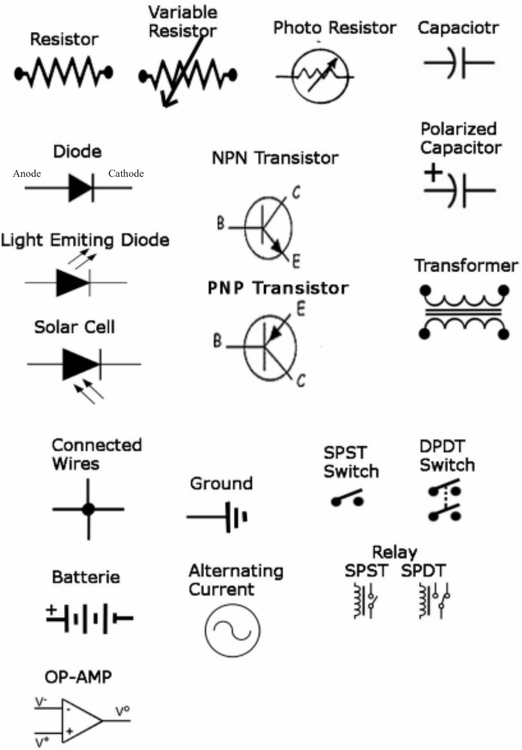


Transistors

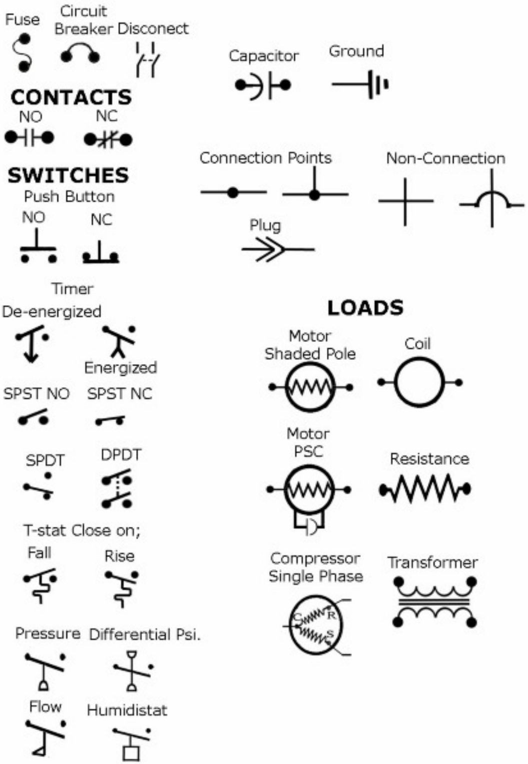


LED




Resistor
Variable Resistor
Photo Resistor
Capaciotr
Diode
Anode
Cathode
NPN Transistor
B
C
E
Polarized Capacitor
+
Light Emiting Diode
PNP Transistor
E
B
C
Transformer
Solar Cell
Connected Wires
Ground
SPST Switch
DPDT Switch
Relay
SPST SPDT
Batterie
+
Alternating Current
OP-AMP
V-
V+
Vo
-
+

Refrigeration Circuit Symbols



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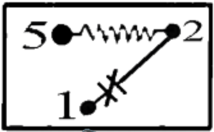
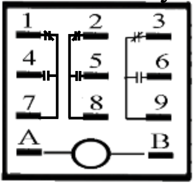
MECHANICAL

Main Index

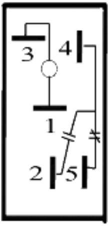
Start



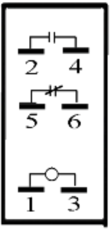
Ice Cube Relay



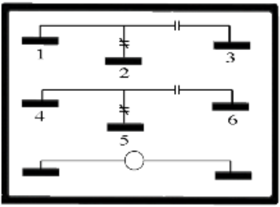
White Rogers
90-293



White Rogers
90-370



Mars 90340 - 90341 - 90342



Iron Pipe Sizes sch. 40

Pipe	Od	Id	Circumference OD	Circumference ID
1/8	0.405	0.271	1.27251	14/16
1/4	0.54	0.366	1.69668	1 2/16
3/8	0.675	0.495	2.12085	1 9/16
1/2	0.84	0.624	2.63928	1 15/16
3/4	1.05	0.826	3.2991	2 10/16
1	1.315	1.049	4.13173	3 5/16
1 1/4	1.66	1.38	5.21572	4 5/16
1 1/2	1.9	1.61	5.9698	5 1/16
2	2.375	2.067	7.46225	6 8/16
2 1/2	2.875	2.469	9.03325	7 12/16
3	3.5	3.068	10.997	9 10/16
3 1/2	4	3.548	12.568	11 2/16
4	4.5	4.026	14.139	12 10/16

Copper "L"						
Refrig	Nom.	Od dec	Id dec	wall	Circumference	
					ID	OD
3/8	1/4	0.375	0.315	0.030	1.178	1 1/8
1/2	3/8	0.500	0.430	0.035	1.571	1 5/8
5/8	1/2	0.625	0.500	0.040	1.964	2
3/4	5/8	0.750	0.666	0.042	2.357	2 3/8
7/8	3/4	0.875	0.785	0.045	2.749	2 3/4
1 1/8	1	1.125	1.025	0.050	3.535	3 1/2
1 3/8	1 1/4	1.375	1.265	0.055	4.320	4 3/8
1 5/8	1 1/2	1.625	1.505	0.060	5.106	5 1/8
2 1/8	2	2.125	1.985	0.070	6.677	6 5/8
2 5/8	2 1/2	2.625	2.465	0.080	8.248	8 1/4
3 1/8	3	3.125	2.945	0.09	9.819	9 7/8
3 5/8	3 1/2	3.625	3.425	0.1	11.390	11 3/8
4 1/8	4	4.125	3.905	0.11	12.961	13

PVC Schedule 40

Nom.	Od	Circumference
1/4	0.540	1.697
1/2	0.840	2.639
3/4	1.050	3.299
1	1.315	4.132
1 1/4	1.660	5.216
1 1/2	1.900	5.970
2	2.375	7.462
2 1/2	2.875	9.033
3	3.500	10.997
4	4.500	14.139
6	6.625	20.816
8	8.625	27.100

