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CITY OF ANCHORAGE
MUNICIPAL POWER & LIGHT
ANCHORAGE, ALASKA

HEAT TREAT FURNACE
SERIAL NO. 3651

TABLE OF CONTENTS

CITY OF ANCHORAGE
MUNICIPAL POWER & LIGHT
ANCHORAGE, ALASKA

SPECIFICATIONS

1. Maximum Power Input: 150 KWH
2. Maximum Temperature: 2400°F
3. Minimum Temperature: 1000°F
4. Time to maximum temperature with cold furnace: 2 hour
5. Design Load Weight: 400 pounds
6. Atmosphere Types: air, inert gases
7. Control Power Circuit: 120 VAC, 10 amp
8. Power Circuit: 480 VAC, 3-phase, 300 amp
9. Maximum excess temperature controller set point: 2430°F
10. Maximum compressed air supply pressure: 120 psig
11. Maximum atmosphere gas supply pressure: 40 psig

OPERATING PROCEDURES

1. Car Operation

   a. Slowly move car in and out of furnace making sure the car load is secure. When removing a hot load, take care to avoid any heat damage to surrounding areas. Make sure adequate personnel protection is provided.

   b. Door ratchets should be tightened until snug only, do not over compress door seals.

   c. Car seals must be opened prior to moving the car. Close seals using manual pneumatic valve near control panel. Adjust speed with limiting screws on exhaust mufflers.

2. Heating Circuit

   a. Element support blocks suspend the heating elements and are sealed against atmosphere leakage with RTV sealant. Molybdenum Disilicide are very fragile, so exercise care to avoid contact. See Kanthal literature concerning their use.

   b. Safety contactor in power panel energizes and de-energized electrical power to heating elements.

   c. Power transformer limits 3-phase voltage to elements to a maximum of 350 VAC. This is a design limitation which keeps the elements from overheating.

   d. SCR power controller is a phase angle fired power control device. The output voltage is proportional to the input mA signal. See Phasetronics product literature.

   e. Manual input control to SCR is enabled until 800°F. This allows elements to heat-up at low input (KW) until resistance change becomes linear with temperature change. After 800°F, an alarm (A2S1) within the temperature controller switches the input SCR signal to auto control.

OPERATING PROCEDURES (Continued)

3. Temperature Control

   a. UDC 5000 temperature controller has a type "R" thermocouple input and a 4-20 mADC output signal.

   b. Temperature controller can operate in local or program mode. See product literature for details.

   c. Roof thermocouples are type "R". One is main temperature control input and one is excess temperature control input. Load thermocouple should be type "K" single use thermocouple wire connected to chart recorder.

4. Alarm Circuit

   a. The alarm circuit may be energized by pushing "ALARM SILENCE" push button. The "ALARM ENERGIZED" amber pilot light illuminates. Buzzer sounds when alarm is tripped. Turn "ALARM" selector switch "OFF" to silence buzzer until fault is corrected.

   b. Alarm will annunciate a change from safe status in the following:

      1. Car seals raised
      2. Car proven in furnace
      3. Excess temperature
      4. Process temperature alarm

5. Safety Considerations

   a. Interlocks are provided in the electrical circuit as follows:

      1. Car must be proven in furnace and seals raised for heating elements to be energized by safety contactor.
      2. "EMERGENCY STOP" button will open 120 VAC control circuit until operator re-energizes circuit.

   b. Although interlocks and safety devices are provided, there is no substitute for proper training and diligence of operating personnel. Contact Armil/CFS with any questions concerning operation or safety of the equipment.

   c. See NFPA 86 for additional information (see inserts).

OPERATING PROCEDURES (Continued)

6. Atmosphere System

a. Purge flow meter is a high flow Dwyer meter used for accelerated atmosphere displacement of air. Duration controlled by Eagle timer inside panel.

b. Normal flow meter is a low flow Dwyer meter used to maintain a positive pressure in chamber and prevent air infiltration.

c. Effluent valve opens during purge period and closes during normal flow conditions.

d. Panel mounted selector switches allow choice of purge and normal or normal flow only. Choose desired mode and the amber pilot lights illuminate while purge and/or normal flow rates are activated.

e. Injection tubes (4) are 99% alumina ceramic which pass atmosphere into process chamber and induce slight convection currents to aid temperature uniformity.

F. Flow Meter Type RMC – 35 PSI
Set FlowMeter to approx 200 CFM
Dwyer Inclined Manometer should read
.001 on scale
Check Manometer During operation and
Adjust as needed.

START-UP PROCEDURE

Step 1. Carefully push car inside furnace and ratchet closed both sides.

Step 2. Use manual air valve to "CLOSE" both car seals.

Step 3. Rotate power control panel disconnect to "ON" position.

Step 4. Turn "CONTROL POWER" selector switch to "ON" position.

Step 5. Push "START CONTROL POWER" push button.

--- "CONTROL POWER ON" green pilot light illuminates.

Step 6. "LIMITS COMPLETE" amber pilot light illuminates when both car seals raise and car is proven in furnace.

Step 7. Begin Honeywell UDC 5000 temperature controller program or adjust local set point to desired valve. Make sure controller is in "AUTO" mode (not "MANUAL" mode).

Step 8. Turn "POWER CIRCUIT" selector switch to "ON" position.

Step 9. Push "START POWER CIRCUIT" push button.

--- "POWER CIRCUIT ENERGIZED" red pilot light illuminates.

Step 10. If atmosphere gas purge and normal flow is desired, turn "PURGE & NORMAL FLOW" selector switch to "ON".

--- "PURGE ENERGIZED" amber pilot light illuminates for 2 minutes and goes out.
--- "NORMAL FLOW ENERGIZED" amber pilot light illuminates continuous.

Step 11. If only normal flow of atmosphere gas (no purge) is desired, turn "NORMAL FLOW" selector switch to "ON".

--- "NORMAL FLOW ENERGIZED" amber pilot light illuminates.

Step 12. Turn "CHART RECORDER" selector switch to "ON".

START-UP PROCEDURE (Continued)

Step 13. Turn "ALARM CIRCUIT" selector switch to "ON" position, buzzer will sound.

Step 14. Push "ALARM SILENCE" push button to silence buzzer.

--- "ALARM ENERGIZED" amber pilot light illuminates.

Step 15. "EMERGENCY STOP" palm push button will shut down control and power circuits if pushed.

NOTE: Always turn main power control panel disconnect to "OFF" when entering equipment and when furnace is not in use.

SCR START-UP INITIAL

1. Install ampere meter on load wire. Install mA meter on SCR input signal. Install voltmeter on load wire lugs (2).

2. Because the heating elements have such a great positive resistance/temperature coefficient, the following approach is being taken to minimize the heat-up time required.

   A. Chamber Temperature -less than- 800°F

      1. Turn the manual 10K potentiometer maximum clockwise and, while watching the ampere meter, energize the power circuit. Having the soft ramp set at approximately 30 seconds will allow trial and error method of adjusting current trip (R42) until cutout point is 300 amperes.

      2. The current will drop rapidly as heating elements gain temperature, therefore, immediately adjust manual 10K potentiometer at cold furnace until amperage measures 250. Amperage will soon drop to 220 or less.

      3. Put temperature controller in "MANUAL" mode and 100% output. Make sure mA meter shows approximately 20 mA current.

      4. When temperature reaches 800°F, alarm #2 indicator light illuminates. At this time, the SCR changes to AUTO control from the UDC 5000 controller.

   b. Chamber Temperature -greater than- 800°F

      1. As alarm #2 switch 1 (A2S1) energizes, the current will jump to 280-290 amperes momentarily. Immediately adjust current limit (R63) potentiometer to allow maximum of 230 amperes of current.

      2. Input to furnace jumps from approximately 40 KWH to 150 KWH at this point.

SCR START-UP INITIAL (Continued)

3. The current draw will lower slightly and the voltage will rise as the furnace temperature increases.

4. Monitor the KWH as you proceed:

$$\text{VAC (3-PH)} \times \text{Amps} \times 1.73 = \text{WATTS}$$

5. Make certain temperature controller is in "AUTO" mode.

CITY OF ANCHORAGE
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MAINTENANCE PROCEDURES

1.	Inspect insulation & refractory -pack/repair as necessary	Monthly
2.	Inspect heating elements & support block	Weekly
	-Replace	As Required
3.	Replace car seals	As Required
4.	Inspect TC protection tubes & atmosphere injection tubes	Weekly
5.	Calibrate temperature controllers (2) and chart recorder	Semi-Annually
6.	Check function of safety limits - Car seals L.S. (2) - Car position L.S. - HTL controller - PTC alarm 1 contact	Weekly
7.	Check SCR controller settings - current limit (above 800°F) - manual pot. resistance - current trip (above 800°F)	Semi-Annually
8.	Clean top of furnace of accumulated dust (vacuum) to prevent localized overheating	Annually
9.	Clean inside/outside control and power panels	Annually
10.	Change pilot light bulbs	As Required
11.	Lubricate door ratchets	Monthly
12.	Change chart recorder pens & paper	As Required
13.	Clean metal "POWER CONTROL PANEL" filter and SCR cooling fan (3) blades & heat sinks (NOTE: make sure main disconnect is "OFF")	Semi-Annually
14.	Replace batteries in chart recorder	2 Years

SPARE PARTS

1. Heating element assemblies (3)

2. Thermocouple (1)

3. Element braid clamp (2 each)

4. Ceramic fiber blanket (50 sq.ft.)

5. Atmosphere injection tube (1)

6. SCR parts
   - Option board (1)
   - fuse (3)

7. Chart recorder supplies
   - paper (1 month supply)
   - batteries (as required)
   - pens (1 each)
   - plotter (1)

8. Car seal cylinder (1)

9. Push-lock hose (10 ft)

KANTHAL SUPER Qualities

KANTHAL SUPER ST

Since KANTHAL SUPER was first introduced in the middle of the 1950's this quality has been the standard one for low as well as high temperature applications.

