Reference Guide

REFRIGERATION INFORMATION

Basic Refrigeration Cycle

Mechanical refrigeration is accomplished by a continuously circulating, evaporating and condensing a fixed supply of refrigerant in a closed system. Evaporation occurs at a low temperature and low pressure while condensation occurs at a high temperature and high pressure. Thus, it is possible to transfer heat from an area of low temperature (i.e., refrigerator cabinet) to an area of high temperature (i.e., kitchen).

Beginning the cycle at the evaporator inlet (1) the low pressure liquid expands, absorbs heat and evaporates, changing to a low pressure gas at the evaporator outlet (2).

The compressor (4) pumps this gas from the evaporator through the accumulator (3), increases its pressure, and discharges the high pressure gas to the condenser (5). The accumulator is designed to protect the compressor by preventing slugs of liquid refrigerant from passing directly into the compressor. An accumulator should be included on all systems subjected to varying load conditions or frequent compressor cycling. In the condenser, heat is removed from the gas, which then condenses and becomes a high pressure liquid. In some systems, this high pressure liquid drains from the condenser into a liquid storage or receiver tank (6). On other systems, both the receiver and the liquid line valve (7) are omitted.

A heat exchanger (8) between the liquid line and the suction line is also an optional item, which may or may not be included in a given system design.

Between the condenser and the evaporator an expansion device (10) is located. Immediately preceding this device is a liquid line strainer/drier (9), which prevents plugging of the valve or tube by retaining scale, dirt and moisture. The flow of refrigerant into the evaporator is controlled by the pressure differential across the expansion device or, in the case of a thermal expansion valve, by the degree of superheat of the suction gas. Thus, the thermal expansion valve shown requires a sensor bulb located at the evaporator outlet. In any case, the flow of refrigerant into the evaporator normally increases as the evaporator load increases.

As the high pressure liquid refrigerant enters the evaporator, it is subjected to a much lower pressure due to the suction of the compressor and the pressure drop across the expansion device. Thus, the refrigerant tends to expand and evaporate. In order to evaporate, the liquid must absorb heat from the air passing over the evaporator.

Eventually, the desired air temperature is reached and the thermostat or cold control (11) will break the electrical circuit to the compressor motor and stop the compressor.

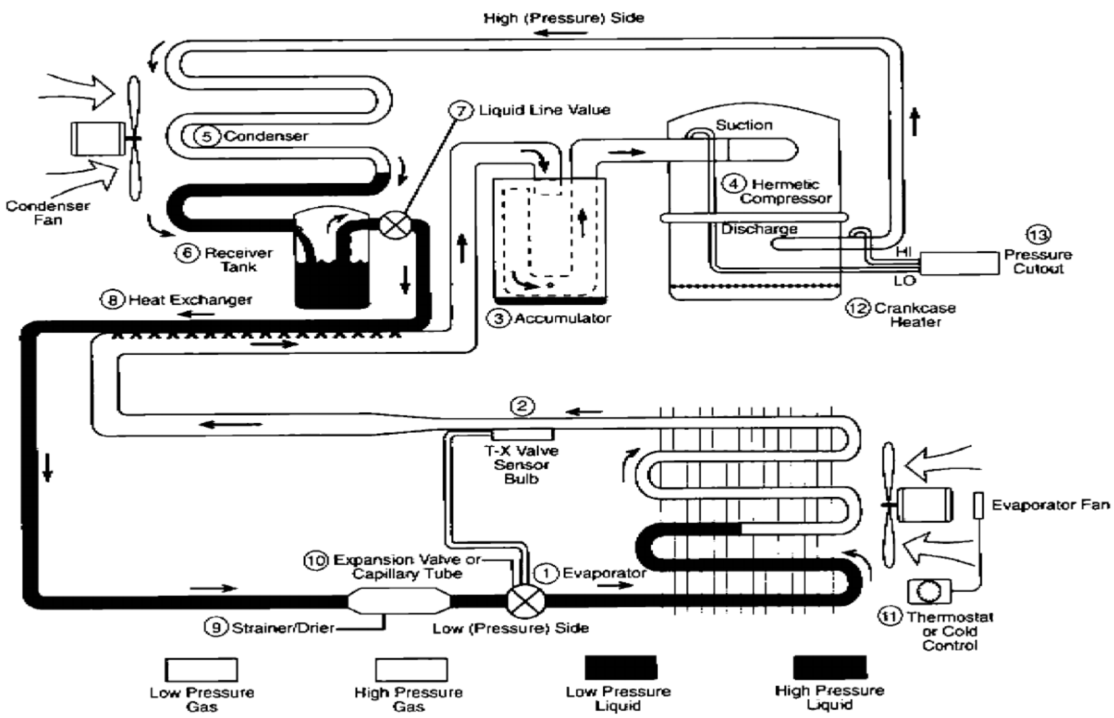
As the temperature of the air through the evaporator rises, the thermostat or cold control remakes the electrical circuit. The compressor starts, and the cycle continues.

In addition to the accumulator, a compressor crankcase heater (12) is included on many systems. This heater prevents accumulation of refrigerant in the compressor crankcase during the nonoperating periods and prevents liquid slugging or oil pump-out on startup.

Additional protection to the compressor and system is afforded by a high and low pressure cutout (13). This control is set to stop the compressor in the event that the system pressures rise above or fall below the design operating range.

Other controls not indicated on the basic cycle which may be part of a system include: evaporator pressure regulators, hot gas by-pass regulators, electric solenoid valves, suction pressure regulators, condenser pressure regulators, low side or high side float refrigerant controllers, oil separators, etc.

It is extremely important to analyze completely every system and understand the intended function of each component before attempting to determine the cause of a malfunction or failure.



Reference Guide

SPLIT TROUBLESHOOTING AC GUIDE

Company name ______________________ Technician name ______________ Date __________

Customer name ______________ Indoor wet bulb ________ Indoor dry bulb ________ Outdoor dry bulb ________

Design suction pressure on charging chart ______ Design discharge pressure on charging chart ______________

Outdoor temp next to condenser ________ Primary voltage (loaded) __________ Secondary (low) voltage __________

Amps to outdoor motor ____________ Compressor amps: Common ________ Run ________ Start ________

Capacitor rating ______________

Return temp at grill ______________ Return temp at unit __________

Supply temp at unit ______________ Supply temp at registers ________ ________ ________ ________

shortest run | middle run | furthest run

Blower speed tap for PSC & CTM	
Cooling CFM setting on VS motor	
Heating CFM setting on VS motor	

Number of green CFM flashes at air handler ______________

Leaving air temp __________

Temp drop across dryer and check valve __________

Discharge temp __________

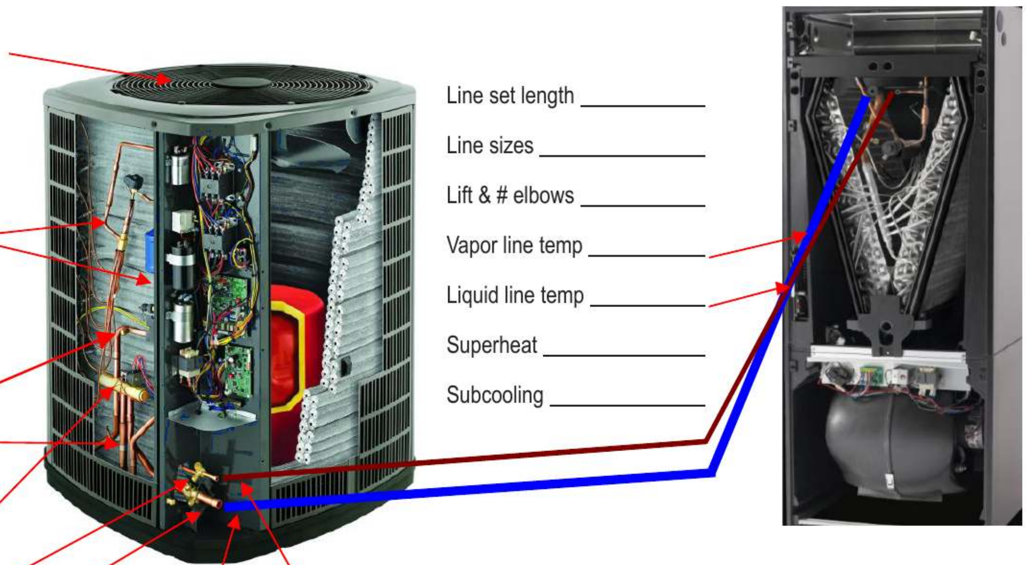
Discharge press __________

Suction press __________

Temp rise on suction lines across valve __________

Liquid pressure __________

Vapor pressure __________



Line set length ________

Line sizes ________

Lift & # elbows ________

Vapor line temp ________

Liquid line temp ________

Superheat ________

Subcooling ________

Liquid line temp __________

Vapor line temp __________

Return static with filter__________ Return static w/o filter ____________ Filter type ________ Filter size ________

Supply static with filter __________

Condenser Model #____________________ Condenser Serial #____________________

Air Handler Model # ____________________ Air Handler Serial # ____________________

Coil Model# ____________________ Coil Serial #____________________

Furnace Model # ____________________ Furnace Serial # ____________________

Refer to manufacturer's instructions and local codes.

Reference Guide

AC / REFRIGERATION: MEASURING LIQUID SUBCOOLING LEVEL

You must measure the liquid subcooling level to confirm there is adequate refrigerant charge in the condenser coil.

Inadequate subcooling could cause flash gas to form in the liquid line. Excessive shooting is an indication of an overcharged system.

REQUIRED TOOLS: DIGITAL TEMPERATURE PROBE, REFRIGERATION GAUGES

1. Run the condensing unit until pressures and temperature stabilize.
2. Read and record the liquid pressure at the liquid line pressure port fitting at the condensing unit.
3. Place a digital temperature probe against the liquid line near the liquid gauge pressure port. Read and record the temperature.
4. Reference the face of your high pressure gauge or use a temperature/ pressure chart and convert the measured liquid pressure to the corresponding condenser coil saturation temperature for the refrigerant being used. Record this value.
5. Next, subtract the measured liquid line temperature from saturation temperature. The result is your actual liquid subcooling level.

