

# Construction Electrical

HEATREX offers a broad range of electrical components for temperature, safety, and power control.

For most applications, the Control Option system, described in the previous section, makes it easy to specify a complete control package.

For applications requiring a special control system, the following section describes components, their applications, and limitations.

## Bi-Metallic Thermal Cutouts

Both UL and NEC require thermal cutout protection against overheating due to insufficient airflow, air blockage or air failure. Two levels of protection are provided:



Figure 22.

The primary or automatic reset thermal cutout (Figure 22) is a fixed temperature, bi-metallic disc type device which opens when its set point is reached and automatically resets when the temperature falls below its set point. The operating disc and contacts are completely enclosed to prevent infiltration of dirt or physical damage. This single pole device is most often wired into the heater control circuit, but will carry single-phase loads up to 25 amps at 240 volts and 22 amps at 277 volts (See **Table V**). Most heaters have only one automatic reset thermal cutout. However, on large heaters, two or more may be supplied, wired in series.

Table V

Single-Phase Voltage	120	208	240	277
Maximum KW	3.0	5.2	6.0	6.0

The secondary manual reset thermal cutout (Figure 23) has a temperature setting approximately 50°F (10°C) higher than the automatic reset cutout to provide protection only if the primary system fails. Once it has tripped, it is necessary to press a reset tab to return the heater to operation.



Figure 23.

Open coil heaters use a cutout rated to carry the maximum heater circuit load allowed by UL and NEC: 48 amps at 480 volts. One cutout is supplied for each heater circuit, or group of circuits, drawing 48 amps or less.

Many manufacturers use heat limiters or fusible links which require field replacement when an overtemperature condition occurs. This often involves removing the heater from the duct and always involves ordering replacement heat limiters from the manufacturer. With HEATREX's manual resets, the heater can immediately be put back into operation, simply by pressing the reset button.

There is no danger that backup protection will be lost because replacement heat limiters are not available. Furthermore, the services of a qualified electrician are not required, since maintenance personnel can easily reset the manual cutouts.

## Linear Thermal Cutouts

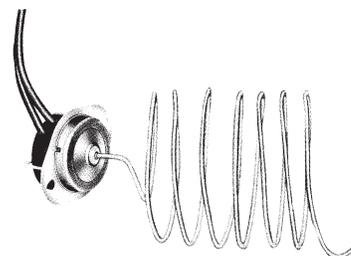


Figure 24.

The linear thermal cutouts (both automatic and manual reset) sensing element (Figure 24) is a fluid-filled capillary tube, strung across the entire heater width. If any 6" (152 mm) segment of the capillary is overheated, the cutout will de-energize the entire heater, providing

additional protection if the airflow is not sufficiently uniform. Furthermore, it is fail safe – it will trip if the capillary loses its fill. These cutouts are normally provided for pilot duty but can carry the heater load directly up to 25 amps, 277 volts, single-phase.

**Custom open coil heaters** – Only one linear automatic and/or one linear manual, set 50°F (10°C) higher than the automatic, may be furnished, in addition to the standard cutouts. They are wired in series with the standard disc type automatic cutout.

**Finned tubular heaters** – Triple overheating protection is standard for finned tubular heaters. In addition to the automatic disc thermal cutout, Figure 22, both automatic and manual reset linear cutouts, Figure 24, are furnished.

An automatic primary linear limit cutout, strung across the top and leaving air face of the coil (Figure 25), protects against overheating caused by low airflow. This device will turn the heater off if the fixed temperature set point is exceeded. It automatically resets when the temperature drops to safe levels.

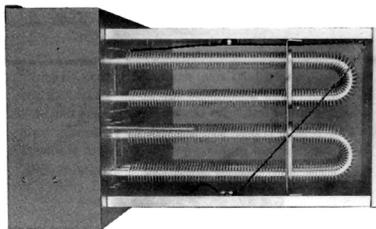


Figure 25.

A manual secondary linear limit cutout protects against failure of the primary overtemperature system. With a fixed temperature setting higher than either of the primary cutouts described above, this device is designed to trip only if both of the primary cutouts stick in the closed position, or controlling contactor points weld together.

