BTU ELECTRIC HEATERS

TECHNICAL DATA

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OUR TECHNICAL INFORMATION Section contains information that is designed to help you in your selection of the proper heater for the job. First turn to the section under Heater Selection and become familiar with the Heat Rise Chart and the "Rules of Thumb" for Airflow Calculations and Electrical Calculations. Note the sub-heading "Select Carefully and Save". Applying the information may help you save a bundle!!

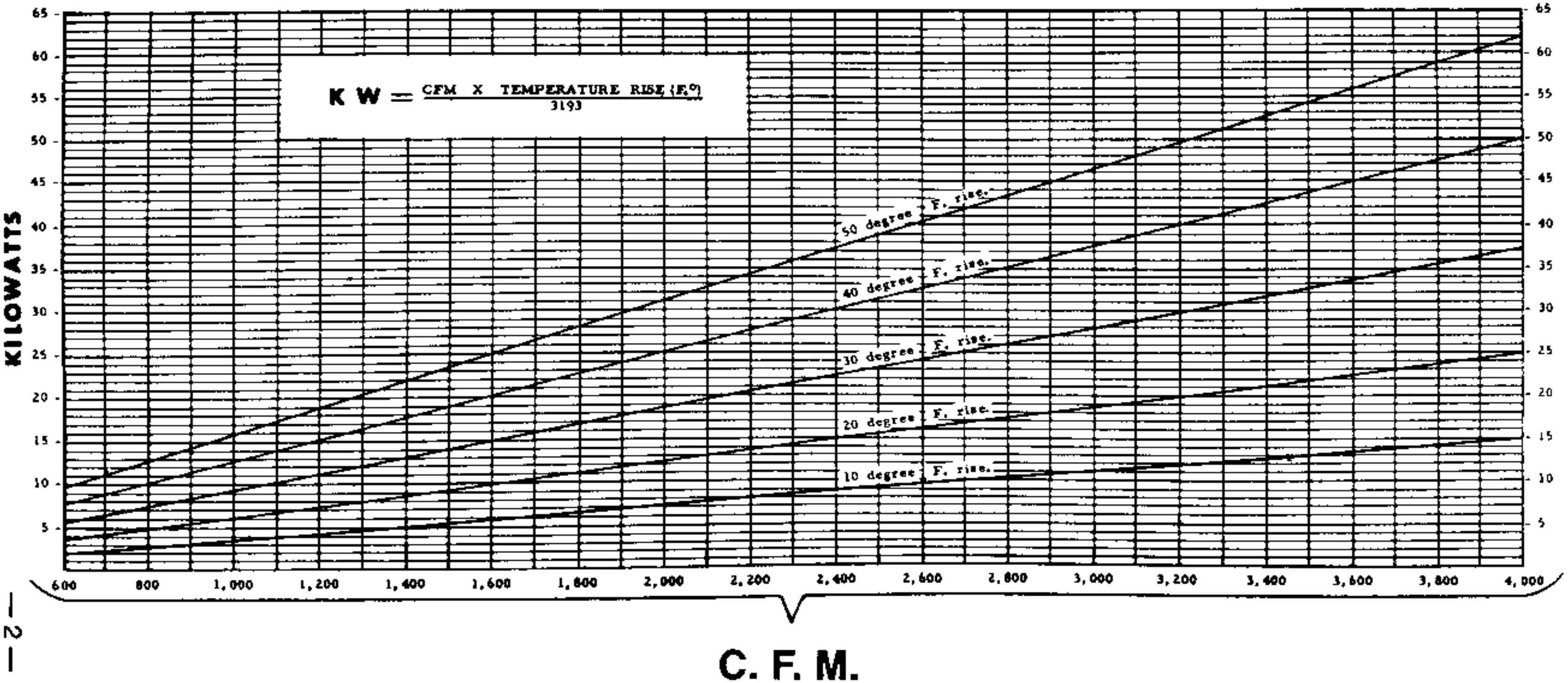
The pages following deal with Field Wiring of Duct Heaters, Ohms Law and other pertinent electrical information.

Information on Pages 9 and 10 under the sub-heading "Servicing Tips for BTU Duct Heaters and Others" is designed to save you time on your service calls and keep your customers happy.