FORMULA:

Saturation Temperature
\- Liquid Line Temperature

Liquid Subcooling

EXAMPLE:

Refrigerant: R-410A

Liquid Line Pressure: 320 PSIG

Correponding Condenser Saturation Temperature 100°F

Liquid Line Temperature: 90°F

100°F - 90°F = Liquid Subcooling

Liquid Subcooling = 10°F

Reference Guide

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REFRIGERATION TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSES	POSSIBLE CORRECTIVE STEPS
Compressor will not run	1. Main switch open. 2. Fuse blown. 3. Thermal overloads tripped. 4. Defective contactor or coil. 5. System shut down by safety devices. 6. No cooling required. 7. Liquid line solenoid will not open. 8. Motor electrical trouble. 9. Loose wiring. 10. Phase loss monitor inoperative.	1. Close switch. 2. Check electrical circuits and motor winding for shorts or grounds. Investigate for possible overloading. Replace fuse after fault is corrected. 3. Overloads are automatically reset. Check unit closely when unit comes back on line. 4. Repair or replace. 5. Determine type and cause of shutdown and correct it before resetting safety switch. 6. None. Wait until calls for cooling. 7. Repair or replace coil. 8. Check motor for open windings, short circuit or burn out. 9. Check all wire junctions. Tighten all terminal screws. 10. Refer to page 18.
Compressor noisy or vibrating	1. Flooding of refrigerant into crankcase. 2. Improper piping support on suction or liquid line. 3. Worn compressor. 4. Scroll compressor rotation reversed.	1. Check setting of expansion valves. 2. Relocate, add or remove hangers. 3. Replace. 4. Rewire for phase change.
High discharge pressure	1. Non-condensables in system. 2. System overcharges with refrigerant. 3. Discharge shutoff valve partially closed. 4. Fan not running. 5. Head pressure control setting. 6. Dirty condenser coil.	1. Remove the non-condensables. 2. Remove excess. 3. Open valve. 4. Check electrical circuit. 5. Adjust. 6. Clean.
Low discharge pressure	1. Faulty condenser temperature regulation. 2. Suction shutoff valve partially closed. 3. Insufficient refrigerant in system. 4. Low suction pressure. 5. Variable head pressure valve.	1. Check condenser control operation. 2. Open valve. 3. Check for leaks. Repair and add charge. 4. See corrective steps for low suction pressure. 5. Check valve setting.
High suction pressure	1. Excessive load. 2. Expansion valve overfeeding.	1. Reduce load or add additional equipment. 2. Check remote bulb. Regulate superheat.
Low suction pressure	1. Lack of refrigerant. 2. Evaporator dirty or iced. 3. Clogged liquid line filter drier. 4. Clogged suction line or compressor suction gas strainers. 5. Expansion valve malfunctioning. 6. Condensing temperature too low. 7. Improper TXV.	1. Check for leaks. Repair and add charge. 2. Clean. 3. Replace cartridge(s). 4. Clean strainers. 5. Check and reset for proper superheat. 6. Check means for regulating condensing temperature. 7. Check for proper sizing.
Little or no oil pressure	1. Clogged suction oil strainer. 2. Excessive liquid in crankcase. 3. Low oil pressure safety switch defective. 4. Worn oil pump. 5. Oil pump reversing gear stuck in wrong position. 6. Worn bearings. 7. Low oil level. 8. Loose fitting on oil lines. 9. Pump housing gasket leaks.	1. Clean. 2. Check crankcase heater. Reset expansion valve for higher superheat. Check liquid line solenoid valve operation. 3. Replace. 4. Replace. 5. Reverse direction of compressor rotation. 6. Replace compressor. 7. Add oil and/or through defrost. 8. Check and tighten system. 9. Replace gasket.
Compressor loses oil	1. Lack of refrigerant. 2. Excessive compression ring blowby. 3. Refrigerant flood back. 4. Improper piping or traps.	1. Check for leaks and repair. Add refrigerant. 2. Replace compressor. 3. Maintain proper superheat at compressor. 4. Correct piping.
Compressor thermal protector switch open.	1. Operating beyond design conditions. 2. Discharge valve partially shut. 3. Blown valve plate gasket. 4. Dirty condenser coil. 5. Overcharged system.	1. Add facilities so that conditions are within allowable limits. 2. Open valve. 3. Replace gasket. 4. Clean coil. 5. Reduce charge.

Refer to manufacturer's instructions and local codes.

Reference Guide

FURNACE TROUBLESHOOTING GUIDE

Company name ____________ Technician name ____________ Date ____________

Customer name ____________

Flash code ____________ Elevation of home ____________ High altitude kit used ____________ Natural or LP gas ____________

Primary voltage: Hot to neutral ____________ Hot to ground ____________

Neutral to ground ____________ Line neutral to 24 V common ____________ Flame rectification ____________

Secondary voltage ____________ Is secondary physically grounded ____________ Low fire pressure ____________

Inlet gas pressure ____________ High fire pressure ____________

Return temp at grill ____________ Return temp at unit ____________

Supply temp at unit ____________ Supply temp at registers ____________ ____________ shortest run ____________ middle run ____________ furthest run

Blower speed tap for PSC & CTM
Cooling CFM setting on VS motor
Heating CFM setting on VS motor

Number of green CFM flashes at furnace ____________

Combustion blower amps____________ System blower amps ____________ Flue size ____________

Length of flue ____________ # of elbows ____________ # of 45's ____________

Combustion length ____________ # of elbows ____________ # of 45's ____________

High fire vent pressure on 80% ____________

High fire vent pressure differential between combustion box and secondary heat exchanger on 90+% ____________

Return static with filter____________ Return static w/o filter ____________ Filter type ____________Filter size ____________

Furnace position: Upflow____________ Downflow ____________

Supply static above coil (w/filter in place) ____________ Supply static between furnace & coil if possible (w/filter) ____________

Horizontal laying on left side ____________ Horizontal laying on right side ____________

Furnace Model # ____________ Furnace Serial #____________

Coil Model # ____________ Condenser Model # ____________

Reference Guide

AIR FLOW IN CFM GAS FIRED FURNACE

$$CFM = \frac{\text{BTU OUTPUT}}{\text{TEMP RISE X 1.08}}$$

EXAMPLE:

SUPPLY AIR = 150°

RETURN AIR = 75°

TEMP RISE = 75°

75 x 1.08 - 81°

FURNACE OUTPUT = 100,000 BTU

$$\frac{100{,}000}{81} = 1235 \text{ CFM}$$

NOTES:

- Switch cooling and heating speeds on board
- Make sure furnace gas pressure = 3.5" BTU
- Wait ten minutes before measuring temperature

Refer to manufacturer's instructions and local codes.

Reference Guide

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FURNACE FAULT DIAGNOSTICS

LED FLASH	LED FLASH
Slow Flash	Normal standby
Fast Flash	Normal with a call for heat.
Continuous ON	Internal fault in the IFC.
2 Flashes	System lockout - no flame. Total of three tries. Automatic reset in one hour.
3 Flashes	Pressure switch error. (Fault may be caused by a vent problem or a wiring connection in the switch circuit.) On two speed furnaces, if there is a high heat pressure switch fault, the IFC will not lock out. It will go back to low heat, cancel the three flash indication for ten minutes and again try high heat.
4 Flashes	Thermal protection device open.
5 Flashes	Flame being sensed with gas valve de-energized (stuck open). Vent motor and indoor blower will be energized.
6 Flashes	No ground or power leads to furnace reversed, or line voltage too low.
7 Flashes	20VAC at gas valve with no call for heat or if no flame is present; keep vent motor on.
8 Flashes	Low flame sense signal.
9 Flashes	Ignitor fault or improper ground or low voltage.

2 Flash code:

- HSI Check (sini) 11-18 ohms & 85 volts
- Flame sensor 2-4 DCMA 1 MIN
- Inlet & Manifold pressure 5' min. inlet
- 1.4" - 1.7" 1st stage 3.5" 2nd stage nat.
- 6.0" 1st stage 10.5" - 11" 2nd stage lp

3 Flash code:

- Monitor negative pressure developed by inducer
- Check against pressure switch rating
- Check for restriction in vent
- Check to see if inducer is running at correct speed

4 Flash code:

- Check filter
- Check blower operation
- Check supply and return registers
- Measure static pressure
- For flame rollout check inducer, vent pipe
- Combustion air

5 Flash code:

- DO NOT TURN OFF POWER
- Check for grounded flame sensor
- Replace gas valve

6 Flash code:

- Voltage check 120 hot to neutral
- Neutral to ground should be 0 volts
- Check furnace grounds
- IFC CNT4677 & 4678 ohm & volt check
- On HSI

7 Flash code:

- Check for 24 volts at gas valve & IFC
- Valve energized before HSI replace IFC

8 Flash code:

- Check flame sensor, clean

9 Flash code:

- Ohm ignitor 11 - 18 for sini
- Check ground
- Check voltage between neutral & b/c term on IFC less than 2 vac
- CNT4677 & 4678 boards inducer limit open

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HEATING & AIR CONDITIONING

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FURNACE FAULT DIAGNOSTICS

The diagnostics will indicate the specific fault through the following code:

GREEN LED FLASH	AMBER LED FLASH	RED LED FLASH	ERROR
		1	Flame sensed when no flame should be present
		2	Pressure switch stuck closed
		3	1st stage pressure switch is open / not closing
		4	Open thermal limit or open rollout
		5	Open low voltage fuse
		6	1st stage pressure switch opened 5 times within one cycle—1 hour lockout
		7	System lockout - retry
		8	System lockout - recycle
		9	Reverse polarity or poor grounding
		10	Gas valve energized without call for heat
		12	Ignitor relay failure internal in board. Replace IFC
		Solid	Gas valve relay failure internal board. Replace IFC
		3 Double	2nd stage pressure switch open; system reverts back to 1st stage heat
	1		1st stage call for heat
	2		2nd stage call for heat
	3		W2 call present without W1
	4		Y call present withough G
	Rapid		Low flame sense current
1			Standby mode or call for cooling

Refer to manufacturer's instructions and local codes.

GAS PIPING INFORMATION

TABLE 402.3(1)
MAXIMUM CAPACITY OF PIPE IN CUBIC FEET OF GAS PER HOUR FOR GAS PRESSURES OF 0.5 PSI OR LESS AND A PRESSURE DROP OF 0.3-INCH WATER COLUMN
Based on a 0.60 Specific Gravity Gas

NOMINAL IRON PIPE SIZE (inches)	INTERNAL DIAMETER (inches)	LENGTH OF PIPE (feet)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/4	.364	32	22	18	15	14	12	11	11	10	9	8	8	7	6
3/8	.493	72	49	40	34	30	27	25	23	22	21	18	17	15	14
1/2	.622	132	92	73	63	56	50	46	43	40	38	34	31	28	26
3/4	.824	278	190	152	130	115	105	96	90	84	79	72	64	59	55
1	1.049	520	350	285	245	215	195	180	170	160	150	130	120	110	100
1 1/4	1.380	1,050	730	590	500	440	400	370	350	320	305	275	250	225	210
1 1/2	1.610	1,600	1,100	890	760	670	610	560	530	490	460	410	380	350	320
2	2.067	3,050	2,100	1,650	1,450	1,270	1,150	1,050	990	930	870	780	710	650	610
2 1/2	2.469	4,800	3,300	2,700	2,300	2,000	1,850	1,700	1,600	1,500	1,400	1,250	1,130	1,050	980
3	3.068	8,500	5,900	4,700	4,100	3,600	3,250	3,000	2,800	2,600	2,500	2,200	2,000	1,850	1,700
4	4.026	17,500	12,000	9,700	8,300	7,400	6,800	6,200	5,800	5,400	5,100	4,500	4,100	3,800	3,500

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m^3/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

TABLE 402.3(2)
MAXIMUM CAPACITY OF PIPE IN CUBIC FEET OF GAS PER HOUR FOR GAS PRESSURES OF 0.5 PSI OR LESS AND A PRESSURE DROP OF 0.5-INCH WATER COLUMN
Based on a 0.60 Specific Gravity Gas

NOMINAL IRON PIPE SIZE (inches)	INTERNAL DIAMETER (inches)	LENGTH OF PIPE (feet)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/4	.364	43	29	24	20	18	16	15	14	13	12	11	10	9	8
3/8	.493	95	65	52	45	40	36	33	31	29	27	24	22	20	19
1/2	.622	175	120	97	82	73	66	61	57	53	50	44	40	37	35
3/4	.824	360	250	200	170	151	138	125	118	110	103	93	84	77	72
1	1.049	680	465	375	320	285	260	240	220	205	195	175	160	145	135
1 1/4	1.380	1,400	950	770	660	580	530	490	460	430	400	360	325	300	280
1 1/2	1.610	2,100	1,460	1,180	990	900	810	750	690	650	620	550	500	460	430
2	2.067	3,950	2,750	2,200	1,900	1,680	1,520	1,400	1,300	1,220	1,150	1,020	950	850	800
2 1/2	2.469	6,300	4,350	3,520	3,000	2,650	2,400	2,250	2,050	1,950	1,850	1,650	1,500	1,370	1,280
3	3.068	11,000	7,700	6,250	5,300	4,750	4,300	3,900	3,700	3,450	3,250	2,950	2,650	2,450	2,280
4	4.026	23,000	15,800	12,800	10,900	9,700	8,800	8,100	7,500	7,200	6,700	6,000	5,500	5,000	4,600

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m^3/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

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METER CLOCKING METHOD

Meter Clocking Method

Caution: Make certain there is no gas flow through the meter other than to the appliance being checked.
Use Table to determine exact rate of gas flow to appliance.