## Airflow Switch

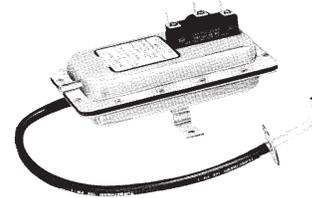


Figure 26.

A diaphragm operated differential pressure switch (Figure 26) is normally used to prevent a heater from operating unless air is flowing. The switch is provided with a velocity pick-up tube extending into the duct area, making it sensitive to static pressure as well as velocity pressure.

The switch requires at least .07" (17.4 Pa) of water column pressure difference between the inside and the outside of the duct. If the pressure is below .07", a fan relay should be substituted as described below.

Airflow switches are normally connected for positive pressure – i.e. for a heater located on the discharge side of a fan. If the heater is on the suction side, the switch may be specified or field converted for negative pressure. In most applications the airflow switch is wired into the heater control circuit, but it can carry the heater load directly up to 15 amps at 277 volts, single-phase.

## Fan Relay

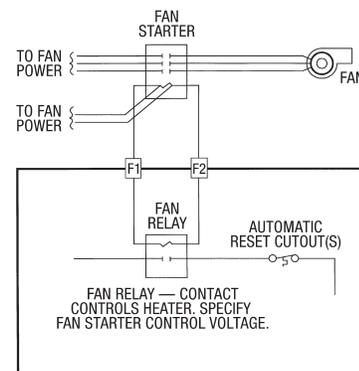


Figure 27.

A fan relay is available as an alternate to the standard airflow switch. It has the advantage of being a positive electrical interlock between the fan and the heater (see Figure 27 for wiring details). Its primary disadvantages are that it requires field wiring back to the fan control circuit and does not protect against conditions such as belt failure. When a fan relay is required, specify the fan starter control voltage. If not specified, it will be assumed to be the same as the heater control voltage. Both a fan relay and an airflow switch can be furnished.



## Magnetic Contactors

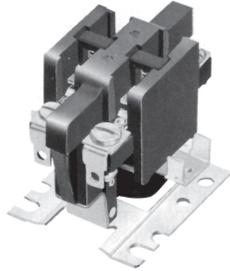


Figure 28.

All magnetic contactors supplied by HEATREX are UL Recognized for limit control duty, as opposed to less severe, general purpose duty. De-energizing contactors, break one power line on single-phase circuits and two lines on three-phase. Disconnecting contactors, break all ungrounded conductors, one power line on 120 and 277 volt single-phase, two power lines on 208 and 240 volt single-phase and all lines on three-phase. Both de-energizing and disconnecting contactors are available with ratings up to 600 volts. Contactors are available with holding coil voltages of 24, 120, 208, 240 or 277.

## Fuses



Figure 29.

Low resistance fuses are mounted in phenolic fuse blocks fitted with extra tension springs to assure cool connections. To protect against faults in both contactors and heating elements, fuses are located on the line side of contactors built into heaters. To meet NEC requirements for continuous loads, fuses are rated at least 25% above the load they are protecting.

## Control Transformer



Figure 30.

Built-in control transformers are available to supply either 24 or 120 volt control circuits. The transformer primary is factory connected to the main supply and the secondary is wired directly to the built-in control components. Overcurrent protection and secondary grounding are provided when required by UL and the NEC.

## Disconnect Switch



Figure 31.

Built-in disconnect switches are an inexpensive, positive way to meet the NEC requirement for a disconnecting means within sight of the heater, controller(s), and overcurrent protection devices. The switches are interlocked with the heater terminal box cover and have labeled "on" and "off" positions. If there are any external sources of control voltage, a separate toggle switch is provided. Together these devices result in a "dead front" design to protect service personnel. Both fused (up to 48 amps) and unfused switches are available. However, unfused switches are most often specified, as they meet code safety requirements.

## Pilot Lights

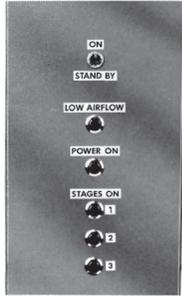


Figure 32.