Socket Depth for Threaded Steel Pipe

Nominal size in inches	Thread length on pipe end	Socket depth when tightened
1/4	0.595	0.367
3/8	0.601	0.407
1/2	0.782	0.534
3/4	0.794	0.553
1	0.985	0.661
1-1/4	1.009	0.681
1-1/2	1.025	0.681
2	1.058	0.697
2-1/2	1.571	0.932
3	1.634	1.016
3 -1/2	1.684	1.071
4	1.734	1.094

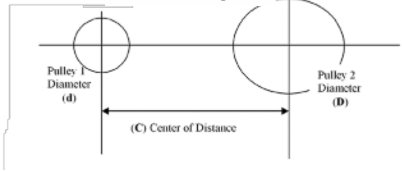
Speed of Sheaves (Pulleys)

DN = Diameter of Driven
DR = Diameter of Driver
RN = RPM of Driven
RR = RPM of Driver

$$DR = \frac{(DN)\,(RN)}{RR} \qquad RR = \frac{(DN)\,(RN)}{DR}$$

$$DN = \frac{(DR)\,(RR)}{RN} \qquad RN = \frac{(DR)\,(RR)}{DN}$$

Belt Length



L = Pitch Length of belt
C = Center of Distance
D = Diameter of Lg. Pulley
d = Diameter of Sm. Pulley

$$L = \frac{(D + d)\,Pi}{2} + 2C$$

Torque Values for Bolts

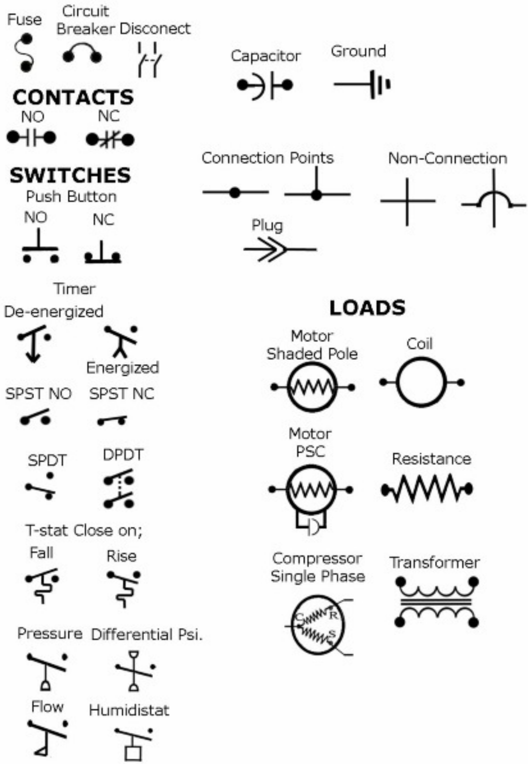
			Plated			Plated			Plated
Bolt size	Grade 2			Grade 5			Grade 8		
in-tpi	N-m	ft-lb	ft-lb	N-m	ft-lb	ft-lb	N-m	ft-lb	ft-lb
1/4 – 20	7.4	5.6	4	11	8	6.3	16	12	9
1/4 - 28	8.5	6	4.7	13	10	7.3	18	14	10
5/16 - 18	15	11	8	24	17	13	33	25	18
5/16 - 24	17	13	9	26	19	14	37	27	20
3/8 - 16	27	20	15	42	31	23	59	44	33
3/8 - 24	31	22	17	47	35	26	67	49	37
7/16 – 14	43	32	24	67	49	37	95	70	52
7/'6 - 20	49	36	27	75	55	41	105	78	58
1/2 - 13	66	49	37	105	76	57	145	105	80
1/2 - 20	75	55	41	115	85	64	165	120	90
9/16 - 12	95	70	53	150	110	82	210	155	115
9/16 - 18	105	79	59	165	120	91	235	170	129
5/8 - 11	130	97	73	205	150	112	285	210	159
5/8 - 18	150	110	83	230	170	128	325	240	180
3/4 - 10	235	170	125	360	265	200	510	375	282
3/4 - 16	260	190	138	405	295	223	570	420	315
7/8 - 9	225	165	129	585	430	322	820	605	454
7/8 - 14	250	185	144	640	475	355	905	670	501
1" - 8	340	250	188	875	645	483	1230	910	682
1" - 12	370	275	210	955	705	541	1350	995	764
1 1/8" - 7	480	355		1080	792		1750	1290	
1 1/8" - 12	540	395		1210	890		1960	1440	
1 1/4" - 7	980	500		1520	1120		2460	1820	
1 1/4" - 12	750	555		1680	1240		2730	2010	
1 3/8" - 6	890	655		1990	1470		3230	2380	
1 3/8" - 12	1010	745		2270	1670		3680	2710	
1 1/2" - 6	1180	870		2640	1950		4290	3160	
1 1/2" - 12	1330	980		2970	2190		4820	3560	

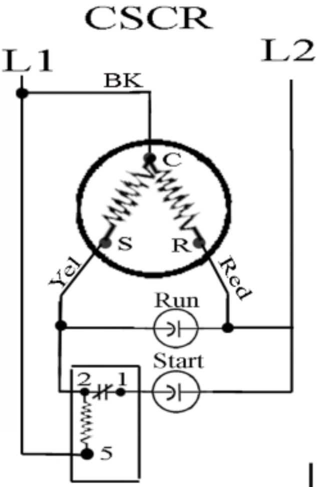
Note: Values for clean dry threads.
Reduce value by 10% for oiled threads.

WIRING Diag.