METER FLOW RATE – CUBIC FEET PER HOUR (cfh).

To convert cfh to cubic meter per hour (M^3/hr) multiply by .0283.

Sec for One Rev.	Meter Dial Used - Cu. Ft. per Rev.		Sec for One Rev.	Meter Dial Used - Cu. Ft. per Rev.			Sec for One Rev.	Meter Dial Used - Cu. Ft. per Rev.		
	1/2	1		1/2	1	2		1	2	5
10	180	360	35	52	103	206	60	60	120	300
11	164	327	36	50	100	200	62	58	116	290
12	150	300	37	49	97	195	64	56	112	281
13	139	277	38	48	95	189	66	55	109	273
14	129	257	39	46	92	185	68	53	106	265
15	120	240	40	45	90	180	70	52	103	257
16	113	225	41	44	88	176	72	50	100	250
17	106	212	42	43	86	172	74	49	97	243
18	100	200	43	42	84	167	76	48	95	237
19	95	189	44	41	82	164	78	46	92	231
20	90	180	45	40	80	160	80	45	90	225
21	86	171	46	39	78	157	84	43	86	214
22	82	164	47	38	77	153	88	41	82	205
23	78	157	48	38	75	150	92	39	78	196
24	75	150	49	37	74	147	96	38	75	188
25	72	144	50	36	72	144	100	36	72	180
26	69	138	51	35	71	141	105	34	69	172
27	67	133	52	35	69	138	110	33	66	164
28	64	129	53	34	68	136	120	30	60	150
29	62	124	54	33	67	133	130	28	55	138
30	60	120	55	33	66	131	140	26	52	129
31	58	116	56	32	64	129	150	24	48	120
32	56	113	57	32	63	126	160	23	45	113
33	55	109	58	31	62	124	170	21	43	106
34	53	106	59	31	61	122	180	20	40	100

To convert meter flow rate (cfh) to BTU per hour, multiply cfh (from table above) by the BTU heat content of the gas being used.

To convert input rating (BTU per hour as stamped on appliance nameplate) to meter flow rate (cfh).

Input rating in BTU per hour.

Input BTU/Hr. Per Spud	Natural Gas 1020 BTU - .65 SG 3-1/2" WC Manifold Drill Size	Natural Gas Decimal Tolerance	Propane 2500 BTU - 1.5 SG 11" WC Manifold Drill Size	Propane Decimal Tolerance
12,000	51	.064 - .067	60	.038 - .040
15,000	48	0.73 - .076	58	.040 - .042
20,000	43	.086 - .089	55	.050 - .052
25,000	41	.093 - .096	53	.056 - .059
27,500	39	.097 - .100	53	.060 - .063
40,000	32	.113 - .116	49	.070 - .073
50,000	30	.124 - .128	46	.078 - .081
60,000	27	.140 - .144	43	.086 - .089
70,000	22	.153 - .157	42	.090 - .093
80,000	20	.156 - .161	40	.095 - .098
90,000	17	.168 - .173	38	.098 - .101
100,000	13	.180 - .185	35	.107 - .110
105,000	11	.186 - .191	34	.108 - .111
110,000	10	.188 - .193	33	.109 - .113
125,000	5	.200 - .205	1/8	.121 - .125
135,000	3	.208 - .213	30	.124 - .128
140,000	7/32	.214 - .219	30	.124 - .128
150,000	1	.223 - .228	29	.132 - .136
160,000	A	.229 - .234	28	.136 - .140
175,000	C	.237 - .242	27	.140 - .144
190,000	E	.245 - .250	25	.145 - .149
200,000	F	.252 - .257	23	.150 - .154
210,000	H	.261 - .266	21	.154 - .159
220,000	I	.267 - .272	20	.156 - .161
240,000	K	.276 - .281	18	.164 - .169
260,000	M	.290 - .295	16	.172 - .177
280,000	5/16	.307 - .312	13	.180 - .185
300,000	O	.311 - .316	11	.186 - .191
310,000	P	.318 - .323	9	.191 - .196
320,000	21/64	.323 - .328	7	.196 - .201

Refer to manufacturer's instructions and local codes.

Reference Guide

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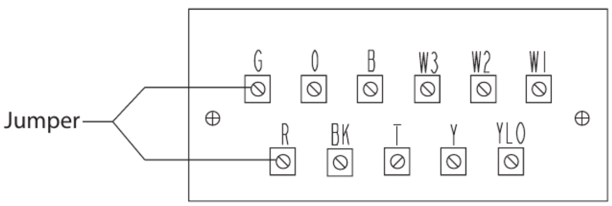
FURNACE QUICK CHECK MOTOR WILL NOT RUN

These service procedures will work on ECM-2™ motors and their motor control board and their 16 wire low voltage control cable.

1. **Jumper 24 Volt A.C. “R” terminal to “G” terminal on the low voltage terminal board.**

   Does motor run?

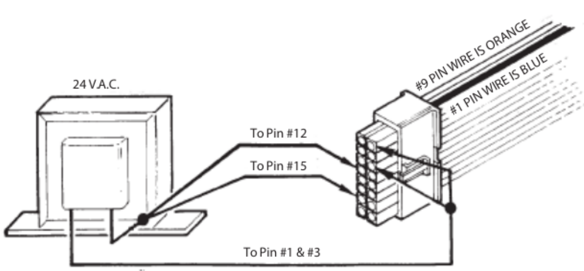
   No: Go to step #2
   Yes: Motor runs, check comfort control and comfort control wire.



2. **Unplug 16 wire low voltage harness from the interface board. Jumper 24 volts A.C. to pins #12, #15 and common pins #1 and #3.**

   Does the motor run?

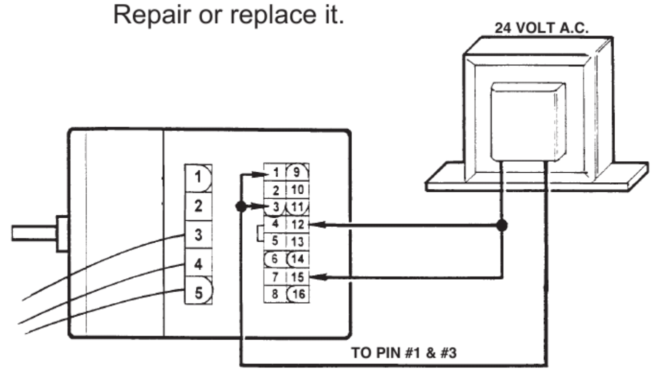
   No: Go to step #3.
   Yes: Replace the variable speed interface board on the furnace.



3. **Unplug 16 wire low voltage harness from the motor. Jumper 24 volts A.C. to motor low voltage plug pins #12 and #15 and pins #1 and #3 which are common.**

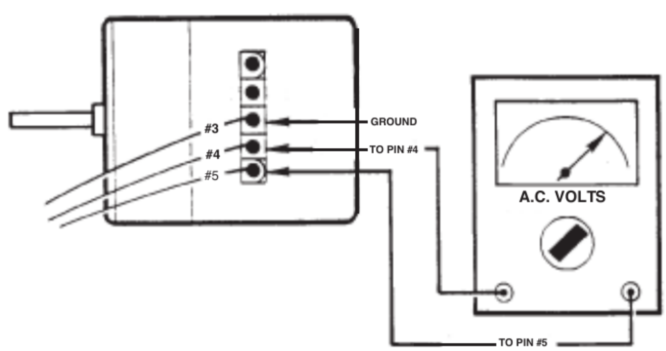
   Does motor run?

   No: Got to step #4.
   Yes: Fault is in the 16 wire low voltage harness. Repair or replace it.



4. **Is the line voltage to the motor high voltage power plug pin #4 and pin #5 correct?**

   No: Correct line voltage fault.
   Yes: Live voltage correct and motor will not run. Replace module.



Reference Guide

HYDRONIC FORMULAS

COMPUTING FLOW FROM BTU/h	
Simplified formula	GPM = BTU/h ÷ (Δt x 500)
Example: Determine the flow of 286,000 BTU/h at a 20°F differential temperature.	GPM = 286,000 ÷ (20 x 500) GPM = 286,000 ÷ 10,000 GPM = 28.6

CALCULATING ACTIVE LOOP LENGTH	
Note: The leader length must be added to the active loop length in order to obtain the total loop length.	Room ft^2 x 1.0 = active loop at 12" o.c. Room ft^2 x 1.2 = active loop at 10" o.c. Room ft^2 x 1.33 = active loop at 9" o.c. Room ft^2 x 1.5 = active loop at 8" o.c. Room ft^2 x 1.7 = active loop at 7" o.c. Room ft^2 x 2.0 = active loop at 6" o.c.

AMOUNT OF JOIST TRAK™ PANELS (A5080375, A5080500)
Active loop length x 0.2125

AMOUNT OF QUIK TRAK™ PANELS (A5060701) AND RETURNS (A5060702)
Room ft^2 x 0.386 (panels)
Room ft^2 x 0.386 (panels)

AMOUNT OF PEX CLIPS (F7060375, F7051258, F7057500, F7051001)
Active Loop Length ÷ 3

FLOOR SURFACE TEMPERATURE
(BTU/h/ ft^2 ÷ 2.0) + Room setpoint

SUPPLY FLUID TEMP. AFTER FIRST INJECTION POINT ON PRIMARY LOOP	
$(F_A \times T_A) + (F_B \times T_B) = (F_C \times T_C)$	
F_A = Primary flow rate after injection leg F_B = Flow rate for return injection leg F_C = Primary flow rate after return leg T_A = Primary temp. after injection leg T_B = Return temp. on return injection leg T_C = Primary temp. after return leg	
Example: Given the detail above, calculate the primary loop (boiler loop) temperature after the first injection location.	(7 x 180) + (3 x 160) = 10x 1260 + 480 = 10x 1740 = 10x The primary loop temperature after the first injection location is 174°F.

INJECTION PUMP FLOW RATES	
$F_V = (F_1 \times T_D) \div (T_1 - T_R)$	
F_V = Flow rate (injection loop) in gpm F_1 = Radiant (secondary loop) flow rate in gpm T_1 = Boiler (primary loop) supply temp. T_2 = Radiant (secondary loop) supply temp. T_R = Radiant (secondary loop) return temp. T_D = Radiant (secondary loop) differential temp.	
Example: If values at design condition are: F_1 = 30 gpm T_1 = 180°F T_2 = 130°F T_R = 120°F T_D = 10°F	Find the injection pump flow rate. F_V = (30 x 10) ÷ (180 - 120) F_V = (300) ÷ (60) F_V = 5 gpm

LOADED FOR MOTORIZED VALVE ACTUATORS (MVA) Computed at a minimum 10% line loss
MVA draw: 0.29 amps Amps x volts = current 0.29 x 24 = 6.96 VA per MVA
Example: 50 VA ÷ 6.96 VA = 7.18 x 0.9 = 6.5 (10%) 6 MVA per 50 VA transformer 40VAC transformer = 5 MVA 50VAC transformer = 6 MVA 75VAC transformer = 9 MVA 100VAC transformer = 12 MVA

LOADED FOR THERMAL ACTUATORS (TA) Computed at a minimum 10% line loss
TA initial draw: 0.1458 amps Amps x volts = current 0.1458 x 24 = 3.5 VA per TA
Example: 50 VA ÷ 3.5 VA = 14.29 14.29 x 0.9 = 12.83 (10% reduction) 12 TAs per 50 VA transformer 40VAC transformer = 10 TA 50VAC transformer = 12 TA 75VAC transformer = 19 TA 100VAC transformer = 25 TA

Continued on next page

Refer to manufacturer's instructions and local codes.