Pilot lights, projecting through the side of the heater terminal box, indicate functional operation. The most commonly specified functions are:

**Heater On** – This indicates that power has been supplied to the heater, but does not necessarily indicate that the control system is calling for heat or that heat is being produced.

**Low Airflow** – This indicates that there is either no airflow, or it is so low that the airflow switch has prevented the heater from operating.

**Each Stage On** – These indicate when each heater stage has been energized. Not available with SCR controlled stages.

**Overtemperature** – This indicates when the automatic reset thermal cutout has tripped due to an overtemperature condition. Only available with custom heaters.

## Pilot Switch

A pilot switch is a simple means of de-energizing the heater between seasons or during prolonged shut-downs. The switch is wired in series with contactor holding coils. It cannot be used as a disconnecting means and is therefore labeled with “on” and “standby” positions. If disconnecting contactors are also specified, the switch will have a labeled “off” position in accordance with UL and NEC provisions.

## Pneumatic/Electric (PE) Switches



Figure 33.

Built-in and pre-wired PE switches are available for pneumatic control systems. To minimize field labor, all PE switches are factory piped to a single port projecting through the terminal box. Pneumatic connections may, therefore, be made without interfering with electrical connections. Standard switches close on pressure rise, resulting in a fail-safe system since a loss of pressure de-energizes the heater. “Open on rise” switches are available on custom heaters for special applications.

PE switches can either be used as pilot duty devices, or to carry heater loads up to 22 amps, 480 volts, single-phase.

PE switches are limited to six stages, because it is difficult to calibrate more switches and still maintain proper staging. For more than six stages, specify a step controller (described on pages 19 and 20) with a pneumatic transducer (described on page 13).



## Electronic Controls

HEATREX duct heaters may be specified with SCR power controllers or electronic step controllers. While these devices are inherently different, they have certain common characteristics:

- **Input Flexibility** – Normally supplied with a thermostat, controls can be used with many field-supplied ohmic sensors or electronically generated control signals, such as proportional milliamp or DC voltages. Thus they are compatible with virtually any field-installed control system.
- **Low Voltage Control** – NEC Class II field wiring may be used on the thermostat circuits of all controls.
- **High Ambient Temperature Rating** – All units are designed for full load operation in high ambient temperatures, making them particularly suitable for use in duct heater terminal boxes and remote control panels.
- **Fail Safe Circuitry** – In the event of either a short or open circuit in the thermostat leads, all controls de-energize the heaters, protecting the heaters from runaway overheating conditions.
- **LED Function Indicator** – Light emitting diodes (LED pilot lights) indicate the operating status of the controls. On SCR power controllers, the LED shows when the heater is on, indicating the percentage output being provided to the heater. On step controllers, LED's show when control power is on and the status of each heater stage.
- **Continuous Feedback** – Logic and control circuits continuously monitor the input signal to determine if more or less heat is required. Appropriate action is then taken automatically.

## SCR Power Controllers

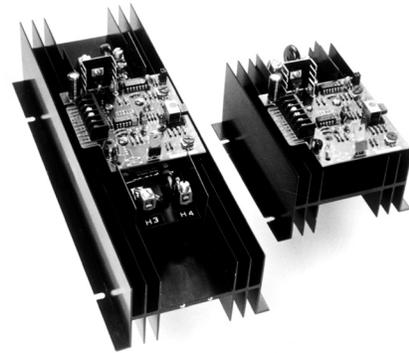


Figure 34. A & B Series for indoor use

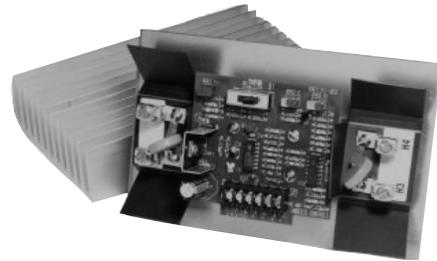


Figure 35. Series 103 for outdoor and dusty applications

The advanced programming and circuitry of the A&B Series and the Series 103 SCR's provides multi-purpose operation and field-switchable temperature control inputs for 4-20 milliamps, 0-10 VDC, 135 ohms, and 2200 ohms. Custom inputs are available. Please consult the factory.