At the end of the Technical Information Section, we have included a sample Submittal Data Sheet and U.L. Installation Instructions.

BTU ELECTRIC HEATERS

HEATER SELECTION



Each KW will produce 3,413 BTU per hour. This fact and the Chart above should prove helpful in making Heater Selections. Knowing what Heat Rise to expect will aid you in educating customers using Electric Heat for the first time. As an example, 10 KW of Heat in a Southern Home with 3 Tons (1200 CFM) of Air Conditioning may well do the Heating job. The customer may complain because the outlet air is just about body temperature and he feels no heat. Save costly call backs by being ready with Chart figures to explain that a 26.3° rise at 1200 CFM will do a proper job, etc. When ordering, always specify Heaters rated for the Supply Voltage that you will have. The BTU output is directly related to the square of the Voltage as in the formula:

Power in Watts = Voltage squared divided by Resistance
Note how a 240 Volt Heater would have to be derated with a lower input Voltage.

A 240 V rated Heater with a supply of 230 V will yield only 92% of its rated output.
A 240 V rated Heater with a supply of 220 V will yield only 84% of its rated output.
A 240 V rated Heater with a supply of 208 V will yield only 75% of its rated output.
A 240 V rated Heater with a supply of 120 V will yield only 25% of its rated output.

Unlike a motor, Heater Amperage draw goes DOWN with Lower than rated Supply Voltage.

HEATER SELECTION

BTU ELECTRIC HEATERS

RULE OF THUMB ON MINIMUM AIRFLOW REQUIREMENTS

Approx. 65 CFM per KW is needed with Heater Inlet Air 77°F as with straight cooling. Approx. 120 CFM per KW is needed with Heater Inlet Air 110°F as with Heat Pump.

Check our Installation Manual for final Airflow determination which could be somewhat less but the above is a conservative "Rule of Thumb" if the.Heater fills the Duct.

HEATER PERFORMANCE FORMULAS

$$KW = \frac{\text{Temp. Rise (F°)} \times \text{CFM}}{3193} \qquad \text{Temp. Rise} = \frac{KW \times 3193}{\text{CFM}} \qquad \text{CFM} = \frac{KW \times 3193}{\text{Temp. Rise}}$$

1 KW produces 3413 BTUH

BTUH = Temp. Rise X CFM X 1.08

MULTIPLIERS FOR DETERMINING THE AMPERAGE DRAW OF DUCT HEATERS

1 Phase @120 Volts -- KW times 8.333
1 Phase @220 Volts -- KW times 4.545
1 Phase @240 Volts -- KW times 4.167
1 Phase @480 Volts -- KW times 2.083
3 Phase @208 Volts -- KW times 2.776
3 Phase @230 Volts -- KW times 2.510
3 Phase @480 Volts -- KW times 1.203

1 Phase @208 Volts -- KW times 4.808
1 Phase @230 Volts -- KW times 4.348
1 Phase @277 Volts -- KW times 3.610
1 Phase @600 Volts -- KW times 1.667
3 Phase @220 Volts -- KW times 2.624
3 Phase @240 Volts -- KW times 2.406
3 Phase @600 Volts -- KW times .962

MAXIMUM KW PER CIRCUIT AND BEGINNING OF OVERCURRENT REQUIREMENTS

Voltage	120V	208V	220V	230V	240V	277V	460V	480V	550V	600V
1 Phase	5.76	9.98	10.56	11.04	11.52	13.29	22.08	23.04	26.40	28.80
3 Phase	-----	17.29	18.29	19.12	19.95	-----	38.24	39.90	45.72	49.88

Note: In each group throughout the Price Lists, the highest KW for a particular voltage and phase without circuit fusing is listed just before a Heater with an asterisk after the price.

SELECT CAREFULLY AND SAVE!!!

Substantial cost increases result when additional elements, controls and/or circuits are required. We are not suggesting that you purchase less capacity than you need but sometimes the lower KW will be quite adequate and save you a bundle!!!