The maximum element temperature is 1700°C *3090°F*. Elements of KANTHAL SUPER ST which operate continuously in air at an element temperature about 1450°C *2640°F* may exhibit low mechanical strength after cooling down to room temperature.

KANTHAL SUPER N

The maximum element temperature is once again 1700°C *3090°F*, but a slight embrittlement may occur at about 1375°C *2510°F*.

KANTHAL SUPER 33

The maximum element temperature permitted for KANTHAL SUPER 33 is 1800°C *3270°F*.

Where the element temperature is expected to be in excess of 1600°C *2910°F*, KANTHAL SUPER 33 will give a longer life than the other qualities. There is no embrittlement temperature range on KANTHAL SUPER 33 material.

Composition

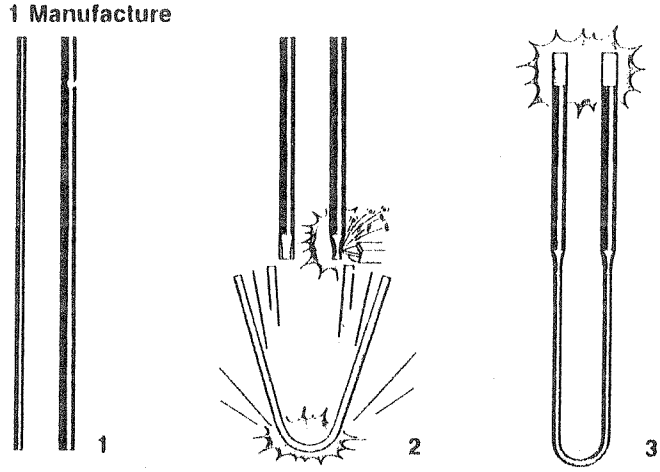
KANTHAL SUPER is a "cermet" material consisting principally of molybdenum disilicide ($MoSi_2$).

Molybdenum disilicide has been known for a long time and has been subject to study mainly due to its good resistance to oxidation at high temperatures. Apart from some metals within the platinum group, there is no other metallic material with as high a resistance to oxidation. However, pure molybdenum disilicide is an intermetallic, brittle compound of practically no commercial use. The addition of ceramic compounds forms a cermet, KANTHAL SUPER, with mechanical properties well up to practical demands without affecting its resistance to oxidation. The main constituent is a glass phase which forms about 20% of the volume. At temperatures exceeding approximately 1200°C *2190°F*, the glass component increases its fluidity making KANTHAL SUPER material ductile at high temperatures.

Manufacture

KANTHAL SUPER elements are produced by the powder metallurgy process. The mixed powder is extruded into straight rods of different diameters for the terminals and heating zones. The rods are dried, sintered and cut into suitable lengths (1). The heating zones are bent under heat to the desired shape and welded to the terminals, one end of which is conically ground to the same diameter as that of the heating zone (2). The other end of the terminal is aluminized to ensure a good electrical contact (3). Additional welds may be necessary on elements with long heating zones. However, these will have no influence on the life or performance of the element.

Fig. 1 Manufacture



Properties

Oxidation Resistance

The ability of KANTHAL SUPER elements to withstand oxidation at high temperatures depends on the formation of a thin, adhesive, protective layer of quartz glass (SiO_2) on the surface. When molybdenum disilicide reacts with oxygen in the atmosphere, the layer of quartz glass is formed and under this a thin layer of molybdenum silicide with a lower silicon content (Mo_5Si_3). The thin protective layer does not flake off when the element is cooled down, in spite of the great difference in coefficient of expansion between the layer and that of the KANTHAL SUPER material. When KANTHAL SUPER elements are operated at high temperatures for extended periods, the thickness of the protective layer increases and may exhibit a tendency to flake off when cooled down. The protective layer is, however, reformed as soon as the element re-attains a high temperature. In this respect, KANTHAL SUPER is similar to high temperature metallic resistance materials.

The protective layer on KANTHAL SUPER has been found to possess the capacity to clean itself from adhering impurities. If the impurities react with the silica skin, the melting point will be lowered. The contaminated layer then flows down the element and drops off at the U-bend. A new silica layer is, however, spontaneously rebuilt. Extensive attack may lead to overheating of the element due to reduction of the cross-sectional area.

On an unprotected element surface, e.g. the surface from which the layer has flaked off, a yellowish, powdery layer (MoO_3) is formed. This, however, does not affect the formation of a new silica skin at temperatures above 800°C *1470°F*. This yellowish layer comes off in the form of smoke when the silica skin is re-formed.

In many respects, KANTHAL SUPER elements can be compared to a quartz glass rod: brittle when cold, ductile when hot, and similar reaction with the environment.

Resistivity

The resistivity of KANTHAL SUPER increases sharply with temperature. This means that when the elements are connected to a constant voltage, the power will be higher at lower temperatures and will be successively reduced with increasing temperature, thus shortening the time for the furnace to reach operating temperature. Furthermore, as the power of the element decreases, the danger of overheating will be reduced.

KANTHAL SUPER ST and N have the same resistivity. KANTHAL SUPER 33 has a somewhat lower resistivity but the difference is only in the order of 5%. The temperature–resistivity curves are almost parallel. (See diagram fig. 13 page 37).

The resistance of KANTHAL SUPER elements does not change due to ageing even after having been in operation for a long time at high temperatures. There is only a slight reduction (≈ 5%) during the first period of time.

Due to the non-ageing properties and strongly positive temperature coefficient of the resistivity of KANTHAL SUPER a failed element can easily be changed without the performance of other elements connected in series being influenced. This is a great advantage over silicon carbide elements, whose resistances have to be carefully matched after use in order to avoid overheating.

Mechanical and Physical Properties

Tensile strength at 1550°C *2820°F*	100 N mm^{-2} ±25% *14 500 lbs/sq.in.*
Bending strength at 20°C *68°F*	350–400 N mm^{-2}
Impact strength Charpy at 20°C *68°F*	0.7 N m cm^{-2} *36 ft.lb,*
Hardness at 20°C *68°F*	8 Mohs scale ≈*1200 Knoop*
Density	5.6 g cm^{-3} *.202 lb./cu.in.*
Porosity	<1%
Thermal conductivity:	
20–600°C *68–1110°F*	30 W m^{-1} °K^{-1} *18 Btu/ft h °F*
600–1200°C *1110–2190°F*	15 W m^{-1} °K^{-1} *9 Btu/ft h °F*
Coefficient of linear expansion	7–8 · 10^{-6} °K^{-1}
Specific heat capacity at 20°C *68°F*	0.42 kJ kg^{-1} °K^{-1} *.10 Btu/lb.°F*
Emissivity	0.70–0.80
Resistivity	See page 15
Change of Resistance as a Function of Temperature, Ct	See page 15 and fig. 13 (page 37).

Thermal, Electrical and Life Factors

3

Maximum permissible Element Temperatures

KANTHAL SUPER ST	1700°C *3090°F*
KANTHAL SUPER N	1700°C *3090°F*
KANTHAL SUPER 33	1800°C *3270°F*

KANTHAL SUPER ST is not recommended for continuous use in the element temperature range 1420–1470°C *2590–2680°F* (See page 11).

KANTHAL SUPER N is not recommended for continuous use in the element temperature range 1350–1400°C *2460–2550°F* (See page 11).

Change of Resistance as a Function of Temperature

The resistivity-temperature curve for the KANTHAL SUPER qualities is very steep, exemplyfied by the following:

KANTHAL SUPER ST and N
at 20°C *68°F* 0.30 *180*
at 1500°C *2700°F*
3.45 Ω mm^2 m^{-1} *2065 Ω/cir. mil. ft.*

KANTHAL SUPER 33
at 20°C *68°F* 0.28 *168*
at 1500°C *2700°F*
3.30 Ω mm^2 m^{-1} *1985 Ω/cir. mil. ft.*

The advantages of this steep resistance change have been mentioned on page 13. One should ensure that all elements connected in series have similar radiating conditions. If the radiation from one element or part of an element is restricted, there is a risk of overheating due to locally increased resistance without a corresponding reduction in amperage.

Diagram fig. 13 (page 37) and table fig. 14 (page 38) show the resistance at different temperatures for the standard rod sizes.

The Effect of Electro-magnetic Force

When current passes through a 2-shank KANTHAL SUPER element a repelling force is set up between the shanks, which, after a time, leads to an increase in the distance "a" between the shanks of the heating zone.

After a long period of use, the effect of the repelling and gravitational forces on the heating zone of a vertically mounted KANTHAL SUPER element tend to reach a state of equilibrium.

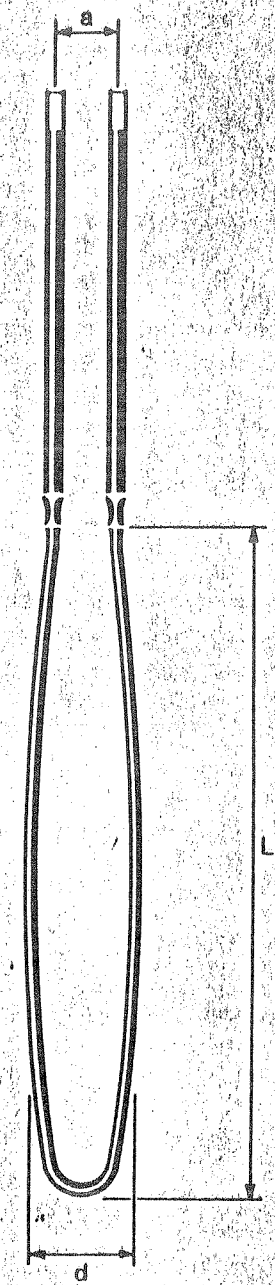
The degree of deformation depends on the amperage, the length of the heating zone (L_e) and the distance between the shanks (a).