Main Index

Refrigeration Circuit Symbols



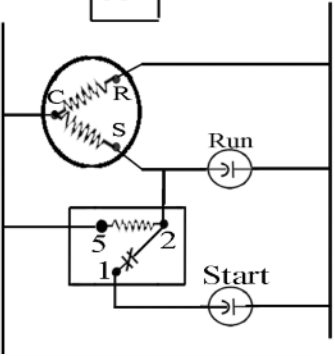


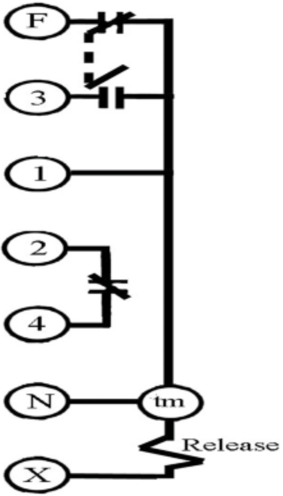
Compressor Resistance

C to R = Run winding
Lowest resistance

C to S = Start winding
Medium resistance

S to R = C to R + C to S
Highest resistance

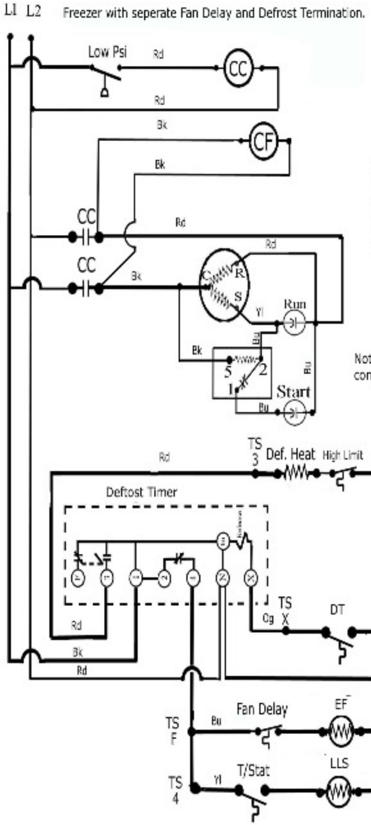




3 Wire Defrost Termination

Red = Common (approximately)
Brn. = Close on Rise (open Fall) (35 deg.)
Bk. = Close on Fall (close Rise) (55 deg.)

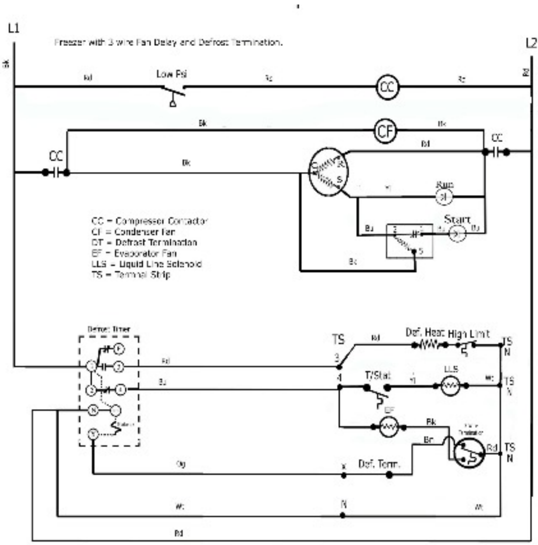
Freezer Wiring

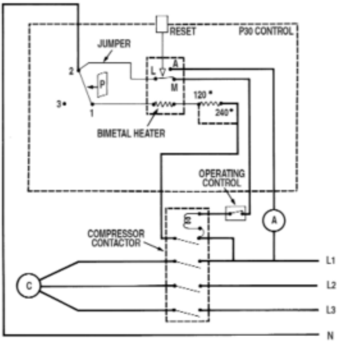


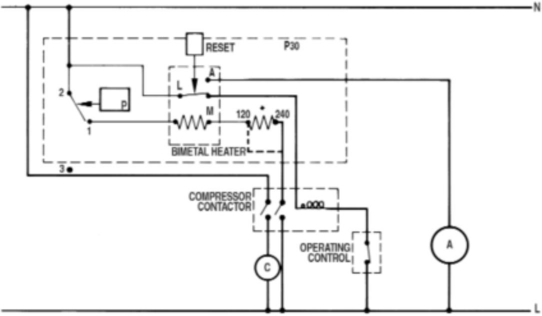
CC = Compressor Contactor
CF = Condenser Fan
DT = Defrost Termination
EF = Evaporator Fan
LLS = Liquid Line Solenoid
TS = Termnal Strip

Note: CPSCR (capacitor start capacitor run) compressor shown.

Freezer (3 wire termination)



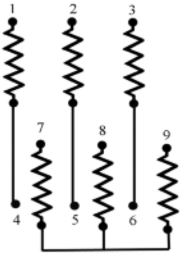

RESET
P30 CONTROL
JUMPER
2
P
L
A
M
3
1
120*
240*
BIMETAL HEATER
OPERATING CONTROL
COMPRESSOR CONTACTOR
A
C
L1
L2
L3
N


N
RESET
P30
A
2
P
L
M
1
120
240
BIMETAL HEATER
3
COMPRESSOR CONTACTOR
OPERATING CONTROL
A
C
L

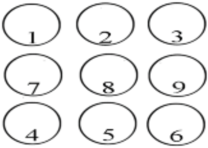
Copeland & Carlyle

Compressor Terminal Design ation

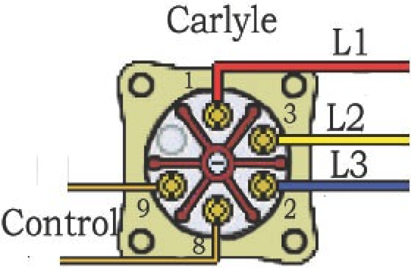
3 Phase Copeland internal wiring



Terminal Designation



Carlyle compressor



MATH

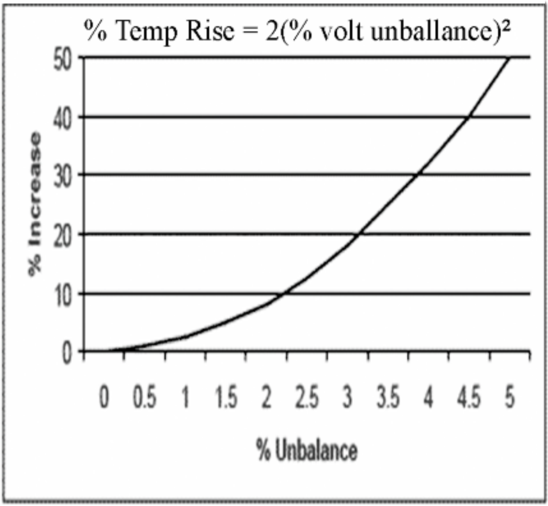
1) Find average: $Avg = \dfrac{L1 + L2 + L3}{3}$

2) Caluclate deviation for each leg. Use max. deviation (MD) from average.