Example: If an 11.5KW Heater @ 240V 1 ϕ will do the job, why use the 12KW Heater @ 240V costing at least 40% more because it is over the allowable 48 Amps per Circuit and requires costly Overcurrent Protection.

Example: If the situation is right and a good safe job can be done, it might be well to consider the installation of separate Heaters, each rated less than 48 Amps and not requiring Overcurrent Protection from the factory. Possibly a Heater in each duct branch or more than one Heater in the main duct could be used. Our Heaters are Listed so that this may be done in a ganged fashion to fill the cross-sectional area or one after the other if the inlet to any Heater is 110°F or less.

BTU ELECTRIC HEATERS

HEATER SELECTION

FIELD WIRING OF DUCT HEATERS

Field Wires to Heater Controls Compartments or Fuse Panels must be Copper suitable for 75°C (167°F). In the following table we show actual maximum load permitted which is 80% of the total ampacity of the wire when there are 6 or less conductors in a conduit and 70% when the conductors exceed 6. U.L. requires that a neutral be counted as a conductor in units rated 120 or 277 Volts. However, they do not require that you count grounding wires.

75°C Copper Wire Size AWG	Maximum Ampacity For 6 or less Conductors In Conduit	Maximum Ampacity For 7 to 24 Conductors In Conduit
14	12	10.5
12	16	14
10	24	21
8	36	31.5
6	48	45.5
4	68	59.5
3	80	70
2	92	80.5
1	104	91
0	120	105
00	140	122.5
000	160	140

NOTE:
Heaters with built-in fusing are designed to accept field electrical supplies as follows:

1 Ph. 20 to 48A @ 208 to 600V — 1 Supply
49 to 144A @ 208 to 240V — 1 Supply
3 Ph. 24 to 48A @ 208 to 600V — 1 Supply
49 to 96A @ 208 to 240V — 1 Supply
97 to 144A @ 208 to 240V — 1 or 3 Supplies
49 to 96A @ 300 to 600V — 1 or 2 Supplies

OPTION: Item just above - 1 Supply
Most other Heaters have provision for 48A. or 96A. supply circuits in multiple.
Heaters requiring circuit fusing are also available with smaller control boxes and a separate U.L. Listed Remote Fuse Panel. Consult Factory for additional information.

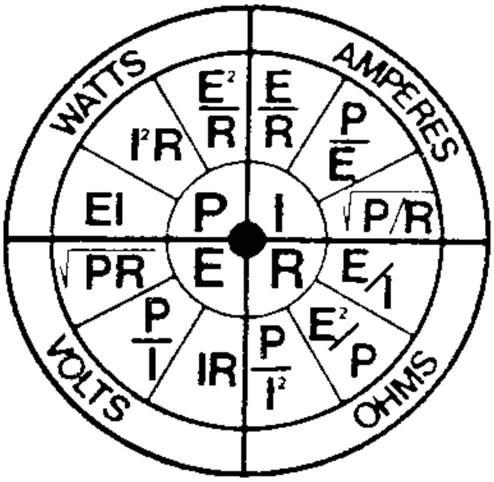
TEMPERATURE EQUIVALENT TABLE

°C	°F	°C	°F	°C	°F	°C	°F
0	32	25	77	50	122	75	167
5	41	30	86	55	131	80	176
10	50	35	95	60	140	85	185
15	59	40	104	65	149	90	194
20	68	45	113	70	158	95	203
						100	212

For other equivalents not listed in table use following formulas:

$F° = C° \times 1.8 + 32°$

$$C° = \frac{F° - 32°}{1.8}$$



BTU ELECTRIC HEATERS

Electric Resistance Heat Values can be found by direct application of Ohm's Law and other known electrical values or equations. Formulas and applications considered are limited to those of benefit to people involved in sales or service of Electric Duct Heaters.