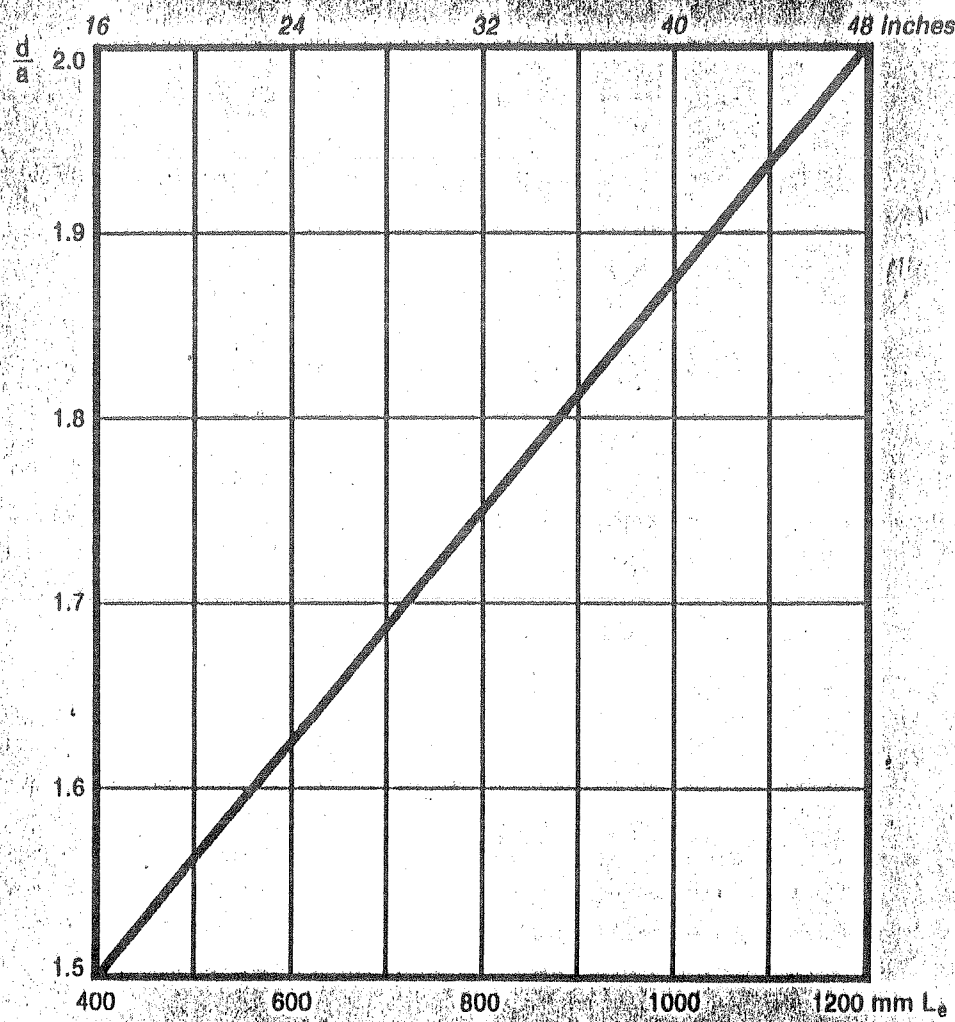
The diagram (Fig. 2, page 16) shows how a KANTHAL SUPER element is deformed due to the effect of magnetic force. The effect of the electro-magnetic repelling force is reduced if the distance between the shanks (a) is relatively large. It has been found from practical experience that to avoid excessive deformation the minimum value of "a" should not be below the following:

Element Ø 6/12 mm	L_e <500 mm *19.7 in.*	a_{min} = 40 mm *1.6 in.*
	L_e ≥500 mm *19.7 in.*	a_{min} = 50 mm *2.0 in.*
Element Ø 9/18 mm	all L_e	a_{min} = 60 mm *2.4 in.*
Element Ø 3/6 mm	all L_e	a_{min} = 25 mm *1.0 in.*

3

Fig. 2 Deformation of KANTHAL SUPER elements due to electro-magnetic forces





L_e = Heating zone length, mm
a = Distance between shanks, mm

Based on the maximum permissible element currents in continuous operation
9/18 mm = 350A; a = 60 mm *2.36 in.*
6/12 mm = 200A; a = 50 mm *1.97 in.*
3/6 mm = 75A; a = 25 mm *.98 in.*

Service Life of KANTHAL SUPER Elements

The life of KANTHAL SUPER elements is basically determined by the operating conditions.

The main reasons for element failure are:

- **Mechanical damage** during maintenance work or operation of the furnace.
- **Reaction with foreign substances** either by direct contact or by dust, fumes or gases. (See page 19).
- **Mechanical stresses** during the cooling down of the furnace to room temperature.
- **Mecanical shocks** due to magnetic forces. If the elements are switched on at a low temperature at too high a voltage, or without a current limiting device, the shock from the resulting high electro-magnetic forces may cause element breakage.
- **Overheating** of the element. Continuous operation of the furnace is the most advantageous condition. Depending on the operating temperature and influence from factors mentioned above, the lifetime of a set of elements may be as long as five years and in some cases even longer.

In the temperature range 1600–1700°C *2910–3090°F*, KANTHAL SUPER 33 has a longer life than KANTHAL SUPER ST and N.

Chemical Resistance of KANTHAL SUPER

Atmospheres

KANTHAL SUPER can be used in most furnace atmospheres. Most favourable are oxidizing atmospheres such as air, carbon dioxide and water vapour, but KANTHAL SUPER elements are also operating successfully in neutral and carburizing atmospheres.

Fig. 3 shows the maximum recommended element temperatures in some common types of furnace atmospheres and gases.

Atmosphere	ST and N °C	ST and N °F	33 °C	33 °F
Air	1700	*3090*	1800	*3270*
Nitrogen	1600	*2910*	1700	*3090*
Argon, Helium	1600	*2910*	1700	*3090*
Dry hydrogen	1350	*2460*	1400	*2550*
Moist hydrogen. Dewpoint 15°C *60°F*	1460	*2660*	1500	*2730*
Exogas (Ex. 10% CO_2, 5% CO, 15% H_2)	1600	*2910*	1700	*3090*
Endogas (Ex. 40% H_2, 20% CO)	1400	*2550*	1450	*2640*
Cracked and partially burnt ammonia (≈ 8% H_2)	1400	*2550*	1450	*2640*

Fig. 3 Maximum recommended element temperatures

Air

The maximum operating temperatures in air are 1700°C *3090°F* (KANTHAL SUPER ST and N) and 1800°C *3270°F* (KANTHAL SUPER 33).

At temperatures exceeding 800°C *1470°F* a layer of silica is formed on the surface thus protecting the element from further oxidation. (See page 13).

At low temperatures such a protective skin does not develop and if the element surface is unprotected, an oxidation of molybdenum and silicon can occur in temperatures about 550°C *1020°F*. The oxidation product is a yellowish powder mainly consisting of molybdenum oxide (MoO_3). This reaction is known as "molybdenum pest" and has no detrimental effect on the performance of KANTHAL SUPER elements.

Carburizing Atmosphere

KANTHAL SUPER elements are widely used in carburizing furnaces. The elements are not attacked by the atmosphere which normally consists of an endogas or nitrogen with controlled additions of a carburizing gas such as propane.

In this type of furnace, the element temperature is normally kept below 1400°C *2550°F* and the only danger is carbon precipitation in the furnace which can lead to element failure. Regular removal of the carbon by firing the furnace under oxidizing conditions is recommended.

Hydrogen Atmosphere

Hydrogen is commonly used as a protective atmosphere in many high temperature sintering and heat treatment operations.

In dry hydrogen, however, the silica layer is reduced and $MoSi_2$ disintegrates whilst forming gaseous silicon and silicides with lower silicon content. This reaction is dependent on temperature and the reduction potential of the hydrogen gas. By increasing the dewpoint the maximum permissible element temperature can be increased. Fig. 4 (page 20) shows the relationship between dewpoint and max. element temperature.

Vacuum

KANTHAL SUPER elements are not suitable for operation in a high vacuum at high temperatures.

Fig. 5 (page 20) shows the maximum permissible element temperatures at different air pressures.

Exogas

A typical gas composition is: 10% CO_2, 5% CO, 15% H_2 and balance N_2. This composition may vary within wide limits but principally this type of atmosphere is oxidizing with respect to KANTHAL SUPER. The maximum element temperatures are about 1600°C *2910°F* for KANTHAL SUPER ST and N, and 1700°C *3090°F* for KANTHAL SUPER 33.

Endogas

A typical gas composition is: 20% CO, 40% H_2, and balance N_2. This type of atmosphere is not as oxidizing with respect to KANTHAL SUPER as exogas but, nevertheless, the elements can operate at 1400°C *2550°F* and 1450°C *2640°F* respectively without any harmful effect on life. Dewpoint is important (see fig. 4 page 20).

Miscellaneous Gases

Nitrogen. Maximum recommended element temperatures in pure nitrogen are 1600°C *2910°F* and 1700°C *3090°F* respectively.

Argon and Helium are both inert with respect to KANTHAL SUPER. Maximum operating temperatures are 1600°C *2910°F* and 1700°C *3090°F* respectively.

Water Vapour in any amount in the atmosphere has only an oxidizing effect. The presence of water vapour in a controlled atmosphere increases the maximum permissible operating temperature.

Sulphur Dioxide sometimes occurs as an impurity in the atmosphere. In normal concentrations, it has no harmful effect on KANTHAL SUPER elements.

Chlorine and Fluorine, as well as their compounds may sometimes contaminate the furnace atmosphere. Fluorine attacks KANTHAL SUPER strongly, even oxidized elements. (For example, in a glass melting furnace for opal glass with a 7% fluorine content, the atmosphere attacked the elements. When the fluorine content was reduced to 1%, there was no longer any attack.)

Chlorine is not as aggressive as fluorine but should, nevertheless, be avoided, as it will attack unprotected parts of an element.

Experience has shown that chlorides added to the glass (borosilicate glass) have no harmful effect on the life of the elements.