SCR power controllers modulate the entire heater load, varying the heater output from 0 to 100% of the total heater KW. Working on a one second time base, the heater will be energized only for the number of AC cycles necessary to produce the exact amount of heat required. For example, multi-stage discharge temperature control of a heater can produce unacceptable temperature swings, resulting in poor comfort levels and inefficient energy use. The same heater controlled by an SCR and a sensitive duct thermostat will produce stable, even heat for maximum comfort and efficiency.

The SCR's power switching devices are mounted on a large finned heat sink which extends outside the heater terminal box or control panel. The conservative SCR rating (no more than 75% of the manufacturer's rating) and this generous heat sink insures against overheating and SCR failure.

Both single-phase and three-phase SCR's are available as are master and slave units. Each master is capable of driving up to three slaves, giving a capability for 100%, fully proportional SCR control. However, when the load exceeds that tabulated in **Table III** on page 11, it is more economical to combine SCR's with an step controller in a vernier configuration. See page 21.

The SCR is switched on only as the voltage wave form crosses the zero point, which virtually eliminates radio frequency interference (RFI). All 480 and 600 volt SCR's have a 1200 peak inverse voltage (PIV) rating and transient absorbers that protect them from the high voltage spikes found on 480 and 600 volt lines.

Except on small, single-phase heaters where the heater load can be carried directly by the automatic thermal cutout (see **Table V**, page 14), all heaters with SCR's require safety contactors for operation of the primary overtemperature protection system.

## Step Controllers (Sequencers)

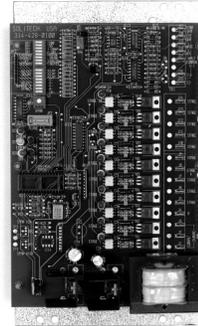


Figure 36. Electronic Sequencers

The S95 step controllers can handle simple multi-stage control to sophisticated vernier systems. The advanced programming and circuitry of the S95 provides multi-purpose operation and field-switchable temperature control inputs for 4-20 milliamps, 0-10 VDC, 135 ohms, and 2200 ohms. Custom inputs are available. Please consult the factory.

In addition to those previously listed features, S95 step controllers have the following important advantages:

- They de-energize and recycle all stages, upon momentary power interruption, to avoid heavy line surges and to provide a soft start when power is restored.
- Adjustable time delay of 5 seconds to 10 minutes between stages can be field programmed. For span settings for each input, see **Table VI** on page 21.
- Both master and slave units are available, with 10 stages of operation. Up to 20 stages may be controlled with master slave combinations. Each S95 step controller is factory programmed for the exact number of stages required.
- The number of stages energized with a proportional S95 step controller is directly proportional to the input signal (normally DC volts or milliamps). Proportional step controllers are used with many building management systems.

## Step Controllers (Microprocessor-based)

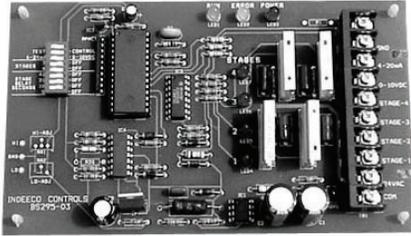


Figure 37. Microprocessor-based S208

Microprocess-based S208 step controller provides temperature control for staged and vernier systems up to 4 stages. The S208 has many of the same advanced features as the S95 step controller but is designed for use with smaller heaters. The S208 includes the following features:

- Up to four stage control.
- Vernier control for heaters up to 240 amps.
- Field-switchable temperature control inputs for 4-20 milliamps and 0-10 VDC.
- Class II - designed to be used in low Class II 24 volt circuits.
- Time delay, the rate the stages are turned ON or shut OFF, is determined by a field adjustable 1-75 second time delay.
- Proportional control, the number of stages turned ON, is proportional to the input signal.

While standard SCR's and step controllers satisfy the majority of HVAC applications, a much broader range of special capabilities is also available with HEATREX custom heaters.