In Formulas and Applications considered below:

P=Watts	I = Amps
E = Volts	R = Ohms
KW = 1,000 Watts	1 KW = 3,413 BTUH

The square root of 3 ($\sqrt{3}$) = 1.732

FORMULAS AND APPLICATION:

I = P/E or Amps = Watts ÷ Volts

EXAMPLE: To determine the Amperage draw of a 9.8 KW Heater at 208V Single Phase, divide Watts by Volts as per formula. (9800 ÷ 208 = 47.1A) For a balanced load Three Phase Heater the Single Phase answer is divided by $\sqrt{3}$. (47.1 ÷ 1.732 = 27.2A)

P = EI or Watts = Volts X Amps

EXAMPLE: To determine the KW of a 240V Single Phase Heater drawing 40 Amps, multiply Volts X Amps as per formula (240 X 40 = 9600 Watts or 9.6KW). For a balanced load Three Phase Heater the Single Phase answer is multiplied by $\sqrt{3}$ (9.6 X 1.732 = 16.63KW).

USEFUL IN HEATER SELECTION: To determine how much KW you can connect to a limited available Amperage and/or wire size. You may not want to exceed a 48 Amp Circuit which would add considerable expense for Circuit Fusing required by U.L. and National Electric Code.

EXAMPLE: You need a Heater not more than 48 Amps at 240V Single Phase. Multiply Volts X Amps as per formula (240 X 48 = 11,500 Watts or 11.5KW). For a balanced load Three Phase Heater, the Single Phase answer is multiplied by $\sqrt{3}$ (11.5 X 1.732 = 19.9KW).

P = E^2/R or Watts = Volts Squared ÷ Ohms. This formula is used to derate the Heater output (Watts) when a lower voltage is applied. Element Resistance (Ohms) remains the same so the reduced output is directly related to the square of the Voltage change.

EXAMPLE: You have a Heater rated 19.6KW, Three Phase at 240V, 47.2A. and want to connect it to a 208V supply and determine the new KW output. Proposed Volts squared divided by the rated Volts squared = the multiplier.

$\frac{208 \times 208}{240 \times 240} = \frac{43.264}{57,600} = .75$ This .75 × 19.6KW at 240V = 14.7KW at 208V.

Note that the Amps go down at the reduced voltage. Using the first formula above for Three Phase, 14,700 divided by 208V = 70.7 Amps and that figure divided by $\sqrt{3}$ (1.732) = 40.8 Amps.

For further examples of connecting Heaters to lower voltages please see the chart that has been worked out on the back of this page. You will note also that the Wattage and related BTUH drop at a faster rate than the Amperage.

BTU ELECTRIC HEATERS

CONNECTING TO LOWER VOLTAGES

When a heater with fixed resistance in ohms is connected to a lower than rated voltage, the Wattage and BTUH output as well as Amps will be reduced as shown in the Chart below.

Heater Rated Voltage	Lower Applied Voltage	% of Heater Wattage and BTUH	% of Heater Data Plate Amps.
600	575	92%	96%
	550	84%	92%
480	460	92%	96%
	440	84%	92%
277	265	92%	96%
	254	84%	92%
240	230	92%	96%
	220	84%	92%
	208	75%	87%
	201	70%	84%
208	200	92%	96%
	190	84%	92%
120	115	92%	96%
	110	84%	92%

CONNECTING TO HIGHER VOLTAGES

NEVER connect a Heater to a higher voltage than the Data Plate rating! Just as the output drops with lower applied voltage, it increases even more rapidly with a higher voltage.

EXAMPLE: Connect 240 V to a 208 V Heater, 17.25 KW, 3 Ph., 47.9 Amps.
RESULT: Heater output increases to 23 KW drawing 55.3 Amps at 240V.
1. Amp Draw is now over the 48 per circuit allowed by UL and NEC.
2. The Element output is now at 1/3 more than factory design limit.
3. Contactor and other component capacities may be exceeded.
4. Safe Wattage Density may now be exceeded and Heater short cycles.
5. UL Label and Warranty are VOID!!
6. Product Liability passes from us!
YOU WILL HAVE PROBLEMS!!!