Resistance to Metals and Oxides

Ideally, KANTHAL SUPER elements should never come in contact with any solid material with the exception of ceramics used as supports, and passage bricks of suitable qualities.

Metals

In oxidizing atmospheres all metals oxidize with the exception of noble metals. These oxides react with the silica layer on the surface of the elements and may lead to premature failure.

Furnaces equipped with KANTHAL SUPER elements are often used for metal melting. In these cases it is important that the elements are protected from splashes of molten metal, dust when charging the furnace, and fumes developed during melting, especilly from fluxes.

Any metal or alloy with a melting point lower than approx. 1300°C *2370°F* may be melted in a KANTHAL SUPER furnace if necessary precautions are taken.

KANTHAL SUPER Elements

Unlike metallic resistance elements, KANTHAL SUPER elements are only delivered in a ready-made form. The properties of the material necessitate a special manufacturing technique as well as a certain amount of standardization of the element shapes and sizes.

Two-shank Elements

The most commonly used elements are U-shaped. These elements are normally vertically mounted but can also be horizontally mounted if suitably supported. At element temperatures above 1600°C *2910°F*, the hot zone must not come in contact with ceramics because of possible reaction between the silica layer and the ceramics.

Qualities:
KANTHAL SUPER ST
KANTHAL SUPER N
KANTHAL SUPER 33

Standard dimensions:

Heating zone, L_e Ø mm	Ø *in.*	Terminal, L_u Ø mm	Ø *in.*
3	*.12*	6	*.24*
6	*.24*	12	*.47*
9	*.35*	18	*.71*

For information on other sizes contact Kanthal Furnace Products.

2-shank elements with straight terminals are defined by:

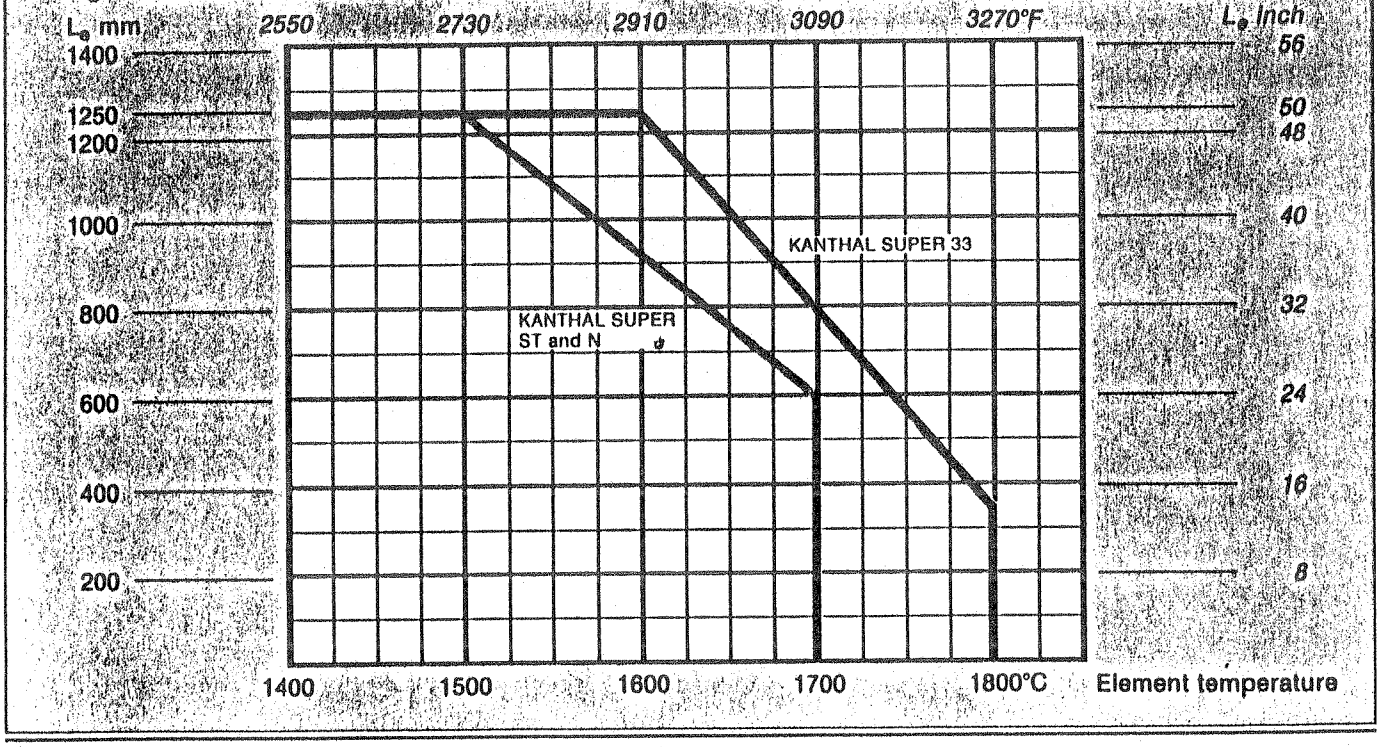
- The quality
- Heating zone diameter, mm *in.*
- Terminal diameter, mm *in.*
- Heating zone length, L_e, mm *in.*
- Terminal length, L_u, mm *in.*
- Centre distance between shanks, a, mm *in.*

Example: KANTHAL SUPER ST 9/18 mm
L_e=560 mm *22 in.*, L_u=450 mm *17.7 in.*, a=60 mm *2.36 in.*

The maximum length of the heating zone depends on the element temperature. Fig. 6 shows the maximum recommended heating zone lengths for vertically suspended 6/12 and 9/18 mm elements.*

* Note: 3/6 mm KANTHAL SUPER 33 elements are not normally manufactured with a heating zone (L_e) longer than 630 mm *24.8 in.*

Fig. 6 Maximum recommended heating zone lengths for vertically suspended 6/12 and 9/18 mm elements



f1

Furnace Temperature	Voltage
20–300°C *68–570°F*	1/3 of operating voltage
300–700°C *570–1290°F*	2/3 of operating voltage
700°C *1290°F*–operating temperature	Operating voltage

On large furnaces (>100 kW), the holding time at 1/3 of operating voltage should be longer. In order to prevent the current intensity from becoming too high, the voltage steps can be switched as per table above.

The table below shows an alternative using four voltage steps.

When switching over from the first to the second voltage step the element temperature must not be allowed to fall below 300–400°C *570–750°F*.

In many cases the voltage can be switched over by means of switches or contactor equipment permitting almost instantaneous change-over. When changing over in this manner, the elements do not have time to cool down, which means that current surges when switching on the higher voltage are considerably reduced. With such equipment, therefore, switching-over can be done at slightly lower furnace temperatures than those mentioned above.

If it is desired to let a furnace "idle" for any length of time, the furnace temperature should be maintained above 600°C *1110 °F*.

Replacement of Elements

One of the greatest advantages of KANTHAL SUPER elements is that a failed element can easily be replaced without the furnace having to be cooled down. Vertically mounted elements are replaced as follows:

After having localized the failed element, unbolt the contacts from the bus-bars and remove the ceramic fibre round the upper part of the passage brick, after which the element and passage brick may be lifted out. A previously assembled unit consisting of a new element complete with passage brick and element holders is now inserted through the hole in the furnace roof.

The contacts which have been removed from the damaged element can be used again providing that they are undamaged. If, on the other hand, the contact surfaces are oxidized or damaged to such an extent that they cannot be restored to a serviceable condition, they should be replaced.

Temperature Control

The type of thermocouple used for temperature control depends on the furnace temperature:

Type K: Thermo-Kanthal P + N has a good stability to 1200°C *2190°F* and can be used in many heat treating furnaces.

Type S: Pt–Pt/Rh 10% should not be used continuously at temperatures exceeding 1500°C *2730°F*.

Furnace Temperature	Voltage
20–300°C *68–570°F*	1/4 of operating voltage
300–600°C *570–1110°F*	1/2 of operating voltage
600–800°C *1110–1470°F*	3/4 of operating voltage
800°C *1470°F*–operating temperature	Operating voltage

Type B: Pt–Pt/Rh 6%–Pt–Pt/Rh 30% has a good stability to 1750°C *3180°F* and should be used in all high temperature furnaces.

The thermocouple should be checked regularly in order to ensure correct temperature readings. For details of the checking procedure, see our Data Sheet 4.C.4.

The temperature regulating instrument to which the thermocouple is connected should be provided with a safety device against thermocouple failure which switches off the furnace if the thermocouple ceases to function.

In order to prevent the elements from overheating, the controlling thermocouple should be placed in the hottest part of the furnace. In certain cases it may be advisable to have thermocouples both for registering the temperature adjacent to the heating elements and the temperature of the charge.

If a thermocouple is used regularly at a particular temperature, it should not be used temporarily for measuring other temperatures. This often leads to structural alterations in the material and impairs the registering accuracy of the thermocouple. Neither should the insertion length of a thermocouple be altered for the same reason. This length should be about eight times the external diameter of the protection tube in order to prevent heat conduction from affecting the temperature at the welded junction.

Safety Precautions

Use dark glasses when watching glowing KANTHAL SUPER elements. The eyes are subjected to great strain when observing temperatures above 1400°C *2550°F.*

KANTHAL SUPER elements which have been operating for a long time at high temperature and have then cooled down, sometimes have internal stresses which cause the glaze to splinter into small fragments. There have been instances where elements which have been cold for several days have emitted a shower of fine glaze particles when touched. Always use eye protection even when handling cooled-down KANTHAL SUPER elements.

CARBORUNDUM

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Anchor-Loc® Ceramic Fiber Modules

Product Specifications

Introduction

The Anchor-Loc® module system is a family of ceramic fiber module products designed to meet a wide range of application requirements in a variety of heat processing vessels.

Ceramic fiber modules used in the Anchor-Loc systems are constructed with Durablanket® S, Durablanket HP-S, Durablanket 2600 or Fibermax® mat. Each type of Anchor-Loc ceramic fiber module can be easily fastened to interior steel shells of all types of heat processing equipment with several different attachment systems.