3) Calculate unbalance:

$\% \text{ Unbalance} = \dfrac{MD \times 100}{Avg}$

% Temp. Rise W/ Current Unbalance



Capacitors in Parallel and Series

Capacitors wired in Series
&
Resistance wired in Parallel.

$$Ct = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} \ldots}$$

$$Rt = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} \ldots}$$

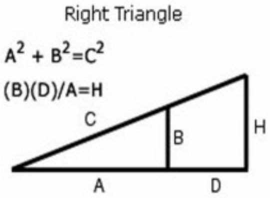
Capacitors in Parallel.
&
Resistance in Series.

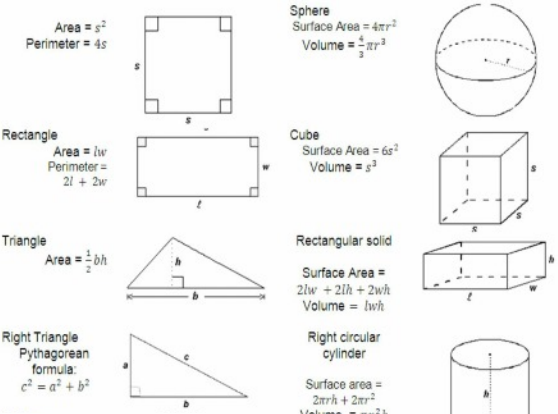
$$Ct = C1 + C2 + C3 \ldots$$

$$Rt = R1 + R2 + R3 \ldots$$

To check Capacitance while running:
Cap.= Cap. Amperage x 2654/ Cap. Volts.

$Xc = 1/(2 \times \pi \times f \times C)$ and $E = I \times Xc$





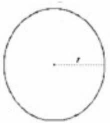
Circle

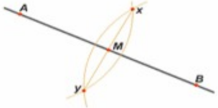
Area = πr^2

Circumference = $2\pi r$

Diameter = 2r

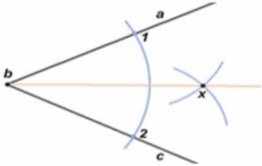
Diameter = Circum./π

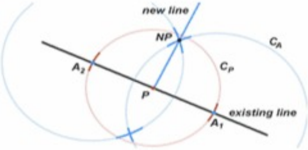




Bisect a Line

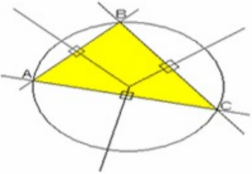
Bisect an Angle





Perpendicular to a Line

Find Radius



2	1.4142	31	5.5678	60	7.7460	89	9.4340	118	10.8628
3	1.7321	32	5.6569	61	7.8102	90	9.4868	119	10.9087
4	2.0000	33	5.7446	62	7.8740	91	9.5394	120	10.9545
5	2.2361	34	5.8310	63	7.9373	92	9.5917	121	11.0000
6	2.4495	35	5.9161	64	8.0000	93	9.6437	122	11.0454
7	2.6458	36	6.0000	65	8.0623	94	9.6954	123	11.0905
8	2.8284	37	6.0828	66	8.1240	95	9.7468	124	11.1355
9	3.0000	38	6.1644	67	8.1854	96	9.7980	125	11.1803
10	3.1623	39	6.2450	68	8.2462	97	9.8489	126	11.2250
11	3.3166	40	6.3246	69	8.3066	98	9.8995	127	11.2694
12	3.4641	41	6.4031	70	8.3666	99	9.9499	128	11.3137
13	3.6056	42	6.4807	71	8.4261	100	10.0000	129	11.3578
14	3.7417	43	6.5574	72	8.4853	101	10.0499	130	11.4018
15	3.8730	44	6.6332	73	8.5440	102	10.0995	131	11.4455
16	4.0000	45	6.7082	74	8.6023	103	10.1489	132	11.4891
17	4.1231	46	6.7823	75	8.6603	104	10.1980	133	11.5326
18	4.2426	47	6.8557	76	8.7178	105	10.2470	134	11.5758
19	4.3589	48	6.9282	77	8.7750	106	10.2956	135	11.6190
20	4.4721	49	7.0000	78	8.8318	107	10.3441	136	11.6619
21	4.5826	50	7.0711	79	8.8882	108	10.3923	137	11.7047
22	4.6904	51	7.1414	80	8.9443	109	10.4403	138	11.7473
23	4.7958	52	7.2111	81	9.0000	110	10.4881	139	11.7898
24	4.8990	53	7.2801	82	9.0554	111	10.5357	140	11.8322
25	5.0000	54	7.3485	83	9.1104	112	10.5830	141	11.8743
26	5.0990	55	7.4162	84	9.1652	113	10.6301	142	11.9164
27	5.1962	56	7.4833	85	9.2195	114	10.6771	143	11.9583
28	5.2915	57	7.5498	86	9.2736	115	10.7238	144	12.0000
29	5.3852	58	7.6158	87	9.3274	116	10.7703	145	12.0416
30	5.4772	59	7.6811	88	9.3808	117	10.8167	146	12.0830

#	Cube	Cube Root	Sauare	Sq RT
1	1	1.0000	1	1.0000
2	8	1.2599	4	1.4140
3	27	1.4422	9	1.7230
4	64	1.5874	16	2.0000
5	125	1.7100	25	2.2360
6	216	1.8171	36	2.4495
7	343	1.9129	49	2.6458
8	512	2.0000	64	2.8284
9	729	2.0801	81	3.0000
10	1000	2.1544	100	3.1623
11	1331	2.2240	121	3.3166
12	1728	2.2894	144	3.4641
13	2197	2.3513	169	3.6056
14	2744	2.4101	196	3.7417
15	3375	2.4662	225	3.8730
16	4096	2.5198	256	4.0000
17	4913	2.5713	289	4.1231
18	5832	2.6207	324	4.2426
19	6859	2.6684	361	4.3589
20	8000	2.7144	400	4.4721

Multiply

	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3		9	12	15	18	21	24	27	30	33	36
4			16	20	24	28	32	36	40	44	48
5				25	30	35	40	45	50	55	60
6					36	42	48	54	60	66	72
7						49	56	63	70	77	84
8							64	72	80	88	96
9								81	90	99	108
10									100	110	120
11										121	132
12											144

One Days Production =
(60 min.) (24 hrs) (batch weight lbs.) / Batch time in min.

or

(1440)(batch weight) / Batch time in minutes.