Reference Guide

HYDRONIC FORMULAS

Continued ...

LOADED FOR THERMAL ACTUATORS (TA)
Computed at a minimum 10% line loss

Fuel consumption based on degree day:

$$F = \frac{HL \times 24 \times DD}{E \times P \times TD}$$

HL = Heating load (BTU/h)

24 = Hours in a day

DD = Degree day

E = Boiler efficiency (AFUE)

P = Heating value of fuel (BTU)

TD = Temperature differential

F = Annual fuel consumption

Example: A 40,000 square-foot hangar in Bangor, Maine using an 82% AFUE oil boiler (Number 2 fuel oil). The heat load for the hangar is 1,288,128 BTU/h at design. Outside design temperature is -11°F with an indoor setpoint temperature of 65°F. Number 2 fuel oil is priced at $0.80 per gallon.

$$F = \frac{1{,}288{,}128 \times 24 \times 8{,}220}{0.82 \times 138{,}000 \times 76}$$

$$F = \frac{254{,}121{,}891.840}{8{,}662{,}480}$$

F = 29,335.93 gallons of fuel oil

F = 29,335.93 x 0.80 = $23,469/season

FUEL COMPARISON IN BTU

Natural Gas	100,000 BTU per 1 CCF (1 therm.)
Propane	91,800 BTU per gallon
No. 2 Fuel Oil	139,000 BTU per gallon
Kerosene	134,000 BTU per gallon
Electric	3,412 BTU per Kilowatt Hour (KWH)
Wood	14,000,000 BTU per cord (mixed)

SUPPLY AND RETURN PIPE SIZING (AT A 10°F Δt)

Tubing	BTU/h	GPM	Pipe Size (in.)
Copper	10K - 20K	2-4	¾"
	20K - 45K	4-9	1"
	30K - 80K	6-16	1 ¼"
	50K - 105K	10-21	1 ½"
	100K - 225K	20-45	2"
Multi-layer Composite (MLC)	10K - 20K	2-4	¾"
	20K - 45K	4-8	1"
PEX (Wirsbo hePEX™ and Uponor AquaPEX®)	2.5K - 10K	0.5-2	½"
	5K - 15K	1-3	¾"
	15K - 25K	3-5	1"
	20K - 45K	4-9	1 ¼"
	30K - 70K	6-14	1 ½"
High-density Polyethylene (HDPE)	75K - 205K	15-41	2"
	150K - 575K	30-115	3"
	250K - 1,125K	50-225	4"

BOILER MAIN PIPE SIZING (AT A 20°F Δt)

Tubing	BTU/h	GPM	Pipe Size (in.)
Copper	20K - 40K	2-4	¾"
	40K - 90K	4-9	1"
	60K - 160K	6-16	1 ¼"
	100K - 210K	10-21	1 ½"
	200K - 450K	20-45	2"

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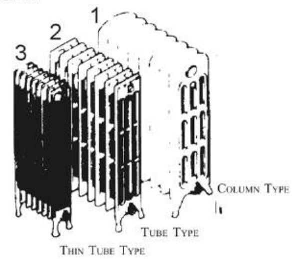
SQUARE FEET OF RADIATION PER SECTION

Radiator Ratings
All dimensions and ratings are approximate.

Radiator output ratings should be used for checking the total radiation on an existing heating plant.

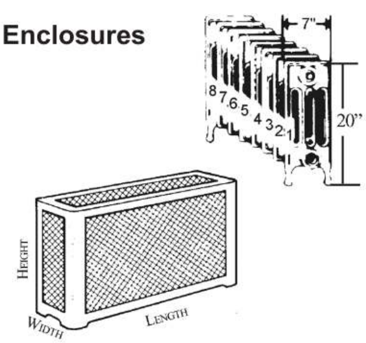
Shown below are the relative sizes of radiator styles. All are 4 tube (column), 8 section radiators. Each rating is different.



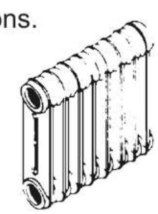
To identify the style of a radiator, count the number of tubes or columns. Then, check the width. When you have identified the style (1, 2, or 3) read the radiation per section beneath the radiator style.

Example: Radiator shown below is a 4-tube, 8-section, style 2 (tube type) radiator, 7" wide and 20" high. Multiplying the 2.2 square feet of radiation per section by 8 equals 17.6 square feet of radiation per radiator.

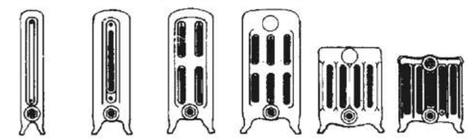
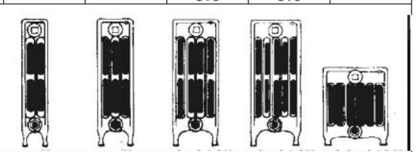
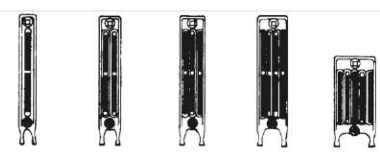
Radiator Enclosures



To determine the number of sections:
Divide length of cover in inches by 2, for example if length of cover is 24", then the radiator has 12 sections.



HEIGHT	SQUARE FT. RADIATION PER SECTION
37"	2 ½
28 ½"	1 ▯
21 ½"	1 ½
15"	1
13 ⅞"	¾

COLUMNS OR TUBES	1	2	3	4	5	6	7
OLD STYLE COLUMN RADIATORS WIDTH							
HEIGHT	4 ½"	7 ⅜"	9"	11 ½"	12 ½"	12 ½"	
45"	3.5	5.0	6.0	10.0			
38"	3.0	4.0	5	8.0	10.0		
32"	2.5	3.3	4.5	6.5	8.5		
26"	2.0	2.6	3.7	5.0	7.0	7.0	
23"	1.6	2.3	3.2	4.5			
22"	1.6	2.2	3.0	4.0	6.0	6.0	
20"	1.5	2.0	2.7	3.5	5.0	5.0	
18"	1.3	1.7	2.2	3.0	5.0	4.3	
17"						4.0	
16"					4.0	3.7	
15"		1.5					
14"					4.0	3.0	
13"					3.0	3.0	
TUBE TYPE							
WIDTH HEIGHT			5"	7"	8 ¼"	9 ¼"	12 ½"
38"			3.5	4.2	5.0	6.0	
36"			3.5	4.2	5.0	6.0	7.0
32"			3.0	3.5	4.3	5.0	6.0
26"			2.3	2.7	3.5	4.3	5.0
23"			2.0	2.5	3.0	3.5	4.5
22"							4.5
20"			1.7	2.2	2.6	3.0	3.6
18"							3.5
17"							3.0
16"							3.0
14"							2.5
THIN TUBE							
WIDTH HEIGHT		3 ½"	4"	4 ¼"	6"	7 ⅞"	
38"		2.5	2.8				
32"		2.0	2.6			3.4	
26"			2.4	2.4	3.0	3.0	
25"		1.5	1.8	2.1	2.4	3.0	
23"			1.7	2.0	2.3		
22"		1.3	1.6	1.8	2.2		
20"			1.5	1.7	2.1	2.3	
19"		1.1	1.4	1.6		2.3	

Coversion Factors
One sq. ft. of steam radiation = 240 Net BTHh
One sq. ft. of forced hot water = 185 Net BTUf at 190˚F

Refer to manufacturer's instructions and local codes.

REPLACEMENT BOILER SIZING CHART

Type of system ☐ Steam ☐ Forced hot water ☐ Gravity hot water

Type of fuel ☐ Natural Gas ☐ Oil

Output (Heating capacity) ____________________________**BTUh**

STANDING RADIATION				BASEBOARD RADIATION
ROOM	SQUARE FT. X PER SECTION (SEE PREVIOUS PAGE)	NUMBER OF = SECTIONS	RADIATION IN SQUARE FEET	LINEAL FEET (LENGTH OF FINNED TUBE ONLY)

TOTAL SQUARE FEET OF RADIATION ____________

X COVERSION FACTOR (SEE BELOW) ____________

TOTAL BTUh LOAD ____________

TOTAL LINEAL FEET ____________

X 600 BTU/FT. ____________

____

Input ____________________ **Heating capacity** ____________________

(Should be equal to or slightly greater than load.)

Conversion Factors

One sq. ft. of steam radiation = 240 Net BTHh

One sq. ft. of forced hot water = 185 Net BTUf at 190˚F

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HYDRONIC FORMULAS

ZONING MADE EASY

RULES OF THUMB

FLOW RATE

$$\frac{\text{NET BTUh LOAD}}{10{,}000} = \text{FLOW RATE}$$

MAXIMUM FLOW RATE

Pipe size (Copper)	Maximum Flow Rate
½"	1 ½ gpm
¾"	4 gpm
1"	8 gpm
1 ¼"	14 gpm

MAXIMUM FLOW RATE & HEAT CARRYING CAPACITY

Pipe size (Copper)	Maximum Flow Rate	Heat Carrying Capacity
½"	1 ½ gpm	15,000 BTUh
¾"	4 gpm	40,000 BTUh
1"	8 gpm	80,000 BTUh
1 ¼"	14 gpm	140,000 BTUh

(Based on 20°F temperature drop across the system.)

MAXIMUM LENGTH OF FIN-TUBE BASEBOARD LOOP

Baseboard Size (Copper)	Typical BTUh per Linear Foot	Maximum Length of Baseboard Loop
½"	600	25'
¾"	600	67'
1"	770	104'
1 ¼"	790	107'

(Based on 180°F average water temperature and a 20°F temperature drop across the system.)

MAXIMUM LENGTH OF FIN-TUBE BASEBOARD LOOP

1. Measure the longest run in feet.
2. Add 50% to this.
3. Multiply that by .04 ... and that's the pump head!

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ITT Industries
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Refer to manufacturer's instructions and local codes.