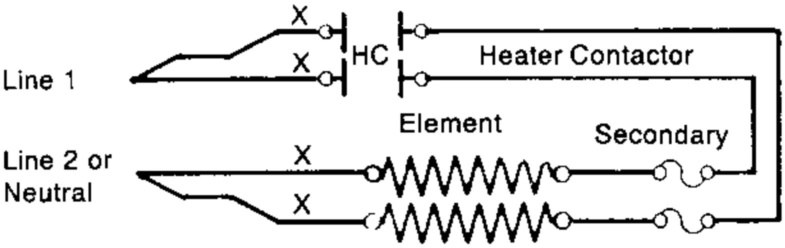
RESISTANCE IN OHMS CALCULATED FOR VARIOUS HEATERS

You are not generally required to know the Ohms of Elements in a Heater unless you need replacement(s) and, even then, you would specify the KW, Voltage, Phase etc. from the Heater Data Plate with the KW per Element determined by dividing total KW by the number of Elements. Sometimes it is necessary to know the Ohms for replacements, particularly for Three Phase Heaters. You may measure the total Ohms of two or more pieces and, when possible, supply nameplate data, Element coil O.D. etc. A review of some sample formulas below will show that it is important to be able to distinguish between Delta or Star (Wye) Three-Phase construction.

$R = E/I$ or — Resistance in Ohms = Volts divided by Amps. You may apply this formula when you have a single element Heater or when you have an Amp reading of just one Element of a Single or Three-Phase, Delta-wired Heater. Each Element is calculated as Single Phase. See note below to get Cold Ohms.

$R = E^2/P$ or — Resistance in Ohms = Volts squared divided by Watts. This formula can be used except for Three-Phase, Star Connected Elements. See "Basic Electric Heat Wiring Diagrams" to help identify Star (Wye) Elements. In a Star-wired set of Elements, you divide the Voltage by $\sqrt{3}$ (1.732) and then proceed to calculate Resistance by the Formula. EXAMPLE: Take a 20 KW Heater, Three-Phase at 240 V. with 6 Elements, 3,333 Watts each that are designed as two 10 KW, star-wired sets. 240 V divided by 1.732 = 138.6 V to be used when applying the Formula. 138.6 squared = 19,210. This divided by 3,333 = 5.76 Hot Ohms each. NOTE: Ohms calculated by formula must be reduced by 5 to 10 per cent to allow for the extra Resistance an Element will have when it is heated. This answer is now Cold Ohms that we use in Element design. The proper wire gauge must be chosen to result in enough surface area to dissipate the heat and avoid premature failure.

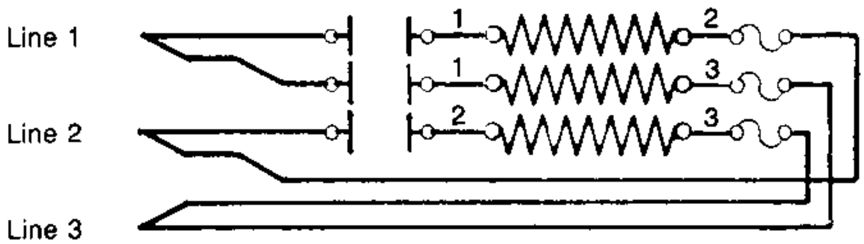
BASIC ELECTRIC HEAT WIRING DIAGRAMS



BASIC SINGLE PHASE 120 to 600V.

Neutral used on 120 and 277V only.

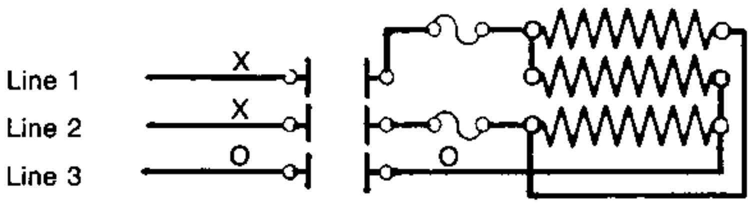
Ohms of each Element calculated individually based on total Heater Watts divided by the number of Elements unless they are not all equal. Manual Resets and Thermal Fusible Links are used for Secondary Protection. Alternate locations shown by X. EXCEPTION--No Neutral through a Secondary! Manual Resets are also used in control circuits of Back-up Contactors as a Secondary and as a specified Third Level Protection.



BASIC THREE-PHASE DELTA

Available at 208 through 600V to 48 Amps per Delta group.