Note: Batch time is complete cycle time, including harvest and freeze cycle.

Blank

DATA

Main Index

X/64 = Decimal

Fraction		Decimal	Mm	Fraction		Decimal	Mm
	1/64	0.01562	0.397		33/64	0.51562	13.097
1/32		0.03125	0.794	17/32		0.53125	13.494
	3/64	0.04688	1.191		35/64	0.54688	13.891
1/16		0.06250	1.588	9/16		0.56250	14.288
	5/64	0.07812	1.984		37/64	0.57812	14.684
3/32		0.09375	2.381	19/32		0.59375	15.081
	7/64	0.10938	2.778		39/64	0.60938	15.478
1/8		0.12500	3.175	5/8		0.62500	15.875
	9/64	0.14062	3.572		41/64	0.64062	16.272
5/32		0.15625	3.969	21/32		0.65625	16.669
	11/64	0.17188	4.366		43/64	0.67188	17.066
3/16		0.18750	4.763	11/16		0.68750	17.463
	13/64	0.20312	5.159		45/64	0.70312	17.859
7/32		0.21875	5.556	23/32		0.71875	18.256
	15/64	0.23438	5.953		47/64	0.73438	18.653
1/4		0.25000	6.350	3/4		0.75000	19.050
	17/64	0.26562	6.747		49/64	0.76562	19.447
9/32		0.28125	7.144	25/32		0.78125	19.844
	19/64	0.29688	7.541		51/64	0.79688	20.241
5/16		0.31250	7.938	13/16		0.81250	20.638
	21/64	0.32812	8.334		53/64	0.82812	21.034
11/32		0.34375	8.731	27/32		0.84375	21.431
	23/64	0.35938	9.128		55/64	0.85938	21.828
3/8		0.37500	9.525	7/8		0.87500	22.225
	25/64	0.39062	9.922		57/64	0.89062	22.622
13/32		0.40625	10.319	29/32		0.90625	23.019
	27/64	0.42188	10.716		59/64	0.92188	23.416
7/16		0.43750	11.113	15/16		0.93750	23.813
	29/64	0.45312	11.509		61/64	0.95312	24.209
15/32		0.46875	11.906	31/32		0.96875	24.606
	31/64	0.48438	12.303		63/64	0.98438	25.003
1/2		0.50000	12.700	1/1		1.00000	25.400

Area of Pipe & Volume					
Size	Area	Area 1 ft.	Gallons	Radius	Circum
	sq. in.	sq. in.	Per Foot		
1/4	0.0491	0.589	0.0026	0.1250	0.7855
3/8	0.1105	1.326	0.0057	0.1875	1.1783
1/2	0.1964	2.357	0.0102	0.2500	1.5710
3/4	0.4418	5.302	0.0230	0.3750	2.3565
7/8	0.6014	7.217	0.0312	0.4375	2.7493
1	0.7855	9.426	0.0408	0.5000	3.1420
1 3/8	1.4851	17.821	0.0771	0.6875	4.3203
1 1/4	1.2273	14.728	0.0638	0.6250	3.9275
1 3/8	1.4851	17.821	0.0771	0.6875	4.3203
1 1/2	1.7674	21.209	0.0918	0.7500	4.7130
2	3.1420	37.704	0.1632	1.0000	6.2840
2 1/2	4.9094	58.913	0.2550	1.2500	7.8550
3	7.0695	84.834	0.3672	1.5000	9.4260
4	12.5680	150.816	0.6529	2.0000	12.5680
5	19.6375	235.650	1.0201	2.5000	15.7100
6	28.2780	339.336	1.4690	3.0000	18.8520
7	38.4895	461.874	1.9995	3.5000	21.9940
8	50.2720	603.264	2.6115	4.0000	25.1360
9	63.6255	763.506	3.3052	4.5000	28.2780
10	78.5500	942.600	4.0805	5.0000	31.4200
11	95.0455	1140.546	4.9374	5.5000	34.5620
12	113.1120	1357.344	5.8759	6.0000	37.7040

C=(F-32)(5/9) F=(C)(5/9)+32

F	C	F	C	F	C	F	C
-33.0	-27.5	32	0.0	100	37.8	168	75.6
-31.2	-24.1	34	1.1	102	38.9	170	76.7
-29.3	-20.8	36	2.2	104	40.0	172	77.8
-27.5	-17.5	38	3.3	106	41.1	174	78.9
-25.6	-14.1	40	4.4	108	42.2	176	80.0
-23.8	-10.8	42	5.6	110	43.3	178	81.1
-21.9	-7.4	44	6.7	112	44.4	180	82.2
-20.1	-4.1	46	7.8	114	45.6	182	83.3
-18.2	-0.1	48	8.9	116	46.7	184	84.4
-16.3	2.6	50	10.0	118	47.8	186	85.6
-14.5	5.9	52	11.1	120	48.9	188	86.7
-12.6	9.3	54	12.2	122	50.0	190	87.8
-10.8	12.6	56	13.3	124	51.1	192	88.9
-8.9	16.0	58	14.4	126	52.2	194	90.0
-7.0	10.3	60	15.6	128	53.3	196	91.1
-5.2	22.7	62	16.7	130	54.4	198	92.2
-3.3	26.0	64	17.8	132	55.6	200	93.3
-1.0	30.2	66	18.9	134	56.7	202	94.4
0	-17.8	68	20.0	136	57.8	204	95.6
2	-16.7	70	21.1	138	58.9	206	96.7
4	-15.6	72	22.2	140	60.0	208	97.8
6	-14.4	74	23.3	142	61.1	210	98.9
8	-13.3	76	24.4	144	62.2	212	100.0
10	-12.2	78	25.6	146	63.3	214	101.1
12	-11.1	80	26.7	148	64.4	216	102.2
14	-10.0	82	27.8	150	65.6	218	103.3
16	-8.9	84	28.9	152	66.7	220	104.4
18	-7.8	86	30.0	154	67.8	222	105.6
20	-6.7	88	31.1	156	68.9	224	106.7
22	-5.6	90	32.2	158	70.0	226	107.8
24	-4.4	92	33.3	160	71.1	228	108.9
26	-3.3	94	34.4	162	72.2	230	110.0
28	-2.2	96	35.6	164	73.3	232	111.1
30	-1.1	98	36.7	166	74.4	234	112.2