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FORMULAS

Formulas - Electrical

VOLTS =

$Amps \times Ohms$ $\quad \frac{Watts}{Amps}$ $\quad \sqrt{Watts \times Ohms}$

AMPS =

$\frac{Volts}{Ohms}$ $\quad \frac{Watts}{Volts}$ $\quad \sqrt{\frac{Watts}{Ohms}}$

WATTS =

$Volts \times Amps$ $\quad Amps^2 \times Ohms$ $\quad \frac{Volts^2}{Ohms}$

OHMS =

$\frac{Volts}{Amps}$ $\quad \frac{Volts^2}{Watts}$ $\quad \frac{Watts}{Amps^2}$

$$Power\ Factor = \frac{KW}{KVA} = Cos\ \Theta$$

	Single Phase	**Three Phase**
$KW =$	$\frac{\sqrt{\ } \times A \times PF}{1000}$	$\frac{\sqrt{3} \times V \times A \times PF}{1000}$
$KVA =$	$\frac{V \times A}{1000}$	$\frac{\sqrt{3} \times V \times A}{1000}$
$AMPS =$	$\frac{KVA \times 1000}{V}$	$\frac{KVA \times 1000}{\sqrt{3} \times V}$

$$\sqrt{3} = 173$$

Approx. Motor KVA = Motor Horsepower (At Full Load)

Capacitors Connected In Parallel $C_1 + C_2 + C_3 = C\ Total$

Capacitors Connected In Series

For Two

$$\frac{C_1 \times C_2}{C_1 + C_2} = C\ Total$$

More Than Two

$$\frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} = C\ Total$$

VOLTAGE UNBALANCE

% Voltage Unbalance =

$$\frac{100 \times Max.\ Voltage\ Deviation\ From\ Average\ Voltage}{Average\ Voltage}$$

BOOST TRANS.:

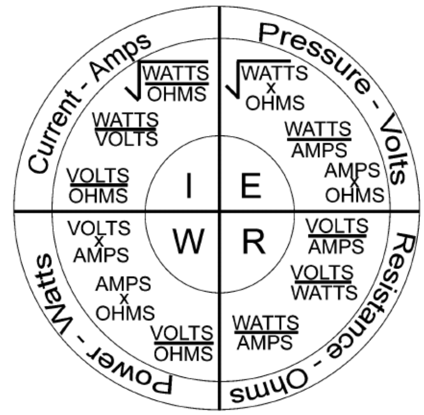
Rating Plate F.L.A. x Rating Plate VOLTS = KVA

$$\frac{Rating\ Plate\ VOLTS}{Rating\ Plate\ VOLTS - Norm.\ Line\ VOLTS} = FACTOR$$

$$\frac{KVA}{FACTOR} = Trans.\ KVA\ Rating$$

$$\left(\frac{V_2}{V_1}\right) 2 \times Heater\ Rating = Rating\ @\ New\ Voltage$$

V_1 Rated Volts $\quad V_2$ = Measured Volts



This chart shows four ways to figure each value: Amps (I), Volts (E), Ohms (R) or Watts (W).

Example: A 4800 Watt electric heat element is connected to a 240 Volt circuit. How many Amps does it draw?

Solution: Locate Amps section of chart: $\frac{\text{Watts (W)}}{\text{Volts (E)}}$ =Amps (I)

Thus 4800 ÷ 240 = 20 Amps. Carried further, what is the resistance?

$\frac{\text{Volts}^2\ E^2}{\text{Watts (W)}}$ = Ohms (R) 240 x 240 ÷ 4800 = 12 Ohms.

Conversion Table For Watts - Amperes - Volts

Watts	Voltage (C - Single Phase) 120	208	240	277
	Amperes			
500	4.2	2.4	2.1	1.8
1000	8.3	4.8	4.2	3.8
1500	12.5	7.2	6.3	5.4
2000	16.7	9.6	8.3	7.2
2500	20.9	12.0	10.4	9.0
3000	25.0	14.4	12.5	10.6
3500	29.2	16.8	14.5	12.6

Reference Guide

AIRFLOW VERSUS TEMPERATURE RISE

Airflow Versus Temperature Rise

HEAT OUTPUT		AIRFLOW – CUBIC FEET PER MINUTE																													
		400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300
KW	BTU	TEMPERATURE RISE – DEGREES FAHRENHEIT																													
3	10242	24	19	16	14	12																									
4	13656	32	25	21	18	16	14	13																							
5	17070	39	32	26	23	20	18	16	14	13																					
6	20484	47	38	32	27	24	21	19	17	16	15	14																			
7	23898	55	44	37	32	28	25	22	20	18	17	16	15	14																	
8	27312	63	51	42	36	32	28	25	23	21	19	18	17	16	15	14															
9	30726	71	57	47	41	36	32	28	26	24	22	20	19	18	17	16	15	14													
10	34140	79	63	53	45	39	35	32	29	26	24	22	21	20	19	18	17	16	15	14											
11	37554	87	69	58	50	43	39	35	32	29	27	25	23	22	20	19	18	17	16	15	14	13									
12	40968	95	76	63	54	47	42	38	34	32	29	27	25	24	22	21	20	19	18	17	16	15	14								
13	44382		82	68	58	51	46	41	37	34	32	29	27	26	24	23	22	21	20	19	18	17	16	15							
14	47796		89	74	63	55	49	44	40	37	34	32	30	28	26	25	23	22	21	20	19	18	17	16	15						
15	51210		95	79	68	59	53	47	43	39	36	34	32	30	28	26	25	24	23	22	21	20	19	18	17	16					
16	54624			84	72	64	56	50	46	42	38	36	34	32	30	28	27	25	24	23	22	21	20	19	18	17	16				
17	58038			89	77	67	60	54	49	45	41	38	36	34	32	30	28	27	26	24	23	22	21	20	19	18	17	16			
18	61452			95	82	72	64	56	52	48	44	40	38	36	34	32	30	28	27	26	25	24	23	22	20	19	18	17	16		
19	64866				86	75	67	60	55	50	46	42	40	38	36	34	32	30	29	27	26	25	24	23	22	21	20	19	18	17	
20	68280				90	79	70	63	57	53	49	45	42	40	37	35	33	32	30	29	27	26	25	24	23	22	22	21	20	20	19
21	71694				95	83	74	66	60	55	51	47	44	41	39	37	35	33	32	30	29	28	27	26	25	24	23	22	21	21	20
22	75108				99	87	77	69	63	58	53	50	46	43	41	39	37	35	33	32	30	29	28	27	26	25	24	23	22	22	21
23	78522					91	81	73	66	61	56	52	48	45	43	40	38	36	35	33	32	30	29	28	27	26	25	24	23	23	22
24	81936					95	84	76	69	63	58	54	51	47	45	42	40	38	36	34	33	32	30	29	28	27	26	25	24	24	23
25	85350					99	88	79	72	66	61	56	53	49	46	44	42	40	38	36	34	33	32	30	29	28	27	26	25	25	24
26	88764						91	82	75	68	63	59	55	51	48	46	43	41	39	37	36	34	33	32	30	29	28	27	26	26	25
27	92178						95	85	78	71	66	61	57	53	50	47	45	43	41	39	37	36	34	33	32	30	29	28	28	27	26
28	95592						98	88	80	74	68	63	59	55	52	49	47	44	42	40	38	37	35	34	33	32	31	30	29	28	27
29	99006							92	83	76	71	65	61	57	54	51	48	46	44	42	40	38	37	35	34	33	32	31	30	29	28
30	102420							95	86	79	73	68	63	59	56	53	50	47	45	43	41	40	38	36	35	34	33	32	31	30	29

Capacity of Gas Piping
Cu. Ft. Per Hour

(At pressure drop of 0.3 in. water. Specific gavity – 0.60.)

Pipe	Iron Pipe Size (IPS) Inches								
Lgth. Ft.	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
10	132	278	520	1050	1600	3050	4800	8500	17,500
20	92	190	350	730	1100	2100	3300	5900	12,000
30	73	152	285	590	890	1650	2700	4700	9700
40	63	130	245	500	760	1450	2300	4100	8300
50	56	115	215	440	670	1270	2000	3600	7400
60	50	105	195	400	610	1150	1850	3250	6800
70	46	96	180	370	560	1050	1700	3000	6200
80	43	90	170	350	530	990	1600	2800	5800
90	40	84	160	320	490	930	1500	2600	5400
100	38	79	150	305	460	870	1400	2500	5100
125	34	72	130	275	410	780	1250	2200	4500
150	31	64	120	250	380	710	1130	2000	4100
175	28	59	110	225	350	650	1050	1850	3800
200	26	55	100	210	320	610	980	1700	3500

Refer to manufacturer's instructions and local codes.

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DRILL SIZES & DECIMAL EQUIVALENTS

Drill Sizes

Drill number or Letter*	Decimal Equiv.
80	0.0135
79	0.0415
1/64	0.0156
78	0.016
77	0.018
76	0.020
75	0.021
74	0.0225
73	0.024
72	0.025
71	0.026
70	0.028
69	0.0292
68	0.031
1/32	0.0312
67	0.032
66	0.033
65	0.035
64	0.036
63	0.037
62	0.038
61	0.039
60	0.040
59	0.041
58	0.042
57	0.043
56	0.0465
3/64	0.0468
55	0.052
54	0.055
53	0.0595
1/16	0.0625
52	0.0635
51	0.067
50	0.070
49	0.073
48	0.076
5/64	0.0781
47	0.0785
46	0.081
45	0.082
44	0.086
43	0.089
42	0.0935
3/32	0.0937
41	0.096

Drill number or Letter*	Decimal Equiv.
40	0.098
39	0.0995
38	0.1015
37	0.104
36	0.1065
7/64	0.1094
35	0.110
34	0.111
33	0.113
32	0.116
31	0.120
1/8	0.1250
30	0.1285
29	0.136
28	0.1405
9/64	0.1406
27	0.144
26	0.147
25	0.1495
24	0.152
23	0.154
5/32	0.1562
22	0.157
21	0.159
20	0.161
19	0.166
18	0.1695
11/64	0.1719
17	0.173
16	0.177
15	0.180
14	0.182
13	0.185
3/16	0.1875
12	0.189
11	0.191
9	0.196
8	0.199
7	0.201
13/64	0.2031
6	0.204
5	0.2055
4	0.209
3	0.213
7/32	0.2187
2	0.221

Drill number or Letter*	Decimal Equiv.
1	0.228
A	0.234
15/64	0.2344
B	0.238
C	0.242
C	0.242
D	0.246
E & 1/4	0.250
F	0.257
G	0.261
17/64	0.2656
H	0.266
I	0.272
J	0.277
K	0.281
9/32	0.2812
L	0.290
M	0.295
19/64	0.2969
N	0.302
5/16	0.3125
O	0.316
P	0.323
21/64	0.3281
Q	0.332
R	0.339
11/32	0.3437
S	0.348
T	0.358
23/64	0.3594
U	0.368
3/8	0.375
V	0.377
W	0.386
25/64	0.3906
X	0.397
Y	0.404
13/32	0.4062
Z	0.413
27/64	0.4219
7/16	0.4375
29/64	0.4531
15/32	0.4687
31/64	0.4844
1/2	0.5000

NOTE: The shank of a numbered drill makes a good gauge to determine the inside diameter of capillary tubing or to measure gas burner orifices.

Decimal and Metric Equivalents

Equivalents of Common Fractions of An Inch

64ths	32nds	16ths	8ths	Decimal	Mm	—	64ths	32nds	16ths	8ths	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			0.53975	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			0.83475	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	25.033
			1/2	0.50000	12.700					1	1.00000	25.400

Reference Guide

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DUCT SIZING GUIDE

Residential Duct Sizing Guide

The following duct sizes are based on a fraction drop of .10 inches per 100 feet of lineal duct. This "Equal-Friction" method of duct sizing should be adecuate for normal residentia furnace heating and air conditioning applications. Larger air volumes or higher static pressures should be dealt with on an individual job basis.