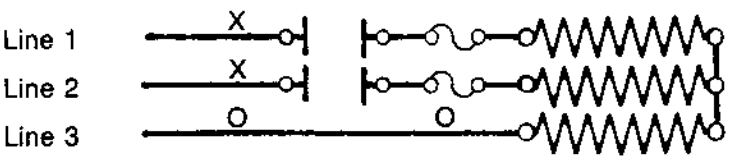
Ohms are calculated on individual Elements, the same as for Single Phase. Delta wired Heaters are balanced load, designed for connection to any Delta or Star power source if the voltages are compatible. Secondary Protection location is optional but preferred in series with power line to the Element. Connected at 6 ends, each end draws half the Amps of each of 3 Supply Lines.



THREE-PHASE DELTA VARIATION

"ALL POLES BREAK"

Same Ohms calculation. Contactor and Manual Resets must carry total Line Amps. 0 indicates Optional Manual Resets. X shows alternate locations.

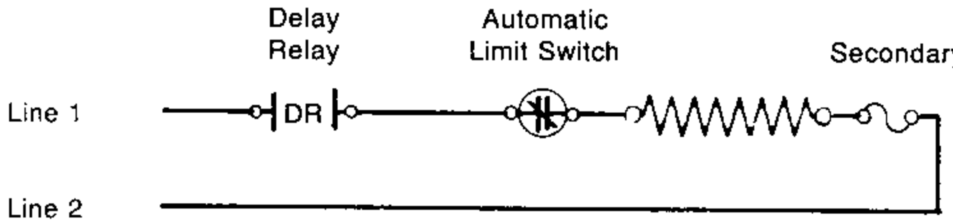


BASIC THREE-PHASE STAR OR WYE DESIGN

FOR ANY THREE-PHASE POWER 208 to 600V.

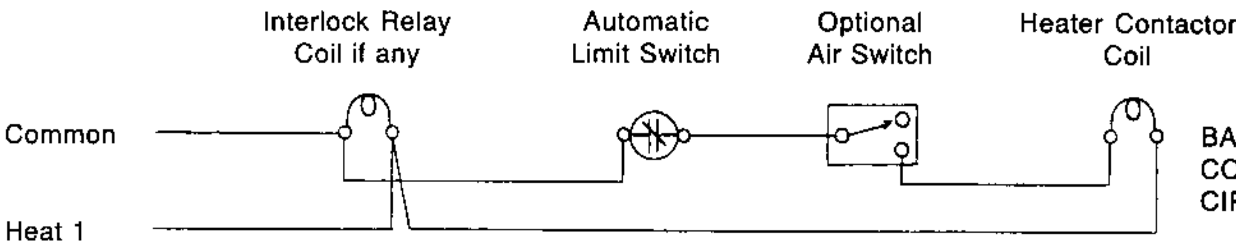
STAR ELEMENT OHMS — First divide Volts by $\sqrt{3}$. Use that to apply $R = E^2/P$.
You may prefer to use an alternate method as follows:
Square Supply Voltage and divide by TOTAL Watts of the 3 Star Elements.

BTU ELECTRIC HEATERS



BASIC SEQUENCER DIAGRAM

Heaters with Delay Relays (Sequencers) controlling Elements must have load carrying Automatic Limit Switches so located in the circuit that Heating Elements will be quickly de-energized during any over-heating circumstance. If more than one Delay Relay is used, it is necessary to select Sequencers with timings that will allow wiring for Fan to be first on and last off.

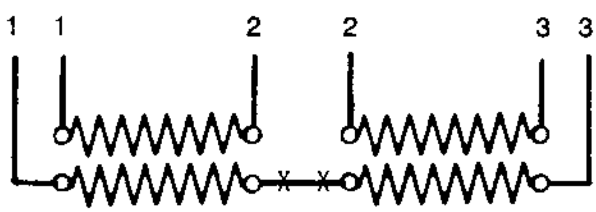


BASIC CONTROL CIRCUIT

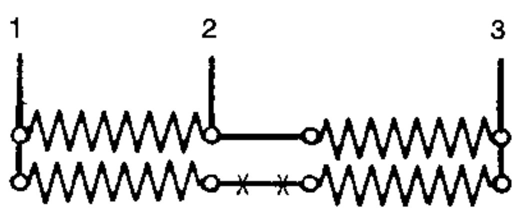
All of these "basic" diagrams are expanded by addition of other components and/or the use of multiples of each basic Heater within the same enclosure.