The ceramic fiber blanket or mat is secured by two alloy through-rods to a metallic module anchor. Flanges on the end of the through-rods effectively lock the position of the rods relative to the anchor at the time of installation.

Anchor-Loc ceramic fiber modules are manufactured in several configurations. A choice of attachment systems is provided to meet a wide range of application needs:

Weld-Loc™ Ceramic Fiber Modules

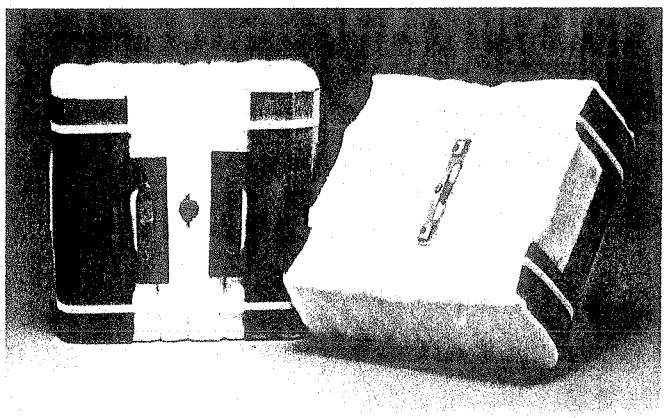
A special weld assembly is installed in each Weld-Loc ceramic fiber module. This stud assembly permits fusion of the stud base to the furnace casing and allows a threaded fastener to be torqued on the stud, drawing the module to the plate. Advantages which are offered by the Weld-Loc module include:

- High installation speed
- Ease and simplicity of installation
- Permits random placement of modules on the casing
- Multiple welds per module are possible
- System provides a positive torque test of the welds

Power-Loc™ Ceramic Fiber Modules

A hardened steel pin mechanically secures each Power-Loc module to the steel casing plate. The anchor pin is installed with a special Hilti® powder actuated fastening tool and powder booster. Advantages which are offered by the Power-Loc ceramic fiber module include:

- High installation speed
- Casing preparation is eliminated
- Permits random placement of modules on the casing
- Ease and simplicity of installation
- Positive mechanical/attachment of modules to the casing plate
- Setup time is reduced



Thread-Loc® Ceramic Fiber Modules

Provided with an all-thread weld stud and flanged nut, the Thread-Loc ceramic fiber module is designed for installation on a prepositioned stud pattern. The Thread-Loc attachment system has several advantages:

- Compatibility with mastic coatings, backup insulation, and foil vapor barriers
- Module design compensates for variations in stud placement
- Access to the welded fastener for full testing before the module is installed

Screw-Loc® Ceramic Fiber Module

A self-tapping screw supplied with each Screw-Loc ceramic fiber module easily penetrates mild steel up to ½" in thickness. The Screw-Loc attachment system provides the following installation advantages:

- Multiple, random anchor placement
- Ease of removal and replacement
- Furnace casing preparation is eliminated
- Low cost installation equipment is readily available

Anchor-Loc ceramic fiber modules offer the same advantages as layered Fiberwall™ furnace linings when compared to refractory construction. They are:

- Faster temperature cycling
- Lower heat storage
- Lower fuel costs
- Increased productivity
- Lower installed cost
- Easier repairs

Hilti® is a trademark of Hilti Tool Corporation.

Form C-1428 Effective 3/90
Supersedes Form C-1230-A, 12/87

Printed in U.S.A.

CARBORUNDUM

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Fiberfrax® Blanket and Mat Products

Product Specifications

Introduction

The Fiberfrax® blanket and mat product family consists of a group of lightweight, thermally efficient ceramic fiber insulating materials that combine the advantages of both low heat storage and complete resistance to thermal shock. Offering a broad range of thermal capabilities and physical characteristics, this product family provides proven and effective solutions to a variety of heat processing applications.

Durablanket® ceramic fiber products are comprised of high strength, needled insulating blankets that are made from spun Fiberfrax ceramic fibers. The extra long spun fibers, cross-locked through a unique forming process, produce a blanket with unexcelled handling strength. The Durablanket product family is completely inorganic and available in a variety of combinations of physical characteristics, temperature capabilities and sizes.

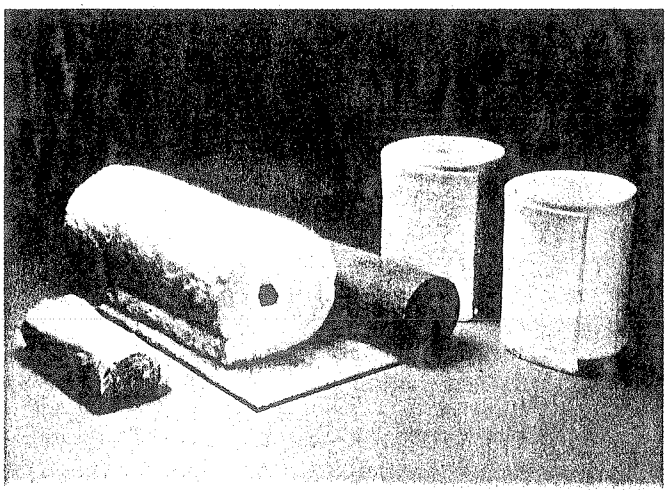
Fibermat™ mat, PH blanket and Moist-Pack™ D insulation provide additional options for specific application needs ranging from cost-effectiveness to high hot gas velocity resistance.

Fibermax® mat is a high temperature, flexible mat product entirely composed of Fibermax polycrystalline mullite fibers, making it an extremely lightweight, highly resilient insulator that is virtually free of unfiberized ("shot") particles.

Having excellent chemical stability, Fiberfrax blanket and mat products are unaffected by most chemicals except hydrofluoric and phosphoric acids and concentrated alkalies. If wet by water or steam, thermal and physical properties remain unaffected after drying.

Durablanket S

Fiberfrax Durablanket S insulation, the flagship of the Durablanket product family, is a strong, lightweight, flexible needled blanket that is made from spun ceramic fibers. Available in a wide variety of thicknesses, widths and densities, Durablanket S insulation provides an array of proven solutions for the broadest spectrum of applications.



Durablanket HP-S

Fiberfrax Durablanket HP-S insulation is made from spun, high purity Fiberfrax ceramic fibers. Coupled with all of the physical characteristics offered by Durablanket S insulation, the high purity level of Durablanket HP-S insulation makes it especially suitable for those applications requiring high purity fiber chemistry.

Durablanket 2600

Fiberfrax Durablanket 2600 insulation is a high temperature version of the Durablanket product line. It is made from high purity alumina, zirconia and silica spun Fiberfrax ceramic fibers. This composition, in combination with a unique manufacturing process, imparts Durablanket 2600 insulation with extremely low shrinkage characteristics at elevated temperatures.

Form C-1421
New 3/90

Printed in U.S.A.

Anchor-Loc 2400 Modules - 149 kg/m³ (9.3 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness - mm (in) Cold Face Temperature -	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)	305 (12) °C (°F)
982 (1800)		94 (201)	81 (177)	72 (161)	66 (150)
1093 (2000)		109 (228)	93 (199)	82 (180)	75 (167)
1204 (2200)		125 (257)	106 (223)	94 (201)	85 (185)

Anchor-Loc 2400 Modules - 192 kg/m³ (12 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness - mm (in) Cold Face Temperature -	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)	305 (12) °C (°F)
982 (1800)		85 (185)	73 (163)	65 (149)	60 (140)
1093 (2000)		97 (207)	83 (182)	74 (165)	67 (153)
1204 (2200)		110 (231)	94 (201)	83 (182)	76 (168)

Anchor-Loc 2600 Modules - 149 kg/m³ (9.3 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness - mm (in) Cold Face Temperature -	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)	305 (12) °C (°F)
1149 (2100)		117 (242)	99 (211)	88 (190)	80 (176)
1260 (2300)		134 (273)	113 (236)	100 (212)	91 (195)
1316 (2400)		142 (288)	121 (250)	107 (224)	96 (205)

Anchor-Loc 2600 Modules - 192 kg/m³ (12 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness - mm (in) Cold Face Temperature -	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)	305 (12) °C (°F)
1149 (2100)		104 (219)	88 (191)	78 (173)	72 (161)
1260 (2300)		117 (243)	100 (212)	88 (191)	80 (176)
1316 (2400)		124 (256)	106 (223)	93 (200)	84 (184)

Anchor-Loc 3000 Modules - 96 kg/m³ (6 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness - mm (in) Cold Face Temperature -	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)	305 (12) °C (°F)
1316 (2400)		164 (327)	139 (283)	123 (253)	111 (231)
1427 (2600)		182 (360)	155 (311)	137 (278)	123 (253)
1538 (2800)		201 (393)	171 (340)	151 (304)	136 (277)

Anchor-Loc 3000 Modules - 128 kg/m³ (8 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness - mm (in) Cold Face Temperature -	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)	305 (12) °C (°F)
1316 (2400)		149 (301)	127 (261)	112 (234)	101 (214)
1427 (2600)		166 (330)	141 (286)	124 (256)	112 (234)
1538 (2800)		183 (361)	156 (312)	137 (279)	124 (255)

All heat flow calculations are based on a surface emissivity factor of .90, an ambient temperature of 27°C (80°F) and zero wind velocity, unless otherwise stated. All thermal conductivity values for Fiberfrax® materials have been measured in accordance with ASTM Test Procedure C-177. When comparing similar data, it is advisable to check the validity of all thermal conductivity values and ensure the resulting heat flow calculations are based on the same condition factors. Variations in any of these factors will result in significant differences in the calculated data.