Rectangular and Round Duct

Air Volume CFM	Duct Height Inches					Equivalent Round Duct"	Air Volume CFM
	4"	6"	8"	10"	12"		
50	6 x 4					5	50
75	6 x 4					6	75
100	8 x 4	6 x 6				6	100
125	10 x 4	6 x 6				7	125
150	10 x 4	8 x 6				7	150
175	12 x 4	8 x 6				8	175
200	14 x 4	8 x 6				8	200
225	16 x 4	10 x 6				8	220
250	16 x 4	10 x 6				9	250
275		12 x 6	8 x 8			9	275
300		12 x 6	8 x 8			9	300
400		14 x 6	10 x 8			10	400
500		18 x 6	12 x 8	10 x 10		11	500
600		20 x 6	14 x 8	12 x 10		12	600
700		24 x 6	16 x 8	12 x 10		12	700
800		26 x 6	18 x 8	14 x 10	12 x 12	13	800
900		30 x 6	20 x 8	16 x 10	12 x 12	14	900
1000			22 x 8	16 x 10	14 x 12	14	1000
1100			24 x 8	18 x 10	16 x 12	15	1100
1200			26 x 8	20 x 10	16 x 12	15	1200
1300			28 x 8	20 x 10	18 x 12	16	1300
1400			30 x 8	22 x 10	18 x 12	16	1400
1500				24 x 10	20 x 12	16	1500
1600				24 x 10	20 x 12	17	1600
1700				26 x 10	22 x 12	17	1700
1800				28 x 10	22 x 12	18	1800
1900				30 x 10	22 x 12	18	1900
2000					24 x 12	18	2000

Suggested Air Changes

Type of Building	Minute Air Change
Assembly halls	3 - 10
Auditoriums	4 - 15
Bakeries	1 - 3
Banks	3 - 10
Bars	2 - 4
Beauty parlors	2 - 5
Boiler rooms	2 - 4
Bowling alleys	2 - 8
Churches	4 - 15
Corridors	6 - 20
Dry cleaners	1 - 5
Engine rooms	1 - 1.5
Factor (gen. vent.)	5 - 10
Factory (fumes)	1 - 5
Forge shops	1 - 2
Foundries	1 - 4
Garages (repairs)	2 - 10
Generating rooms	2 - 5
Glass plants	1 - 2
Gymnasiums	2 - 10
Heat treat rooms	0.5 - 1
Kitchens	1 - 3
Laundries	2 - 5
Locker rooms	2 - 5
Machine shops	3 - 5
Mills (paper)	2 - 3
Mills (textile)	5 - 15
Offices	2 - 8
Packing houses	2 - 5
Production rooms	1 - 2
Projection rooms	1 - 3
Recreation rooms	2 - 8
Residences	2 - 5
Restaurants	5 - 10
Retail stores	3 - 10
Sales rooms	3 - 10
Shops (gen. vent.)	3 - 10
Stores	5 - 10
Theaters	3 - 8
Toilets	2 - 5
Transformer rooms	1 - 5
Turbine room elec.	2 - 6
Waiting rooms	10
Warehouses	2 - 10

In selecting the size and capacity of a fan, find the total cubic feet of air space of the building and divide by the number of air changes necessary to give proper ventilation.

$$\text{CFM} = \frac{\text{Building volume in cubic feet}}{\text{Minute air change}}$$

Example:
A building 100' long x 60' wide with a 20' ceiling: Multiply 100 x 60 x 20 = 120,000 cubic feet. Assuming a 6 minute air change is required: 120,000 cubic feet of air divided by 6 gives you 20,000 CFM required to change the air every 6 minutes.

Refer to manufacturer's instructions and local codes.

Reference Guide

CONVERSIONS

Conversion Factors

MULTIPLY	BY	OBTAIN
Atmospheres (Std.) 760 MM of Mercury at 32°F	14.696	lbs./sq. in.
Atmospheres	76.0	cms mercury
atm	29.92	ins mercury
atm	33.90	ft. water
atm	1.0333	kgs/sq. cm.
atm	14.70	lbs./sq. in.
atm	1.058	tons/sq. ft.
Barrels-Oil	42	gals-oil
BT Units	0.2520	kgs-calories
BTUs	777.5	ft.-lbs.
BTUs	0.000393	hp-hrs
BTUs	107.5	kg-meters
BTUs	0.293	w-hrs
BTU/Min.	12.96	ft.-lbs./sec.
BTU/min	0.2356	hp
BTU/min	0.01757	kw
BTU/min	17.57	watts
Calorie	0.003968	BTU
Centimeters	0.3937	inches
cm	0.0328	feet
cm	0.01	meters
cm	10	mm
Cms Mercury	0.01316	atm
cms mercury	0.4461	ft. water
cms mercury	136.0	kgs/sq. meter
cms mercury	27.85	lbs./sq. ft.
cms mercury	0.1934	lbs./sq. in.
Cms/Second	1.969	ft./min.
cms/second	0.03281	ft. sec.
cms/second	0.036	km/hr.
cms/second	0.6	meters/min.
cms/second	0.02237	miles/hr.
cms/second	0.0003728	miles/min.
Cms/Sec/Sec	0.03281	ft./sec./sec.
Cubic Cms	0.00003531	cu. ft.
cu cms	0.06102	cu. in.
cu cms	0.000001	cu meters
cu cms	0.000001308	cu. yds.
cu cms	0.0002642	gals
cu cms	0.001	liters
cu cms	0.002113	pints (liq.)
cu cms	0.001057	quarts (liq.)
Cubic Feet	28320	cubic cms
cu. ft.	1728	cu. inches
cu. ft.	0.02832	cu. meters
cu. ft.	0.03704	cu. yds.
cu. ft.	7.48052	gals
cu. ft.	28.32	liters
cu. ft.	59.84	pints (liq.)
cu. ft.	29.92	quarts (liq.)
Cubic Ft./Min.	472.0	cu. cms/sec.
cu. ft./min.	0.1247	gals/sec.
cu. ft./min.	0.4720	liters/sec
cu. ft./min.	62.43	lbs. w/min.

MULTIPLY	BY	OBTAIN
Cubic Ft./Sec.	0.646317	million gals/day
cu. ft./sec.	448.831	gals./min.
Cubic Ft. Water	62.4	lbs. @ 60°F
Cubic Inches	16.39	cc
cu. ins.	0.0005787	cu. ft.
cu ins.	0.00001639	cu. meters
cu. ins.	0.00002143	cu. yds.
cu. ins.	0.004329	gals
cu. ins.	0.01639	liters
cu. ins.	0.03463	pints (liq.)
cu. ins.	0.01732	quarts (liq.)
Cubic Meters	100,000	cc
cu. meters	35.31	cu. ft.
cu. meters	61.023	cu. ins.
cu. meters	1.308	cu. yds.
cu. meters	264.2	gals
cu. meters	1000	liters
cu. meters	2113	pints (liq.)
cu. meters	1057	quarts (liq.)
Cubic Yards	764,600	cu. cms
cu. yds	27	cu. ft.
cu. yds	46.656	cu. ins.
cu. yds	0.7646	cu. meters
cu. yds	202.0	gals
cu. yds	764.6	liters
cu. yds	1616	pints (liq.)
cu. yds.	807.9	quarts (liq.)
Decimeters	0.1	meters
Degrees (Angle)	60	minutes
degs (angle)	0.01745	radians
degs (angle)	3600	secs
Degrees/Sec.	0.01745	radians/sec.
degs/sec.	0.1667	revs/min.
degs/sec.	0.002778	revs/sec.
Fathoms	6	ft.
Feet	30.48	cms
ft.	12	ins
ft.	0.3048	meters
ft.	1/3	yds
Feet of Water	0.02950	atms
ft. of w	0.8876	ins mercury
ft. of w	0.03048	kgs/sq. cm
ft. of w	62.43	lbs./sq. ft.
ft. of w	0.4335	lbs./sq. in.
Feet/Min.	0.5080	cms/sec
ft./min.	0.01667	ft./sec.
ft./min.	0.01829	kms/hrs
ft./min.	0.3040	meters/min.
ft./min.	0.01136	miles/hr.
Ft./Sec./Sec.	30.48	cms/sec./sec.
ft./sec./sec.	0.3048	ms/sec./sec.
Foot-Pounds	0.001286	BTUs
ft.-lbs.	0.000000505	hp-hrs
ft.-lbs.	0.0003241	kg-calories
ft.-lbs.	0.1383	kg-meters
ft.-lbs.	0.0000003766	kw-hrs

Reference Guide

CONVERSIONS

MULTIPLY	BY	OBTAIN
Ft.-Lbs./Min.	0.001286	BTUs/min.
ft.-lbs./min.	0.01667	ft.-lbs./sec.
ft.-lbs./min.	0.0000303	hp
ft.-lbs./min.	0.0003241	kg-calories/min.
ft.-lbs./min.	0.0000226	kws
Ft.-Lbs./Sec.	0.007717	BTUs/min
ft.-lbs./sec.	0.001818	hp
ft.-lbs./sec.	0.01945	kg-calories/min.
ft.-lbs./sec.	0.001356	kws
Gallons	3785	ccs
gals	0.1337	cu. ft.
gals	231	cu. ins
gals	128	fl. ozs.
gals	0.003784	cu. meters
gals	3.785	liters
gals	8	pints (liq.)
gals	4	quarts (liq.)
Gallons, Imp	1.20095	US gals
Gallons, US	0.83267	Imp gals
Gallons Water	8.3453	lbs. water
Gallons/Min.	0.002228	cu. ft./sec.
gals/min.	0.06308	liter/sec.
gals/min.	8.0208	cu. ft./hr.
Gals Water/Min.	6.0086	tons water/24 hrs
Grams	15.432	grains
grams	.001	kgs
grams	1000	milligrams
grams	0.03527	ozs
grams	0.03215	ozs (troy)
grams	0.002205	lbs.
Grams/Cm	0.0056	lbs./in.
Grams/Cu. Cm	62.43	lbs./cu. ft.
grams/cu. cm	0.03613	lbs./cu. in.
Grams/Liter	58.417	grains/gal
grams/liter	8.345	lbs./1000 gals
grams/liter	0.062427	lbs./cu. ft.
grams/liter	1000	parts/million
Horsepower	42.44	BTUs/min.
hp	33.000	ft.-lbs./min.
hp	550	ft.-lbs./sec.
hp	1.014	hp (metric)
hp	10.70	kg-calories/min.
hp	0.7457	kws
hp	745.7	watts
Horsepower (boiler)	33,479	BTU/hr.
hp (boiler)	9,803	kws
HP-Hours	2547	BTUs
hp-hrs	1,980,000	ft.-lbs.
hp-hrs	641.7	kg-calories
hp-hrs	273,700	kg-meters
hp-hrs	0.7457	kw-hrs
Inches	2540	cms
ins	25.4	mm
ins	0.0254	M
ins	0.0833	ft.
Inches of Mercury	0.03342	atms

MULTIPLY	BY	OBTAIN
ins mercury	1.133	ft. water
ins mercury	13.57	in. water
ins mercury	0.03453	kgs/sq. cm
ins mercury	70.73	lbs./sq. ft.
ins mercury	0.4912	lbs./sq. in.
Inches of Water	0.002458	atms
ins of w	0.07355	ins mercury
ins of w	0.002540	kgs/sq. cm
ins of w	0.5781	ozs/sq. in.
ins of w	5.202	lbs./sq. ft.
ins of w	0.03613	lbs./sq. in.
Kilograms	980.665	dynes
kgs	2.205	lbs.
kgs	0.001102	tons (short)
kgs	1000	grams
Kgs/Sq. Cm	0.9678	atms
kgs/sq. cm	32.81	ft. water
kgs/sq. cm	28.96	ins mercury
kgs/sq. cm	20.48	lbs./sq. ft.
kgs/sq. cm	14.22	lbs./sq. ft.
Kiloliters	1000	liters
Kilometers	100,000	cms
kms	3281	ft.
kms	1000	meters
kms	0.6214	miles
Kms/Hr.	27.78	cms/sec.
kms/hr.	54.68	ft./min.
kms/hr.	0.9113	ft./sec.
kms/hr.	16.67	meters/min.
kms/hr.	0.6214	miles/hr.
Kms/Hr. Sec.	27.78	cms/sec./sec.
kms/hr. sec.	0.9113	ft./sec./sec.
kms/hr. sec.	0.2778	meters/sec./sec.
Kilowatts	56.92	BTUs/min
kws	44,250	ft.-lbs./min.
kws	737.6	ft.-lbs./sec.
kws	1.341	hp
kws	14.34	kg-calories/min.
kws	1000	watts
Killowatt-Hrs.	3415	BTUs
kw-hrs.	2,665,500	ft.-lbs.
kw-hrs.	1.341	hp-hours
kw-hrs.	860.5	kg-calories
kw-hrs.	367,100	kg-meters
Liters	100	ccs
liters	0.03531	cu. ft.
liters	61.02	cu. ins
liters	0.01	cu. meters
liters	0.2642	gals
liters	2.113	pints (liq.)
liters	1.057	quarts (liq.)
Liters/Min.	0.004403	gals/sec.
Meters	100	cms
meters	3.281	ft.
meters	39.37	ins
meters	0.001	kms

Refer to manufacturer's instructions and local codes.