BELOW ARE OTHER PHYSICAL LAYOUTS OF ELEMENTS ONLY AS THEY WOULD APPEAR IN TWO LAYERS OF FRAME. ELEMENT ENDS MAY BE JOINED INSIDE OR OUTSIDE OF CONTROL BOX.

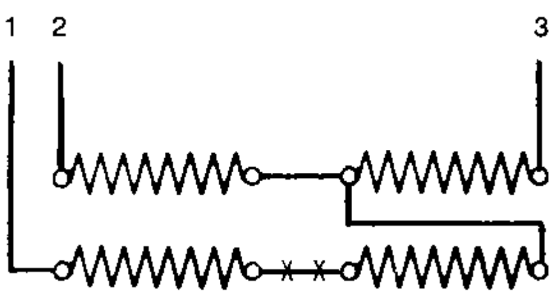
Half-Element jumpers are indicated by —x—x— and not used on whole Elements.



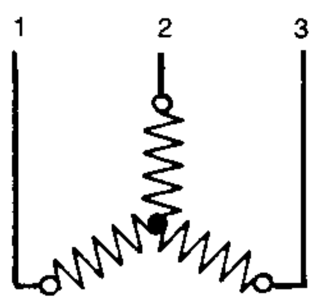
3 Phase Delta with 6 connecting points, each at half the Delta load amperage.

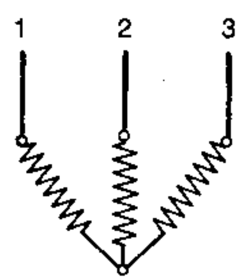


Same Delta with only 3 connections, each at full Delta load amperage.



3 Phase Star or Wye 3 point connection





Star wiring shown on some diagrams

Many additional layouts are employed in the design of physically larger Heaters.

SERVICING TIPS FOR BTU AND OTHER DUCT HEATERS

NO HEAT

1. Check that the controlling T'Stat is set to call for Heating. If the T'stat has a Fan Switch, check the ON position. If the Fan runs, you have learned there is power to that section and the Transformer, Fan Relay and Motor are apparently OK. Return Fan Switch to the Auto position for checking out the Heater next.

2. The Heater should be checked only by qualified service personnel who know how to safely check that there is Power and Control Voltage to the Heater. After that various components can be checked with a Continuity Meter with ALL HIGH VOLTAGE POWER OFF. Replace parts that have failed but remember the following:
   (a) An open Fusible Link or Manual Reset is usually caused by a stuck contactor that allows Heater to "run on" after T'stat is satisfied and the Fan goes off.
   (b) Our U.L. Label is voided and liability passes from us when other than an exact replacement part is used or an Approved Alternate Listed in our U.L. Procedure. The same holds true if any safety device is by-passed. All parts are readily available from our Distributor or on "ship today" basis from our plant.

NOT ENOUGH HEAT

1. Check that the Ampere draw is reasonably close to that on the Heater data plate. If that is not feasible, check Heat Rise against Performance Formula on page 3. Some systems have slower Fan speed on Heating so calculate Heat Rise accordingly. You shouldn't be more than 10% short on either check unless the Supply Voltage is lower than the Heater Data Plate rating or part of the Heater is not operational. Replace any non-functioning parts with EXACT BTU PARTS or Approved Alternates listed in our U.L. Procedure.
2. A Heater that cycles off before the Thermostat is satisfied may cause complaints only during the coldest days when maximum performance is required. (See Section on "Heater Cycling" on back of this page.)
3. Thermostat with Heat Anticipator current draw set too low will "short cycle" a Heater off before the set temperature is reached and when maximum running time may be required. Be sure to figure the extra components that may be energized during the defrost cycle on Heat Pumps. DO NOT FORGET that other than exact replacement components may require a change in the Heat Anticipator setting.
4. If the shortage of heat is in only some areas you might have a condition that requires seasonal damper adjustments to balance differing ratios of Heat Loss and Heat Gain. A kitchen may require proportionately more summer cooling than winter heating. A recently crushed or broken duct would affect a particular area. Also restricted airflow usually affects rooms at the end of the duct system first.
5. TIP: Your customer may have turned on the heat after the area had gotten cold and expected it to warm up quickly or may have made some preliminary checks before calling you. Discharge Air with a low Heat Rise blowing on a 98°F. hand or face might seem like the system wasn't working properly or that there was no heat at all. This is a typical complaint in southern climates or in commercial applications if the Heat Rise is relatively low. If the system is functioning properly, you will have to educate your customer to turn on the Heat before it gets so cold. U.L. Listed "Zero Clearance" Duct Heaters are more acceptable than those with more Heat Rise but without Zero Clearance to combustible surfaces. Maintaining a satisfactory Heat Level on the coldest days, with safety, is the primary concern.