Water

1 cu ft = 62.4 Lbs
1 cu ft = 7.4805 gal
1 gal = 231 cu in
1 gal = 8.3453 lbs
1 gal = (cu ft)(7.5)
1 gal = 46,080 drops

1 oz. = 359 drops
1 Tbs = 180 drops
1 ml = 20

Acre inch = 27,150 gallons

1 ft. Static Head = 0.433 psi
Volume @ 32F = 27.2 cu in
@ 212F = 28.8 cu in

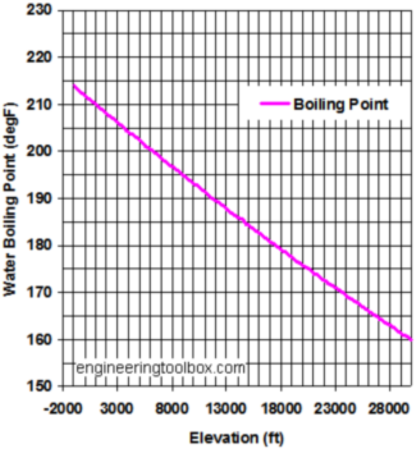
Latent Heat
Fusion 143.57 BTU
Vaporization 897.6 BTU

Boiling Point of Water

Inches Mercury	Deg F
26.45	120
27.32	110
27.99	100
28.50	90
28.89	80
29.89	70
29.40	60
29.66	50
29.71	40
29.76	30
29.82	20
29.86	10

Altitude,	°F
0'	212°
500'	211.1°
1,000'	210.2°
2,000'	208.4°
5,000'	203°
6,000'	201.1°
8,000'	197.4°
10,000'	193.6°
12,000'	189.8°
14,000'	185.9°

Water Pressure Temperature



Steam Table

Pressure		Temperature	
PSIG	PSI	°F	°C
0	14.7	212.0	100.0
1	15.7	215.5	101.9
2	16.7	218.5	103.6
3	17.7	221.5	105.3
4	18.7	224.5	106.9
5	19.7	227.4	108.6
6	20.7	230.0	110.0
7	21.7	232.4	111.3
8	22.7	234.8	112.7
9	23.7	237.1	113.9
10	24.7	239.4	115.2
11	25.7	241.6	116.4
12	26.7	243.7	117.6
13	27.7	245.8	118.8
14	28.7	247.9	119.9
15	29.7	249.8	121.0
16	30.7	251.7	122.1
17	31.7	253.6	123.1
18	32.7	255.6	124.2
19	33.7	257.2	125.1
20	34.7	258.8	126.0
21	35.7	260.6	127.0
22	36.7	262.3	127.9
23	37.7	263.8	128.8
24	38.7	265.3	129.6
25	39.7	266.8	130.4
26	40.7	268.3	131.3
27	41.7	269.9	132.2

Pressure		Temperature	
PSIG	PSI	°F	°C
28	42.7	271.4	133.0
29	43.7	272.7	133.7
30	44.7	274.0	134.4
31	45.7	275.4	135.2
32	46.7	276.7	135.9
33	47.7	278.1	136.7
34	48.7	279.4	137.4
35	49.7	280.7	138.2
36	50.7	281.9	138.8
37	51.7	283.2	139.6
38	52.7	284.4	140.2
39	53.7	285.6	140.8
40	54.7	286.7	141.5
41	55.7	287.9	142.2
42	56.7	289.0	142.8
43	57.7	290.2	143.4
44	58.7	291.3	144.1
45	59.7	292.4	144.7
46	60.7	293.5	145.3
47	61.7	294.6	145.9
48	62.7	295.6	146.4
49	63.7	296.7	147.1
50	64.7	297.7	147.6
51	65.7	298.7	148.2
52	66.7	299.7	148.7
53	67.7	300.7	149.3
54	68.7	301.7	149.8
55	69.7	302.7	150.4

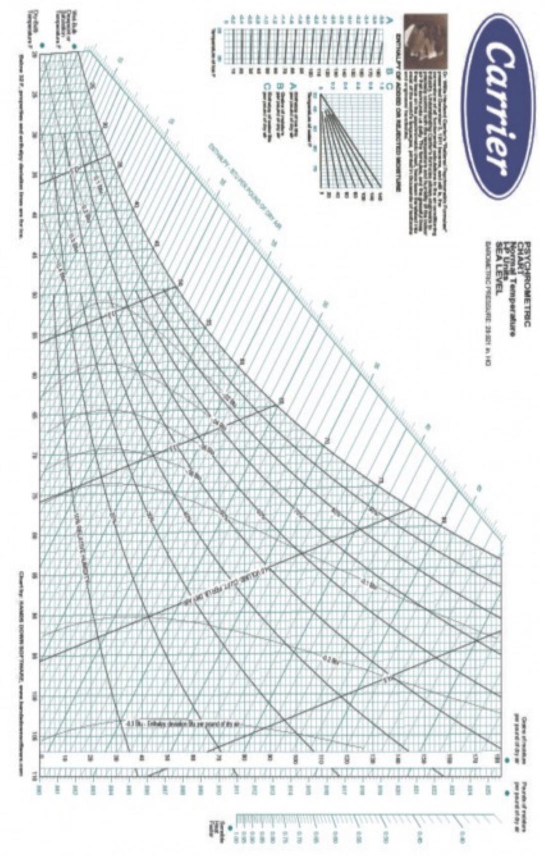
Natural Gas 1,030 Btu/Cu ft.
Propane: 2,500 Btu/cu ft.
92,500 Btu/ gal.
Ethanol 76,000 Btu/ gal.
Kerosene 135,000 Btu/ gal.
Fuel Oil #2 138,500 Btu/ gal.
Waste Oil 125,000 Btu/ gal.
Gasoline 125,000 Btu/ gal.
Animal Fat 178,00 Btu/ Lbs.
50-60 Btu/ cu. Ft.