Reference Guide

BellSimons COMPANIES — Right Products. Right Now.™

CONVERSIONS

MULTIPLY	BY	OBTAIN
meters	1000	mms
meters	1.094	yards
Meters/Min.	1.667	cms/sec.
meters/min.	3.281	ft./min.
meters/min.	0.05468	ft./sec.
meters/min.	0.06	kms/hr.
meters/min.	0.03728	miles/hr.
Meters/Sec.	196.8	ft./min.
meters/sec.	3.281	ft./sec.
meters/sec.	3.6	kms/hr.
meters/sec.	0.06	kms/min.
meters/sec.	2.237	miles/hr.
meters/sec.	0.03728	miles/min.
Microns	0.000001	meters
microns	25.400	in.
Miles/Hr.	44.70	cms/sec.
miles/hr.	88	ft./min.
miles/hr.	1.467	ft./sec.
miles/hr.	1.609	kms/hr.
miles/hr.	0.8684	knots
miles/hr.	26.82	meters/min.
Millimeters	0.1	cms
mms	0.03937	ins
Mins (Angle)	0.0002909	radians
Ounces	16	drams
ozs	437.5	grains
ozs	0.0625	lbs.
ozs	28.349527	grams
ozs	0.9115	ozs (troy)
ozs	0.0000279	tons (long)
ozs	0.00002835	tons (metric)
Ounces (Fluid)	1.805	cu. in.
ozs (fluid)	0.02957	liters
Pints	0.4732	liters
Pounds	16	ozs
lbs	256	drams
lbs	7000	grains
lbs	0.0005	tons (short)
lbs	453.5924	grams
lbs	1.21528	lbs. (troy)
lbs	14.5833	ozs (troy)
Lbs. of Water	0.01602	cu. ft.
lbs. of water	27.68	cu. in.
lbs. of water	0.1198	gals
Lbs. of Water/Min.	0.0002679	cu. ft./sec.
Pounds/Cu. Ft.	0.0005787	lbs./cu. in.
Pounds/Cu. In.	1728	lbs./cu. ft.
Pounds/Sq. Ft.	0.01602	ft. of water
Pounds/Sq. Ft.	0.006945	lbs./sq. in.
Pounds/Sq. In.	0.06804	atms
lbs./sq. in.	2.307	ft. water
lbs./sq. in.	2.036	in. mercury
lbs./sq. in.	27.68	in. water
lbs./sq. in.	0.07031	kgs/sq. cm
Radians	57.29578	degrees
Temp. (°C) +273	1	abs. temp. (°C)

MULTIPLY	BY	OBTAIN
Temp. (°C) +17.78	1.8	temp. (°F)
Temp. (°F) +460	1	abs. temp. (°F)
Temp. (°F) -32	5/9	temp. (°C)
Therm	100,000	BTUs
Tons (Long)	1016	kgs
tons (long)	2240	lbs
tons (long)	1.12000	tons (short)
Tons, Refrigeration	12,000	BTU/hr.
Tons (Short)	2000	lbs.
tons (short)	907.18486	kgs
tons (short)	2430.56	lbs. (troy)
tons (short)	0.89287	tons (long)
tons (short)	29,166.66	ozs (troy)
tons (short)	0.90718	tons (metric)
Watts	0.05692	BTUs/min.
watts	44.26	ft.-lbs./min.
watts	0.7376	ft.-lbs./sec.
watts	0.001341	hp
watts	0.01434	kg-calories/min.
watts	0.001	kws
Watt-Hours	3.415	BTU/hr.
watt-hrs.	2655	ft.-lbs.
watt-hrs.	0.001341	hp-hrs
watt-hrs.	0.8605	kg-calories
watt-hrs.	367.1	kg-meters
watt-hrs.	0.001	kw-hrs

Five Basic Laws of Nature

Law 1: Heat exists in the air at all temperatures – below freezing as well as above – all the way down to absolute zero (-460° F).

Law 2: Heat flows from a higher temperature to a lower temperature regardless of how small the temperature difference might be.

Law 3: All gases become warmer when compressed.

Law 4: Most matter can be in a solid (ice), liquid (water) or gaseous (steam) state.

Law 5: The temperature at which a material changes from a liquid to a gas (evaporates or boils) or from a gas to a liquid (condenses or liquefies) depends on the pressure at which it is contained.

DEFINITIONS OF TERMS

ABSOLUTE HUMIDITY: The weight of water vapor in a given amount of air. Grains per cubic foot.

ABSOLUTE PRESSURE: Pressure measured with a base of zero.

ABSOLUTE TEMPERATURE: A temperature scale expressed in degrees, F or C, using absolute zero as a base. Referred to as the Rankin or Kelvin scale.

ABSOLUTE ZERO: The temperature at which molecular activity theoretically ceases (-459.69°F or -273.16°C)

AFUE %: AFUE stands for "annual fuel utilization efficiency". This rating is based on average usage, including on and off cycling, as set out in the standardized Department of Energy test procedures.

AIR CONDITIONING: The process of controlling the temperature, humidity, cleanliness and distribution of the air.

AIR STANDARD CONDITIONS: Conditioning at which BTU ratings for summer air conditioning equipment is rated. 95°F dry bulb, 75°F wet bulb at the condenser inlet and 80°F dry bulb, 67°F wet bulb at the evaporator inlet.

AIR: Atmospheric air is composed of approximately 78% Nitrogen, 21% Oxygen and 1% rare gases including Carbon Dioxide, Krypton, Neon, Argon, Ozone, Helium and Ammonia. Over the sea, traces of salt are present, and over the land, traces of sulfates. Dust and micro-organisms are also present.

ATMOSPHERIC PRESSURE: The weight of 1 square inch column of the earth's atmosphere. At sea level this pressure is 14.696 pounds per square inch.

BIMETAL: Two metals with different rates of expansion fastened together. When heated or cooled they will warp and can be made to open or close a switch or valve.

BOILING POINT: The temperature at which the addition of any heat will begin a change of state from a liquid to a vapor.

BRITISH TERHMAL UNIT (BTU): The amount of heat necessary to raise the temperature of 1 pound of pure water (about 1 pint) by 1° Fahrenheit.

CAPILLARY TUBE: A refrigerant control consisting of a small diameter tube which controls flow by restriction. They are carefully sized by inside diameter and length for each particular application.

CENTIGRADE: A temperature scale with the freezing point of water 0° and the boiling point 100° at atmospheric pressure.

COEFFICIENT OF PERFORMANCE (COP): A ratio calculated by dividing the total heating capacity provided by the refrigeration system, including circulating fan heat but excluding supplementary resistance (BTUs per hour), by the total electric input (watts) x 3.412.

COMPRESSION: The reduction of volume of a vapor or gas by mechanical means.

COMPRESSOR: A mechanical device used to compress gases. Four main types are: Reciprocating; Centrifugal, Rotary and Scroll.

CONDENSATION POINT: The temperature at which removal of any heat will begin a change of state from a vapor to a liquid.

CONDENSER: A device in which the superheat and latent heat of condensation are removed to effect a change of state from a vapor to a liquid. Some sub-cooling is also usually accomplished.

CONDENSING MEDIUM: The substance, usually air or water, to which the heat in a condenser is transferred.

CONDENSING UNIT: The portion of a refrigeration system where the compression and condensation of refrigerant is accomplished. Sometimes referred to as the "high side".

CONDUCTION: The transfer of heat from molecule to molecule within a substance.

CONTACTOR: An electro-magnetic actuated relay. Usually used to refer to the relay which closes the circuit to a compressor.

CONVECTION: The transfer of heat by a moving fluid.

COOLING ANTICIPATOR: A resistance heater (usually not adjustable) in parallel with the cooling circuit. It is "on" when the circuit is "off" adding heating to shorten the off cycle.

CYCLE: The complete course of operation of a refrigerant back to a selected starting point in a system. Also used to describe alternating current through 360 space degrees.

DENSITY: Mass or weight per unit of volume, i.e.: Standard air .075 pounds per cubic foot.

DISCHARGE LINE: A tube used to convey the compressed refrigerant vapor from the compressor to the condenser inlet.

DISCHARGE PRESSURE: The pressure read at the compressor outlet. Also called head pressure or high pressure.

DOE: Department of Energy.

DRY BULB TEMPERATURE: Temperature read with an ordinary thermometer.

ENERGY EFFICIENT RATIO (EER): A ratio calculated by dividing the cooling capacity in BTUs per hour (BTUH) by the power input in watts or any given set of rating conditions, expressed in BTUH per watt (BTUH/watt).

EVAPORATIVE COOLING: The cooling effect of vaporization of a liquid in a moving air system.

EVAPORATOR SUPERHEAT: The actual temperature of the refrigerant vapor at the evaporator exit as compared to the saturated vapor temperature indicated by the suction pressure.

EVAPORATOR: A device in which a liquid refrigerant is vaporized. Some superheating usually takes place.

FAHRENHEIT: A temperature scale with freezing point of water 32° and the boiling point 212° at atmospheric pressure.

FREEZING POINT: The temperature at which the removal of any heat will begin a change of state from liquid to a solid.

GAUGE PRESSURE: Pressure measured with atmospheric pressure as a base.

TERMINOLOGY

HEAT EXCHANGER: A device for the transfer of heat energy from the source to the conveying medium.

HEAT FLOW: Heat flows from a warmer to a cooler substance. The rate depends upon the temperature difference, the area exposed and the type of material.

HEAT OF COMPRESSION: The heat added to a vapor by the work done on it during compression.

HEAT OF THE LIQUID: The increase in total heat (Enthalpy) per pound of saturated liquid as its temperature is increased above a chosen base temperature. (Usually -40°F for refrigerants). It is expressed in BTUs.

HEAT TRANSFER: The three methods of heat transfer are conduction, convection and radiation.

HEAT: A form of energy causing the agitation of molecules within a substance.

HEATING SEASONAL PERFORMANCE FACTOR (HSPF): The total heating output of a heat pump during its normal annual usage period for heating divided by the total electric power input in watt-hours during the same period.

INCHES OF MERCURY: Atmospheric pressure is equal to 29.92 inches of mercury.

LATENT HEAT OF CONDENSATION: The amount of heat energy, in BTUs, that must be removed to change the state of 1 pound of a vapor to 1 pound of liquid at the same temperature.