Form C-1428 Effective 3/90
Supersedes Form C-1230-A, 12/87

CARBORUNDUM

Typical Physical Properties

	Duraback™	Durablanket® S	Durablanket HP-S	Durablanket 2600
Color	White	White	White	White
Continuous Use Limit*	982°C (1800°F)	1260°C (2300°F)	1260°C (2300°F)	1430°C (2600°F)
Melting Point	1648°C (3000°F)	1760°C (3200°F)	1760°C (3200°F)	1760°C (3200°F)
Fiber Diameter	2-4 microns (mean)	2.5-3.5 microns (mean)	2.5-3.5 microns (mean)	3.5 microns (average)
Specific Heat @ 1093°C (2000°F)	1130 J/kg °C (0.27 Btu/lb °F)	1130 J/kg °C (0.27 Btu/lb °F)	1130 J/kg °C (0.27 Btu/lb °F)	1130 J/kg °C (0.27 Btu/lb °F)
Specific Gravity	2.73 g/cm³	2.73 g/cm³	2.73 g/cm³	2.73 g/cm³
Average Tensile Strength (ASTM 686-76)	—	5.5 lb/in² @ 4 PCF 9.9 lb/in² @ 6 PCF 12.5 lb/in² @ 8 PCF	—	—
Available Density kg/m³ (lb/ft³)	64 (4)	64, 96, 128 (4, 6, 8)	64, 96, 128 (4, 6, 8)	96, 128 (6, 8)

Typical Chemical Analysis

	PH Blanket	Moist-Pack™ D	Fibermat™ Blanket	Fibermax® Mat
Al_2O_3	44%	34.5%	31-35%	72%
SiO_2	51%	62.8%	50-54%	27%
ZrO_2	5%	—	5%	—
Fe_2O_3	—	0.64-0.80%	1.3%	0.02%
TiO_2	—	0.54-1.37%	1.7%	0.001%
MgO	—	—	**0.5%	0.05%
CaO	—	—	≤7.5%	0.05%
Na_2O_3	—	—	—	0.10%
Alkali	—	0.23%	—	—
Leachable Chlorides	<10 ppm	—	<10 ppm	11 ppm
Other Inorganics	—	—	—	—

Typical Physical Properties
PH Blanket

Color:	Tan
Continuous Use Limit*:	1260°C (2300°F)
Melting Point:	1790°C (3260°F)
Fiber Diameter:	
PH Fine:	5 microns (mean)
PH Coarse:	13 microns (mean)
Fiber Length:	Up to approximately 254 mm (10")
Density:	96 kg/m³ (6 lb/ft³)
Binder Content:	3-5%

Typical Physical Properties
Moist-Pack D

Color:	White
Basic Composition:	Alumina-silica
Recommended Use Limit*:	1093°C (2000°F)
Melting Point:	1790°C (3260°F)
Typical Dry Density:	190-290 kg/m³ (12-18 lb/ft³)
Specific Heat Capacity at 1093°C (2000°F):	1130 J/kg °C (0.27 Btu/lb °F)
Tensile Strength - 6.4 mm (¼"):	Wet = 1.2 x 10^5 N/m² (17 psi) Dry = 3.5 x 10^5 N/m² (50 psi)
Hot Gas Erosion Resistance:	Test procedure based on British Gas Council Research Comm. GC173 = over 30.5 m/sec (100 ft/sec)

Normal shelf life one year in unopened containers.

*The continuous use limit of Fiberfrax® insulation is determined by irreversible linear change criteria, not product melting point.
**MgO and other trace inorganics

Form C-1421
New 3/90

CARBORUNDUM

Typical Physical Properties
Fibermat™ Blanket

Color:	White
Continuous Use Limit*:	760°C (1400°F)
Fiber Diameter:	2.5-3.5 microns (mean)
Specific Gravity:	2.73 g/cm³
Nominal Weight:	½" thickness = 3.7 oz/ft²
	1" thickness = 7.3 oz/ft²
	2" thickness = 14.7 oz/ft²
Tensile Strength (ASTM 686-76):	7-10 psi (typical)

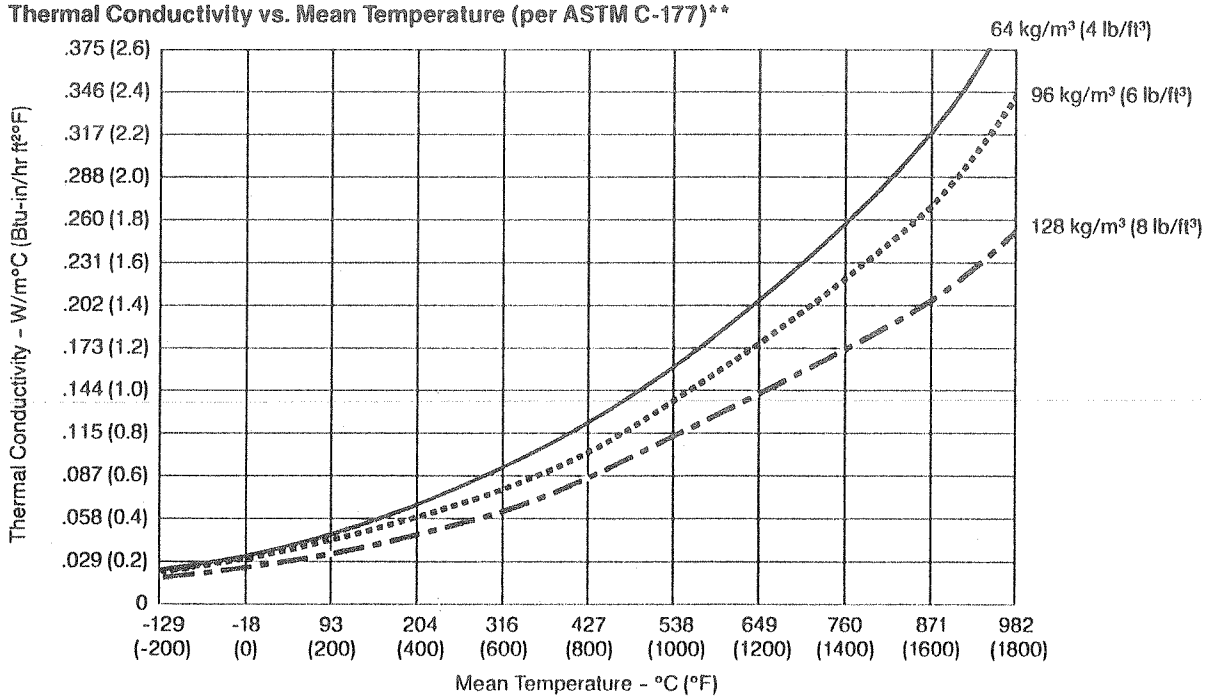
Typical Physical Properties
Fibermax® Mat

Color:	White
Continuous Use Limit*:	1650°C (3000°F)
Melting Point:	1870°C (3400°F)
Fiber Diameter:	2-3.5 microns (mean)
Specific Gravity:	3 g/cm³
Specific Heat Capacity	1246 J/kg °C
at 1093°C (2000°F):	(0.297 Btu/lb °F)
Fiber Surface Area:	7.65 m²/g

Typical Mechanical Properties
Compression Recovery

Percent Compression	Percent Recovery
10	93
30	82
50	71

Duraback™
Durablanket® S
Durablanket HP-S
Durablanket 2600
Thermal Conductivity vs. Mean Temperature (per ASTM C-177)**



*The continuous use limit of Fiberfrax® insulation is determined by irreversible linear change criteria, not product melting point.

**All heat flow calculations are based on a surface emissivity factor of 0.90, an ambient temperature of 27°C (80°F), and zero wind velocity, unless otherwise stated. All thermal conductivity values for Fiberfrax materials have been measured in accordance with ASTM Test Procedure C-177. When comparing similar data, it is advisable to check the validity of all thermal conductivity values and ensure the resulting heat flow calculations are based on the same condition factors. Variations in any of these factors will result in significant differences in the calculated data.

Form C-1421
New 3/90

CARBORUNDUM

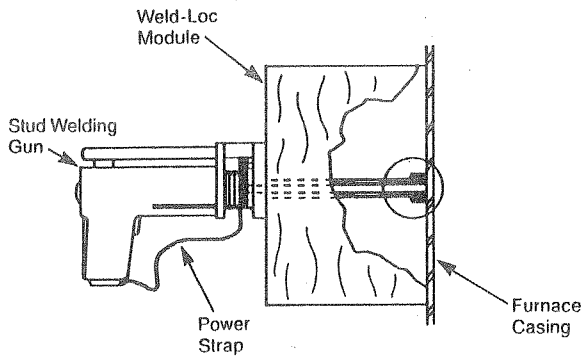
Applications

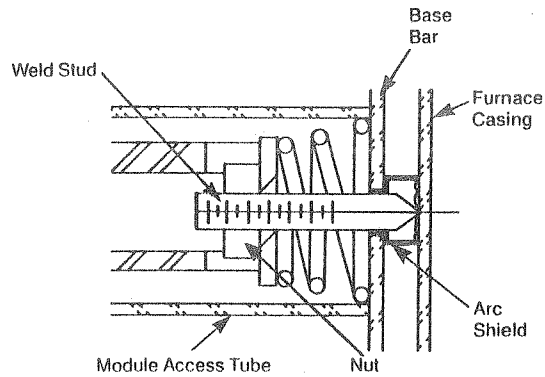
- Stress relieving furnaces
- Annealing furnaces
- Carbottom heat treating furnaces
- Process heaters
- Reheat furnaces
- Furnace, kiln and boiler linings
- Incineration equipment and stack linings
- Soaking pit covers
- Ladle covers
- Ladle preheaters
- Forge furnaces

Available Anchor-Loc® Ceramic Fiber Modules
305 mm x 610 mm (12" x 24"), 305 mm x 305 mm (12" x 12"), 305 mm x 152.5 mm (12" x 6")