- **Close Tolerance Controller** - When used with a properly designed system, this modified SCR is capable of maintaining tight temperature control in a controlled space, such as clean rooms and calibration labs.
- **Fan Motor Controls** - In addition to control of the heater, it is often desirable to control and power the fan through the heater. The heater is designed so that the electrician brings only one power circuit into the terminal box which is subdivided for fan power. The motor controller, overloads and overcurrent protection for this auxiliary fan circuit and motor will be provided.
- **Low Limit Discharge Control** - A thermostat is placed in the occupied area which has primary control of the heater. A second thermostat is placed in the discharge duct which is set for a predetermined minimum discharge temperature and will override the room thermostat, if the discharge temperature falls below the duct sensor set point. This prevents cold air from being discharged into the occupied area.
- **Temperature Averaging** - Multiple sensors, with a single set point, are placed in different zones or in several locations of a large area, such as a warehouse. The controller averages the readings of all the sensors to determine the heater output. This design can be used in the hot deck of multizone units.

## Vernier Proportional Control

Recommended for large KW heaters, the economical vernier control system offers many of the advantages of full SCR control. One vernier heater stage is connected to a slave SCR controller. Additional stages are sequenced on and off while the SCR-vernier stage automatically fills the gap between the step controlled stages, providing full proportional control over the entire heater KW range. Both the slave SCR-vernier stage and the step-controlled stages are controlled by the step controller. The vernier system is normally recommended for heaters drawing more than 96 amps for three-phase or 192 amps for single-phase (see **Table III**, Page 11).

For proportional vernier control systems used with building management systems, HEATREX recommends that the SCR stage be sized the same KW as the non-SCR stages to obtain the optimum control. See Figure 38.

## Thermostats/Inputs for Electronic Controls

An electronic proportional room thermostat (page 12, Figure 15) is standard for the A&B Series Power Controllers and the S208 Step Controllers. A duct type thermostat can be specified as well (page 13, Figure 21). A tamperproof electronic proportional room thermostat is standard for the S95 Series Step Controllers (page 12, Figure 15). A duct type thermostat is also available (page 13, Figure 20). When a special thermostat or field-installed control is used, the controller can be specified with any of the inputs listed in **Table VI**.

**Table VI**

**Typical Thermostat Inputs Available for Step Controllers & SCR's**

Inputs	Spans (Factory Set)	
	SCR's	S95 Step Controller
2200 ohms	100 ohms	100-400 ohms (adjustable)
135 ohms	100 ohms	120 ohms
4-20 mA*	12.8 mA	15 mA
0-10 VDC	8.0 VDC	9 VDC

\* Standard input impedance is 250 ohms

All inputs listed are available with HUA and HUP type heaters. These inputs plus a variety of other inputs are available with custom heaters.

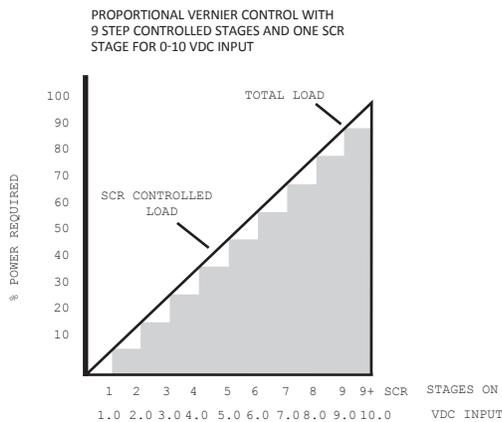


Figure 38.

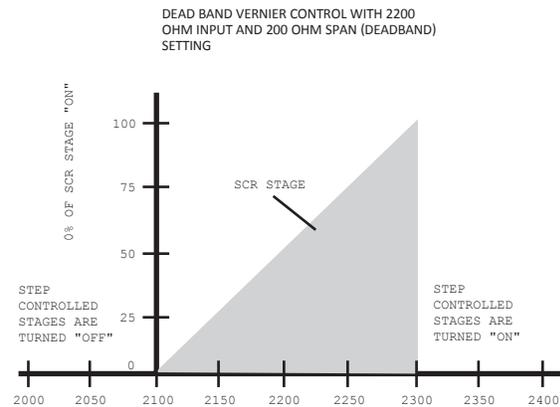


Figure 39.



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