Hardwood 18-24,000 Btu/ cord (128 sq ft)
4-5,000 Lbs/cord (35 lbs/cu ft.)
148,437 Btu/ cu ft.
4,241 btu/lbs
Softwood 10-15,000 Btu/ Cord
2-3,000 Lbs/ cord.
97,656 Btu/ cu ft.
1,907 Btu/ lbs.
Newspaper 7,957 Btu/ cu ft.
7 lbs/ cu ft
1,139 Btu/ lbs

Hard Coal (anthracite)
13,000 Btu/ lbs. = 26,000,000 Btu/ ton.
Soft Coal (bituminous)
12,000 Btu/ lbs. = 24,000,000 Btu/ ton.

Blank

LOADS


Carrier
PSYCHROMETRIC
CHART
Normal Temperature
SEA LEVEL

ANONIMOTER METHOD

R/A Size:_______ x ________= sq. in. / 144 = ________ sq. ft.

____________ ____________ ____________ ____________

____________ ____________ ____________ ____________

____________ ____________ ____________ ____________

____________ ____________ ____________ ____________

____________ ____________ ____________ ____________

Sub total:

____________ ____________ ____________ ____________

Total ____________ / ____________ = X sq. ft. =

CFM ____________

CAPACITY CHECK

BTU = (5.4)(CFM)(Delta H)

BTU = (5.4)(____________)(____________)

BTU = ____________

VELOCITY W/ MAGNEHELIC

Duct Size:________ X _________ = ___________sq. in. / 144 =

___________ sq. ft.

PSI	=	Velocity	]	PSI	=	Velocity
_________	=	_________	]	_________	=	_________
_________	=	_________	]	_________	=	_________
_________	=	_________	]	_________	=	_________
_________	=	_________	]	_________	=	_________
_________	=	_________	]	_________	=	_________
_________	=	_________	]	_________	=	_________
_________	=	_________	]	_________	=	_________

Sub Total Velocity:

___________ / # measurments ______ =

___________ CFM

CAPACITY CHECK

BTU = (5.4)(CFM)(Delta H)

BTU = (5.4)(___________)(___________)

BTU = ___________

Air Flow Temp Rise

CFM= (Watts)(3.414)/1.08 (Temp Rise)

Load Calculation

BTU A/C = (4.5)(CFM)(Delta H)

BTU Heat = (CFM)(Temp Rise)

Standard Resistance in duct 0.08"wg

Acquire duct pressure; take Pitot Tube reading every 6".

Velocity

V = (4,005) ($\sqrt{}$ Velocity Pressure Inches Water)

i.e. Velocity Pressure of 0.49

$\sqrt{0.49} = 0.7$

(0.7)(4,005)

= 2,803 ft/min.

Calculate Total Area of Duct:

Area: Square feet = (pi)(R^2)

Circumference = (3.142)(D)

CFM = (Area)(Velocity)

Air Flow Requirements

Return air: 200 Square Inches per ton.

Air flow: 350 - 400 CFM per ton .

Chiller Capacity

Capacity (tons):
= (specific heat) (specific gravity) (fluid flow rate) (ΔT) (500) / 12,000.

or

= (ΔT) (GPM) / 24

Capacity with Water:
specific heat is 1.0 Btu/lb (F)
specific gravity is 1.0.

Therefore; for water, the equation is simplified to:
Capacity (tons) = (ΔT) (GPM) (500) /12,000
or
Capacity (tons) = (ΔT) (GPM) / 24

Explanation w/example:
1) Find ΔT: If chiller entering water is 64 degrees F and leaving at 51 degrees F
Then: ΔT = 64 - 51 = 13 F.

2) Multiply by flow rate, in gallons per minute.
If, 300 GPM
Then: 13 x 300 = 3,900 GPM.

3) Convert to volumetric flow rate (measured in gpm.) to mass flow rate (measured in pounds of water per hour), multiply your answer by 500.

Example is:
Capacity in BTU/hr: 3,900 x 500 = 1,950,000.
Capacity in tons: Divide your answer by 12,000:
1,950,000 / 12,000 = 162.5.

The Math:
Heat Load and Water Flow
Water systems heat load in Btu/h can be simplified to:

$$h = c_p \, p \, q \, \Delta T$$

$$\begin{array}{lllll} & c_p & p & q & \Delta T \\ h = & (1\,Btu/lb_m F) & (8.33\,lbm/us\,gal) & q\,(60\,min/hr) & \Delta T \\ h = & 500 & & q & \Delta T \end{array}$$

Where:
h = heat load (Btu/h)
c_p = specific heat, 1 ($Btu/lb_m\,^oF$) for water
p = 8.33 (lb_m/US gal) for water
q = water volume flow rate (US gal/min)
dt = temperature difference (^oF)

or

Cooling capacity = (specific heat)(specific gravity)(fluid flow rate)(delta T)(500) / 12,000.

or

Cooling capacity = (specific heat) (specific gravity) (fluid flow rate) (delta T) / 24.

Where:
Specific heat is in units of Btu/Lb. (F).
Specific gravity = density of the fluid/ density of water.
Fluid flow rate is in units of Gallons/minute (gpm)
Delta T = fluid temperature leaving process – fluid temperature entering process (F).

Pump Flow Measurement

GPM = (Bucket volume /time in seconds)(60)

Tools: a 5-gallon bucket, a stop watch.
1) Determine time to fill the bucket.
2) Divide volume (5 gallons) by the time in seconds fill, multiply by 60 (seconds).

GPM = (Bucket volume / time in seconds) (60)

For example:
36 seconds to fill a 5 gallon bucket.
$5 \div 36 = 0.14$.
$0.14 \times 60 = 8.4$ gallons per minute.

Blank

Blank

MISC.