LATENT HEAT OF FUSION: The amount of heat energy, in BTUs, required to change the state of 1 pound of a liquid to 1 pound of solid at the same temperature.

LATENT HEAT OF MELTING: The amount of heat energy, in BTUs, that must be removed to change the state of 1 pound of a solid to 1 pound of liquid at the same temperature.

LATENT HEAT OF VAPORIZATION: The amount of heat energy, in BTUs, required to change the state of 1 pound of liquid to 1 pound of vapor at the same temperature.

LATENT HEAT: Heat that produces a change of state without a change in temperature. i.e.: Ice to water at 32°F; Water to steam at 212°.

LIQUID LINE: A tube used to convey the liquid refrigerant from the condenser outlet to the refrigerant control device of the evaporator.

MANOMETER: A tube filled with liquid used to measure pressure.

MELTING POINT: The temperature at which the addition of any heat will begin a change of state from a solid to a liquid.

MERCURY MANOMETER: Used to measure vacuum in inches of mercury.

MICRON: A unit used to measure high vacuums. One micron equals 1/25,400 of 1 inch mercury.

PARTIAL PRESSURE: The pressure exerted by an individual gas in a mixture.

PRESSURE - TEMPERATURE RELATIONSHIP: The change effected in temperature when pressure is changed or visa versa. Only used at saturated conditions. An increase in pressure results in a temperature increase. A decrease in temperature results in a pressure decrease.

PRESSURE DROP: The decrease in pressure due to friction of a fluid or vapor as it passes through a tube or duct.

PSYCHROMETER: A device having both a dry and a wet bulb thermometer. It is used to determine the relative humidity in a conditioned space. Most have an indexed scale to allow direct conversion from the temperature readings to the percentage of relative humidity.

PSYCHROMETRIC CHART: A chart on which can be found the properties of air under varying conditions of temperature, water vapor content, volume, etc.

RADIATION: The transfer of heat without an intervening medium. It is absorbed on contact with a solid surface.

REFRIGERANT CONTROL: A device used to meter the amount of refrigerant to an evaporator. It also serves as a dividing point between the high and low pressure sides of the system.

REFRIGERANT: A substance which produces a refrigerating effect while expanding or vaporizing.

REFRIGERATION: The transfer of heat from a place where it is not wanted to a place where its presence is not undesirable.

RELATIVE HUMIDITY: The percentage of water vapor present in a given quantity of air compared to the amount it can hold at its temperature.

RELAY: A device used to open and close an electrical circuit. The relay may be actuated by a bimetal electrically heated strip, a rod wrapped with a fine resistance wire causing expansion when energized, a bellows actuated by expansion of a fluid or gas or an electromagnetic coil.

SATURATED VAPOR: Vapor in contact with a liquid.

SATURATION: A condition of stable equilibrium of a vapor and a liquid.

SEASONAL ENERGY EFFICIENCY RATIO (SEER): The total cooling of a central unitary air conditioner or unitary heat pump in BTUs during its normal annual period for cooling divided by the total electric energy input in watt-hours during the same period.

SENSIBLE HEAT: Heat that can be measured or felt. Sensible heat always causes a temperature rise.

SOUND RATING (SR): A tone corrected A-weighted sound power level expressed in bels. The Sound Rating is based on tests performed at Standard Rating Conditions (cooling).

SPECIFIC HEAT: The amount of heat necessary to change the temperature of 1 pound of substance 1°F.

SPECIFIC VOLUME: The volume of a substance per unit of mass. i.e.: standard air 13.33 cubic feet per pound. The reciprocal of density.

STANDARD AIR DENSITY: .075 pounds per cubic foot. Equivalent to dry air at 70°F and at sea level pressure.

STATE CONDITION: Substances can exist in three states – Solid, Liquid or Vapor.

SUB-COOLING: Cooling of a liquid, at a constant pressure, below the point at which it was condensed.

SUCTION LINE: A tube used to convey the refrigerant vapor from the evaporator oulet to the suction inlet of a compressor.

SUCTION PRESSURE: The pressure read at the inlet side of a compressor. Also called back pressure or low side pressure.

SUPERHEAT: Heat added to a vapor after all liquid has been vaporized.

TEMPERATURE: A measure of heat intensity.

THERMOSTAT: A switch to close and open a circuit to indicate or terminate operation of a heating or air conditioning system.

THERMOSTATIC EXPANSION VALVE: Refrigerant control which monitors the flow rate according to the superheat at the evaporator outlet.

TON OF REFRIGERATION: The amount of heat necessary to completely melt 1 ton of 32°F ice in 24 hours. 200 BTUs per minute; 12,000 BTUs per hour; 288,000 BTUs in 24 hours. This is based on the latent heat fusion for ice which is 144 BTUs per pound.

TOTAL HEAT: (Enthalpy) The total heat energy in a substance. The sum of sensible and latent heat.

TOTAL PRESSURE: The sum of all partial pressures in a mixture of gases.

VACUUM: Any pressure below atmosphere pressure.

WATER MANOMETER: Used to measure pressure in inches of water.

WET BULB TEMPERATURE: Temperature read with a thermometer whose bulb is encased in a wetted wick.

Reference Guide

ALTERNATE WAYS TO SIZE ERVS / HRVS

Traditionally, square footage of a home was needed to correctly size an ERV or HRV (Energy Recovery Ventilator, Heat Recovery Ventilator). If you don't know the square footage of your home, there is an easier way to size the ERV or HRV that you need to get the job done.

Either of the methods below give a result that relates to the CFMs (cubic feet per minute) that the ventilator unit can move with it's internal fans. For example, the HOneywell HR150B 1005 Heat Recovery Ventilator is rated 150 CFM. The Fantech Heat Recovery Ventilator Model SHR 2005R will do 168 CFM.

Traditional Method - Square Footage
ERVs/HRVs are typically sized to ventilate the whole house at a minimum of .35 air changes per hour. To calculate minimum CFM requirements, simply take the square footage of the house (including basement) and multiply by the height of the ceiling to get cubic volume. Then, divide by 60 and multiply by .35.

Alternate Method - Room Count
With the room count method, each room in the home is assigned a certain number of CFMs. When the values from the rooms are added together - the total number of required CFMs are the result. Use the chart below to figure the number of CFMs needed to properly size your ERV or HRV.

ROOM	NO. OF ROOMS	CFM (L/s)	CFMs REQUIRED
Master Bedroom		x 20 CFM (10 L/s)	
Basement	Yes or No	If yes add CFM (10 L/s)	
Bedrooms		x 10 CFM (5 L/s)	
Living Room		x 10 CFM (5 L/s)	
Other		x 10 CFM (5 L/s)	
Kitchen		x 10 CFM (5 L/s)	
Bathroom		x 10 CFM (5 L/s)	
Laundry Room		x 10 CFM (5 L/s)	
Utility Room		x 10 CFM (5 L/s)	

Total Ventilation Required (add last column) ______________________

Refer to manufacturer's instructions and local codes.

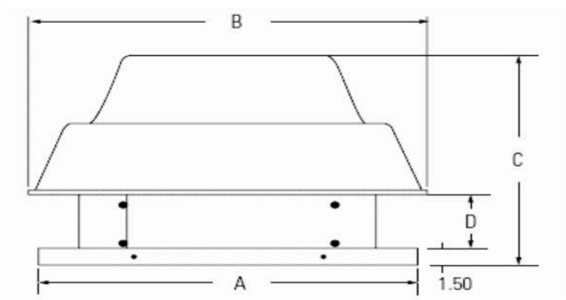
Reference Guide

EXHAUST FANS

PART NO.	DOWN BLAST, ROOF MOUNTED, DIRECT DRIVE FAN	PRICE (FAN ONLY)	VOLTAGE	MAX CFM	WEIGHT LBS.	ROOF MOUNTED DAMPER	FLAT ROOF CURB, INSULATED	115V	230V
^64408	FAN 5DDD085A 8"	Non-stock*	115V 1 PH	417	26	5ACC12RD	5ACC17FT	5ACC03SC	x
^59551	FAN 5DDD10AA 10"	$336.15	115V 1 PH	944	44	5ACC12RD	5ACC17FT	5ACC03SC	x
^59549	FAN 5DDD12CA 12"	$398.98	115V 1 PH	1744	55	5ACC15RD	5ACC20FT	5ACC06SC	x
^62624	FAN 5DDD13DB 13"	$535.92	115/230V 1 PH	2223	66	5ACC15RD	5ACC20FT	RPE10	RPE210
^65287	FAN 5DDD16DB 16"	$659.12	115/230V 1 PH	2913	149	5ACC15RD	5ACC24FS	RPE10	RPE210
^69242	FAN 5DDD18EB 18"	Non-stock*	115/230V 1 PH	4030	164	5ACC19RD	5ACC28FS	RPE10	RPE210

*Call for pricing.

Dimensions



MODEL	A	B	C	D
5DDD 085A	19"	18 ⅞"	13 ¼"	3 ½"
5DDD 106A	19"	22 ⅜"	16 ½"	3 ⅜"
5DDD 10AA	19"	22 ⅜"	16 ½"	3 ⅜"
5DDD 12CA	22"	24 ¼"	17 ⅛"	4"
5DDD 13DB	22"	25 ⅝"	18 ⅛"	4 ⅜"
5DDD 15CA	26"	27 ⅞"	18 ½"	4 ⅜"
5DDD 16DB	26"	29 ¾"	20 ¼"	4 ¾"
5DDD 18EB	30"	31 ⅝"	21 ⅜"	5 ⅝"

5ACC..RD

Roof Mount Damper

Manufactured from 19-gauge galvanized steel fram 2" deep with 1" flange. For quiet operation aluminum blades have felted edges. Pre-punched conduit hole knock-out.

Specification Data

MODEL	FAN SIZE	RECOMMENDED ROOF OPENING	OUTSIDE FLANGE	WEIGHT, LBS	ITEM #
5ACC12RD	10"	12 ½" x 12 ½"	12" x 12"	3	47196
5ACC15RD	12", 13"	15 ½" x 15 ½"	15" x 15"	4	47203
5ACC19RD	15", 16"	19 ½" x 19 ½"	19" x 19"	5	47210
5ACC23RD	18", 20"	23 ½" x 23 ½"	23" x 23"	9	47215

Fantech

Reference Guide

GEOTHERMAL VERIFICATION SHEET

All geothermal units are built to order based on your specifications. Therefore, they are non-returnable and non-cancellable. Please review this sheet carefully before signing.

Customer name: ________________________________ PO #: ______________

Ship to: ____

Unit model number: ______________________________________

Compressor stages: ☐ single stage ☐ two stage

Tonnage: ________________ Unit voltage: ______________

Heat transfer type: ☐ water-to-air ☐ water-to-water

Unit configuration: ☐ packaged ☐ interior split ☐ exterior split

Heat exchanger: ☐ copper ☐ cupronickel ☐ braze-plate

Supply location: ☐ top ☐ rear ☐ bottom ☐ end ☐ side ☐ N/A

Return location: ☐ left ☐ right

Blower type: ☐ PSC ☐ ECM ☐ X-13 (5 spd. ECM) ☐ oversized PSC ☐ oversized ECM

Back-up heat: ____

Accessories: ____

____

Options:

☐ no hot water, no geo-start

☐ hot water with pump and no geo-start

☐ hot water with pump and geo-start

☐ hot water (external pump)

☐ geo-start only

I agree that the unit ordered is correct and understand that geo-thermal products are non-returnable and non-cancellable once ordered.

Signature: ______________________ Date: ______________________

Printed name: ____

Refer to manufacturer's instructions and local codes.