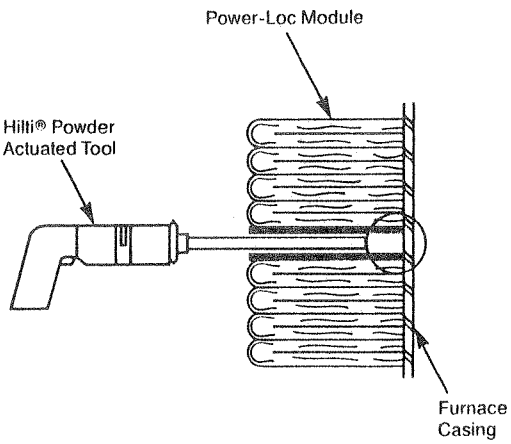
Module Type	Design Temperature Limit	Recommended Operating Temperature Limit	Construction	Module Density
Anchor-Loc 2200	1204°C (2200°F)	1093°C (2000°F)	Folded Durablanket®-S	128 kg/m³ (8 lb/ft³) 160 kg/m³ (10 lb/ft³)
Anchor-Loc 2400	1316°C (2400°F)	1232°C (2250°F)	Folded Durablanket HP-S	149 kg/m³ (9.3 lb/ft³) 192 kg/m³ (12 lb/ft³)
Anchor-Loc 2600	1427°C (2600°F)	1343°C (2450°F)	Folded Durablanket 2600	149 kg/m³ (9.3 lb/ft³) 192 kg/m³ (12 lb/ft³)
Anchor-Loc 3000	1649°C (3000°F)	1532°C (2800°F)	Layered Fibermax® mat	96 kg/m³ (6 lb/ft³) 128 kg/m³ (8 lb/ft³)

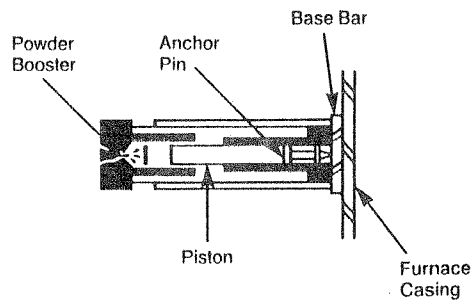
A. Weld-Loc™ Ceramic Fiber Module





B. Power-Loc™ Ceramic Fiber Module





Form C-1428 Effective 3/90
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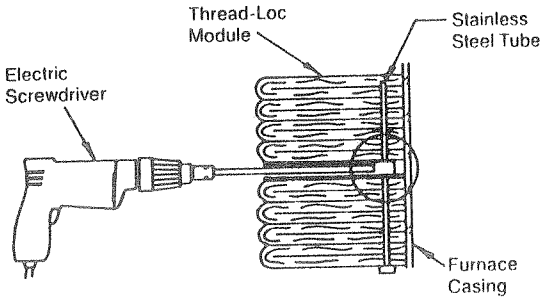
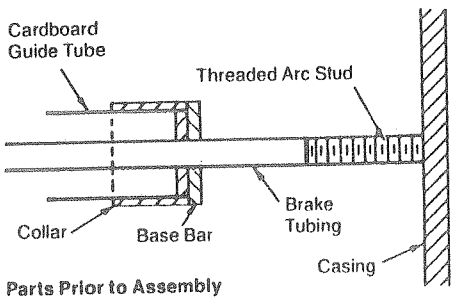
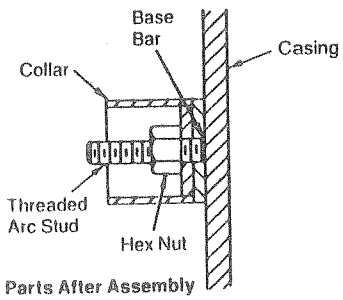
C. Thread-Loc® Ceramic Fiber Module



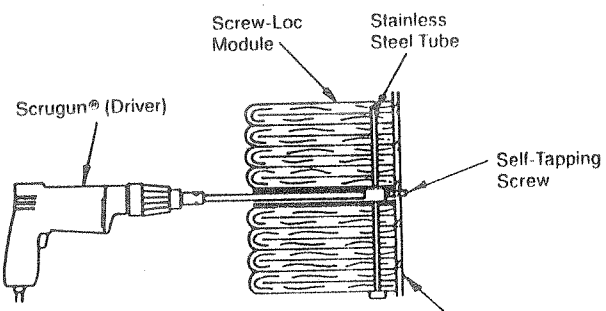


Parts Prior to Assembly



Parts After Assembly

D. Screw-Loc® Ceramic Fiber Module



Scrugun® is a registered trademark of
The Black and Decker Manufacturing Co., Towson, MD

Anchor-Loc® Modules

Anchor-Loc 2200 Modules – 128 kg/m³ (8 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness – mm (in) Cold Face Temperature –	102 (4) °C (°F)	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)
649 (1200)		73 (164)	61 (141)	53 (128)	49 (120)
871 (1600)		106 (223)	85 (185)	73 (164)	66 (150)
1093 (2000)		147 (296)	117 (242)	99 (211)	88 (190)

Anchor-Loc 2200 Modules – 160 kg/m³ (10 lbs/ft³)

Hot Face °C (°F)	Insulation Thickness – mm (in) Cold Face Temperature –	102 (4) °C (°F)	152 (6) °C (°F)	203 (8) °C (°F)	254 (10) °C (°F)
649 (1200)		71 (159)	58 (137)	52 (125)	47 (117)
871 (1600)		98 (209)	79 (175)	68 (155)	62 (143)
1093 (2000)		133 (272)	106 (223)	91 (195)	81 (177)

See note on bottom of next page.

Form C-1428 Effective 3/90
Supersedes Form C-1230-A, 12/87

CARBORUNDUM

RATEMASTER® FLOWMETER
Installation and Operating Instructions

DIMENSIONS & MOUNTING INFORMATION

DIMENSIONS – IN INCHES

	RMA	RMB	RMC
A	4 9/16	8 1/2	15 1/8
B	3	6 7/16	12 1/4
	1/8 NPT CONN.	1/4 NPT CONN.	1/2 NPT CONN.
C	1-5/8" 10-32 THDS.	3-15/16 1/4-20 THDS.	8 3/4 3/8-24 THDS.
D	3/8	5/8	1
E	1-1/16	1-7/8	2-3/4
F	1-3/16	1-3/4	2-1/4
G	11/16	1	1-7/16
H	1	1-7/16	1-31/32
I (OPEN)	1-3/8	1-13/16	2 1/2
	3/4	1-1/4	2
K	4-13/16	8 3/4	15 3/8
L	1	1 1/2	2 1/4

PANEL CUT OUT (FOR FLUSH MOUNTING)

HIGH	4-5/8	8 9/16	15-3/16
WIDE	7/8	1-5/16	2 1/16

PANEL HOLE SIZES (FOR SURFACE MOUNTING)

PIPE	7/16	5/8	15/16
BOLT	1/4	9/32	13/32

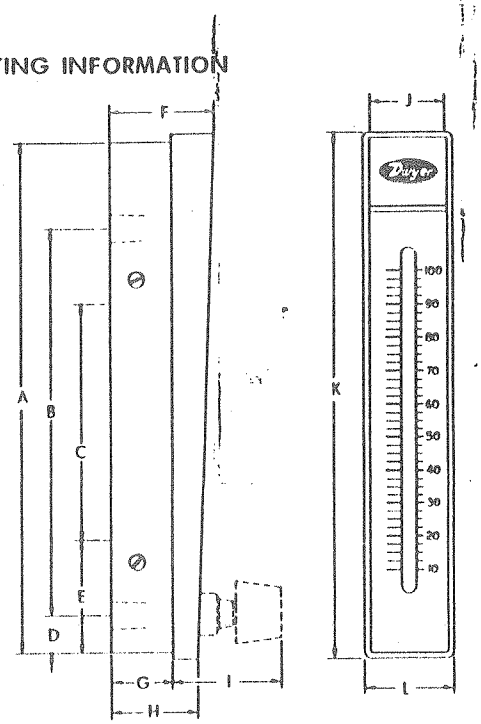


Figure 1

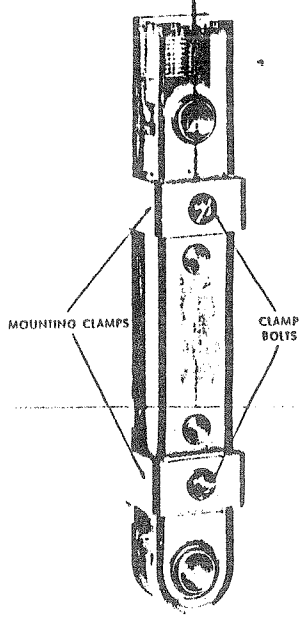


Figure 2

Dwyer Rate-Master® Series RM Flowmeters are furnished in three models (see Figure 1) each available in a broad choice of flow ranges with direct reading scales for air, gas or water. Installation, operation and maintenance are very simple and only a few common sense precautions must be observed to assure long, trouble-free service.

CAUTION

Dwyer Rate-Mater(R) flowmeters are designed to provide satisfactory long term service when used with air, water or other compatible media. Refer to factory for information on questionable gases or liquids. Avoid solutions of acids, bases or salts having a pH below 5.0 or above 8.5. Caustic solutions, anti-freeze (ethylene glycol) and aromatic solvents should definitely not be used.

CALIBRATION

Each Dwyer flowmeter is calibrated at the factory. If at any time during the meter's life, you wish to recheck its calibration, do so only with devices of certified accuracy. DO NOT attempt to check the Dwyer Rate-Master® Flowmeter with a similar flowmeter as seemingly unimportant variations in piping and back pressure may cause noticeable differences in the indicated reading. If in doubt, return your Dwyer flowmeter to the factory. It will be calibration checked for you at no charge.

Before proceeding with the installation of your Dwyer Rate-Master Flowmeter, check to be sure you have the model and flow range you require.