HEATER CYCLING ON AUTOMATIC LIMIT

1. The possibility of a defective or wrong temperature Limit Switch is always there but, more often than not, other conditions contribute to a Heater Cycling problem.
2. Improper airflow caused by obstructions to Return Air, Loose or Broken Fan Belt, Clogged Filters and/or Evaporator Coils may cause the Limit Switch to cycle Heater off before T'stat is satisfied and could cause not enough heat in general or just in the "end of the line" rooms because of the reduced pressure in the duct system.
3. Improper Installation - with insufficient or uneven airflow over the entire Heater. Borderline installations may start cycling after Coil, Filter and Blower get dirty. Heaters are designed not to nuisance cycle provided that sufficient velocity and thickness of inlet air curtain flows between the Primary Limit and Heating Element. The UL rule for Duct Heaters to be located 4 feet downstream from an A/C unit and 2 feet before or after an elbow has its place in elimination of nuisance cycling. Some other conditions that contribute to cycling of a Heater are listed below:
   (a) Heater in a large plenum but too close to a small blower prevents even airflow.
   (b) Baffles bouncing air off Heating Element onto Limit Switch can add to problem.
   (c) Base of Heater Controls Box not flush with the air stream reduces air curtain
   (d) Heater connected to higher than rated voltage results in Superheated Elements.
   (e) Installing Heaters in the top of a horizontal duct is not authorized. Primary Limit Switch cut-out point is lowered by its location on top.

OPEN SECONDARY PROTECTIVE DEVICE

1. An open Manual Reset, Fusible Link or other Secondary Thermal Device is usually the result of a stuck Contactor where the T'stat is satisfied and there is no more Fan. The Heater "runs on" in this abnormal condition until the Secondary Device opens.
2. Lack of proper air over the Heater could cause enough cycling of the Limit Switch so that a Secondary would open after a build up of enough residual heat. This is particularly so when a Heater is installed from the top of the duct.
3. Grounded Heating Element may generate enough heat without Fan to open a Secondary. Overcurrent Fuses or Circuit Breakers may or may not open depending on the amount of Element Resistance to ground and the amount of related current it draws.

CONTACTOR CHATTER

1. Improper Wiring
2. Insufficient Transformer Capacity
   (This may occur during defrost on some heat pumps when many extra components are temporarily energized OR if chatter happens after a component substitute change the substitute may draw more VA overloading the transformer.)
3. Vibration or Contamination of Mercury Thermostat.
4. Excessive Static Pressure on an open face Limit Control (Rare)

ELEMENT FAILURE (Not prevalent if properly designed and not abused)

1. Excessive overheating with wrong temperature or by passed Primary Limit Control
2. Improper installation with enough air directed over the Primary Limit to keep the Heater operating but severely overheating other places not getting enough air.
3. Improper filtering so that Elements can not dissipate heat through dirty covering.
4. Corroded hardware or loose connections causing burned-off wires or Elements.
5. Any physical damage, grounding, a nick or an impurity in the Element itself.
6. Bad Element Design with too much KW in a given space and/or not enough Element mass to dissipate heat. The hotter an Element operates, the quicker it deteriorates.
7. Very light gauges of Element wire may be sufficient electrically but they simply flutter in the high velocity air until they are grounded out and burn through.