$D = (S)(T)$

$T = \frac{D}{S}$

$S = \frac{D}{T}$

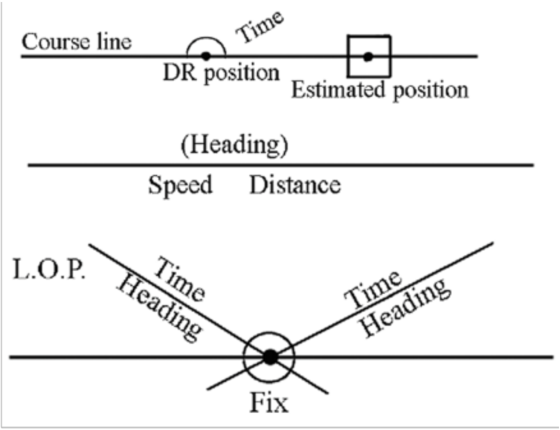
Statue Mile = 5,280’
Nautical Mile = 6,076

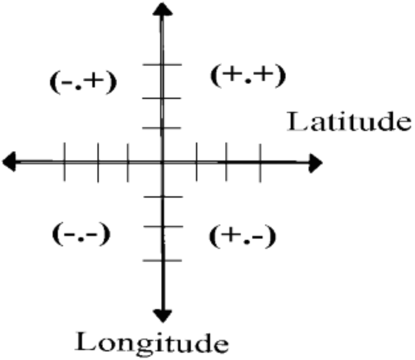
Speed Distance

Miles per hour = (Feet per Minute)(0.01136)
Feet per minute = (Miles per hour)(88)

Time Decimal Equivalents

To convert Decimal to minutes:
(Tenth of hour)(60) = Min.
i.e. ¼ hr. Or (0.25)(60) = 15 min.


Course line
Time
DR position
Estimated position
(Heading)
Speed
Distance
L.O.P.
Time
Heading
Time
Heading
Fix


(-.+)
(+.+)
Latitude
(-.-)
(+.-)
Longitude

International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.

A	● ▬	U	● ● ▬
B	▬ ● ● ●	V	● ● ● ▬
C	▬ ● ▬ ●	W	● ▬ ▬
D	▬ ● ●	X	▬ ● ● ▬
E	●	Y	▬ ● ▬ ▬
F	● ● ▬ ●	Z	▬ ▬ ● ●
G	▬ ▬ ●		
H	● ● ● ●		
I	● ●		
J	● ▬ ▬ ▬		
K	▬ ● ▬	1	● ▬ ▬ ▬ ▬
L	● ▬ ● ●	2	● ● ▬ ▬ ▬
M	▬ ▬	3	● ● ● ▬ ▬
N	▬ ●	4	● ● ● ● ▬
O	▬ ▬ ▬	5	● ● ● ● ●
P	● ▬ ▬ ●	6	▬ ● ● ● ●
Q	▬ ▬ ● ▬	7	▬ ▬ ● ● ●
R	● ▬ ●	8	▬ ▬ ▬ ● ●
S	● ● ●	9	▬ ▬ ▬ ▬ ●
T	▬	0	▬ ▬ ▬ ▬ ▬

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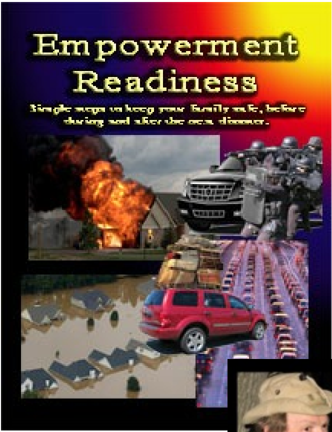
Empowerment Readiness



Take responsibility now!

Helpful Videos

Foreword
Tom Cassilly

“Be Prepared” has been the Boy Scout motto for the last 100 years. These two words have inspired generations to learn, plan, and be ready for life’s challenges. I have the privilege of being a scoutmaster and teaching young men the skills necessary to survive in this complex world. My father was an Eagle Scout for 74 years and is my inspiration to carry on this tradition of learning. He taught me how to camp in all seasons with all types of gear. He taught me that with proper planning “roughing it” could be both fun and comfortable. Each camping experience provided a new opportunity to try new skills and practice what I already knew.

After 40 years of camping with family and the Boy Scouts I thought I pretty well knew all the tricks. Then I met Gerald Pinckard; he was a fellow scoutmaster who visited my troop and asked if I needed any help. The adventure began that evening. It didn’t take me long to realize that he knew the true meaning of “Be Prepared”. We camped and hiked in all seasons and all weather. Most of the time we used gear we made ourselves. Alcohol stoves from soda cans and tents made from visqueen were the order of the day. What I have learned and continue to learn from Gerald is “The more you know, the less you need”. After you read his book, practice the outdoor skills, make your own survival kits for home and auto, you will know what it means to “Be Prepared”.

As found in “Empowerment Readiness”

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As found in “Empowerment Readiness”

First Aid Index

As found in “Empowerment Readiness”

AUTHORS RANT

Are you as tired of all the mega-disaster and end of the world movies as am I?

Disasters come in all forms. Quite often the difference between a large or small disaster is perception; large when the roads ice over and you are stranded for hours or days on the highway, or small when you must get out of your car in bad weather and install your snow chains, thus turning a 30 minute commute into a 2 hour trek. The difference is what this book is all about.

Optimism bias: The false belief. that it can’t happen to me. Procrastination, apathy, complacency, and defeatism will kill as easily as a tornado.

You may be reading this because you know something could happen to you. Perhaps deep down you do not expect timely or honest help from the government. You know that your life is your responsibility.

Going whole hog with preparedness is not required. Empowerment takes just a little effort. A few simple easy steps have the potential to save you and your family’s life.

This manual is designed to aid those who are ready to do something, but are not quite sure what to do or where to start.

A little preparedness and forethought can mean the difference between a life-threatening situation and a nuisance. I am not promoting an under ground bunker with 500,000 rounds of ammunition and enough food for 3 years. The truth is smaller disturbances are more common and are a reality. Preparation (however small) will afford you considerable peace of mind.

This book is a self-help manual to provide information for those who choose to be responsible for their own safety. If you are intelligent enough to learn and help yourself, this book is for you. However if you expect the government to come to your rescue, I cannot help you.

Do something and do it now!

Note from the author:

Please feel free to pass this book along.
Send any one who wants a copy to
geraldpinckard.com/HVAC