LOCATION

TEMPERATURE, PRESSURE, ATMOSPHERE, AND VIBRATION: Rate-Master Polycarbonate Flowmeters are exceptionally rough and strong. They are designed for use at pressures up to 100 PSI (RMB units 70 PSI, RMC 35 PSI) and temperatures up to 130 deg. F. DO NOT EXCEED THESE LIMITS! The installation should not be exposed to strong chlorine atmospheres or solvents such as benzene, acetone, carbon tetrachloride, etc. The mounting panel should be free of excessive vibration since it may prevent the unit from operating properly.

INLET PIPING RUN: It is good practice to approach the flowmeter inlet with as few elbows and restrictions as possible. In every case the inlet piping should be at least as large as the connection to the flowmeter i.e. 1/8" Iron Pipe Size for RMA, 1/4" IPS for RMB and 1/2" IPS for RMC. Length of inlet piping makes little difference for normal pressure fed flowmeters.

For flowmeters on vacuum air service the inlet piping should be as short and open as possible. This will allow operation near atmospheric pressure and thereby insure the accuracy of the device. (Note that for vacuum air service the flow control valve if any, should be on the discharge side of the flowmeter. Either the TMV unit or a separate in line valve may be applied.)

DISCHARGE PIPING: As on the inlet, discharge piping should be at least as large as the flowmeter connection. In addition, for pressure fed flowmeters on air or gas service the discharge piping should be as short and open as possible. This will allow operation of the flow tube at near atmospheric pressure and insure the accuracy of the device. This is of less importance on water or liquid flowmeters since the flowing medium is generally incompressible and moderate back pressure will not affect the accuracy of the instrument as calibrated.

POSITION AND MOUNTING

All Rate-Master Flowmeters must be mounted in a vertical position with the inlet connection at the bottom rear and outlet at top rear.

BEZEL OR THROUGH PANEL MOUNTING: Make the panel cutout using the appropriate dimensions from Figure 1. Flowmeter must fit into the panel freely without force or squeeze.

Insert the Rate-Master Flowmeter from the front of the panel and install the mounting clamps from the rear, insert and tighten the clamp bolts in the locations shown in Figure 2. Do not exceed 5 in./lbs. Make connections to inlet and outlet ports using small amount of RTV sealant or Teflon® thread tape to avoid leakage. Avoid excess torque which may damage flowmeter body.

DWYER INSTRUMENTS, INC.
P.O. BOX 373 • MICHIGAN CITY, INDIANA 46360, U.S.A.
Telephone 219/879-8000
Fax 219/872-9057 Telex 25916

RATEMASTER® FLOWMETER
Instructions

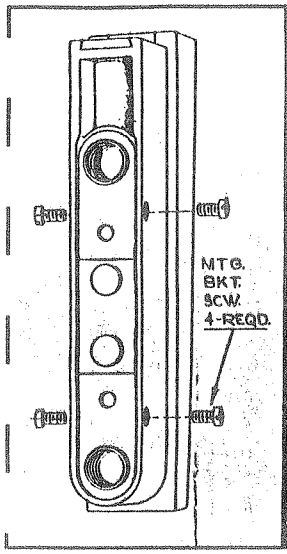


Figure 3

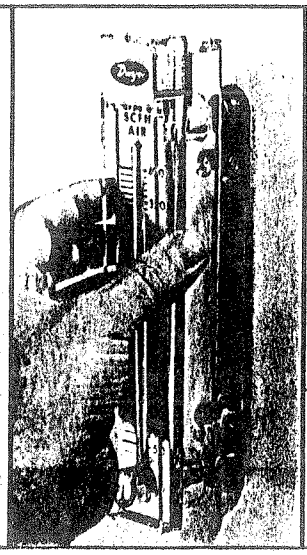


Figure 4

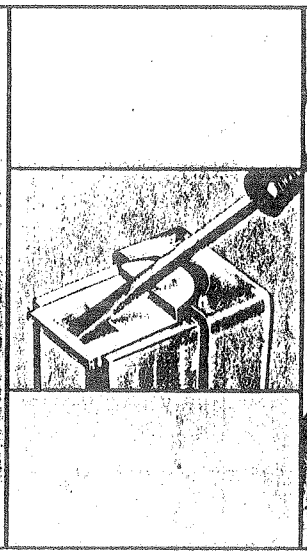


Figure 5


Figure 6

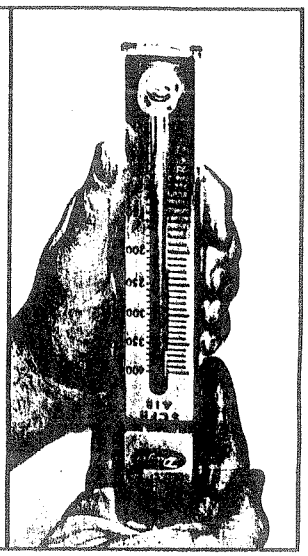


Figure 7

SURFACE MOUNTING: Drill appropriate holes in panel using the dimensions shown in Figure 1. Hold the flowmeter in position in front of the panel and install the clamp bolts through the panel from the rear. (The mounting clamps may be used as washers if desired by installing them backwards or straightening them out.) Pipe up inlet and discharge following the directions in previous sections.

SURFACE MOUNTING ON PIPING ONLY: An alternate method of surface mounting omitting the clamp bolts and supporting the Rate-Master Flowmeter on the connecting piping only is possible. For this method extra long or straight pipe threads should be used so that nuts may be run onto the pipe and later tightened against the back of the panel to retain the unit in proper position. Use the appropriate hole layout information from Figure 1, but omit the small holes.

MOUNTING ON PIPING ONLY WITHOUT PANEL: For temporary or laboratory type installation, the panel may be omitted altogether and the flowmeter installed directly in rigid piping. Its light weight permits this without difficulty.

OPERATION

To start system, open the valve slowly to avoid possible damage. Rate of flow is read at the point of maximum horizontal width for spherical floats or at the top of the largest diameter for non-spherical floats. Control valves on BV and SSV models are turned clockwise to reduce flow, counter clockwise to increase flow. A nylon insert is provided in the threaded section of the valve stem to give a firm touch to the valve and to prevent change of setting due to vibration.

CAUTION

Do not completely unscrew valve stem unless flowmeter is unpressurized and drained of any liquid. Removal while in service will allow gas or liquid to flow out front of valve body and could result in serious personal injury. For applications involving high pressure and/or toxic gasses or fluids, special non-removable valves are available on special order. Contact factory for details.

MAINTENANCE

The only maintenance normally required is occasional cleaning to assure reliable operation and good float visibility.

DISASSEMBLY: The flowmeter can be disassembled for cleaning simply as follows:

1. Remove valve knob from RMB or RMC — BV or SSV units by pulling the knob forward. It is retained by spring pressure on the stem half-shaft so that a gentle pull will remove it. On RMA-BV or SSV models, turn the valve knob counter-clockwise until the threads are disengaged. Then withdraw the stem from the valve by gently pulling on the knob.

2. Remove the four mounting bracket screws located in the sides of the flowmeter. See Figure 3.

Pull the flowmeter body gently forward away from the back plate and pipe thread connections. Keep the body parallel with the back plate to avoid undue strain on the body. Leave the piping connections intact. There is no need to disturb them. See Figure 4.

3. Remove the slip cap with a push on a screwdriver as shown in Figure 5. Remove the plug-ball stop as shown in Figure 6 using allen wrench sizes as follows: Model RMA — 1/4", Model RMB — 1/2", and Model RMC — 3/4".

4. Take out the ball or float by inverting the body and allowing the float to fall into your hand as shown in Figure 7. (Note: It is best to cover the discharge port to avoid losing the float through that opening.)

CLEANING: The flow tube and flowmeter body can best be cleaned with a little pure soap and water. Use of a bottle brush or other soft brush will aid the cleaning. Avoid benzene, acetone, carbon tetrachloride, alkaline detergents, caustic soda, liquid soaps (which may contain chlorinated solvents), etc. and avoid prolonged immersion which may harm or loosen the scale.

REASSEMBLY: Simply reverse Steps 5A, 1 through 4 and place back in service. A little stop cock grease or petroleum jelly on the "O" rings will help maintain a good seal as well as facilitate assembly. No other special care is required.

ADDITIONAL INFORMATION

For additional flowmeter application information, conversion curves, factors and other data covering the entire line of Dwyer Rate-Master Flowmeters, send for Bulletin F-41.

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Litho in U.S.A. 9/88

DWYER INSTRUMENTS, INC.
P.O. Box 373 Michigan City, Indiana 46361 U.S.A.
Phone: 219/879-8000 Telex: 25916 Fax: 219/872-9057

DOUBLE-WALL® REPAIR PARTS LIST

NOTICE: An asterisk (*) indicates that the part (or kit) is common to multiple bore sizes, and is available in two sizes. One size is common to 1-½", 2", and 2-½" bores, and the other size is common to 3-¼" and 4" bores.

NO.	PART DESCRIPTION	QUANTITY BY MODEL TYPE						
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P- 1	ROD	–	–	–	–	1	1	1
P- 2	PISTON	–	–	–	–	1	1	1
P- 3	PISTON SEAL	2	2	2	2	2	2	2
P- 4	PISTON BEARING RING	1	1	1	1	1	1	1
P- 5	FREE THREAD NUT *	–	–	–	–	1	1	1
P- 6	FREE THREAD RING *	–	–	–	–	4	4	4
P- 8	O-RING (FREE THREAD) *	–	–	–	–	1	1	1
P- 9	ROD SEAL *	1	1	1	1	2	2	2
P-10	CUSHION SEAL *	–	1	1	2	–	1	2
P-11	CUSHION SLEEVE (HEAD END) *	–	–	–	–	–	1	1
P-12	CUSHION SLEEVE (CAP END) *	–	–	–	–	–	–	1
P-13	CUSHION B/U WASHER *	–	1	1	2	–	1	2
P-14	CUSHION RETAINING RING *	–	1	1	2	–	1	2
P-15	CUSHION ADJUSTING SCREW *	–	1	1	2	–	1	2
P-18	O-RING (CUSHION SCREWS) *	–	1	1	2	–	1	2
P-19	TIE-TUBE	1	1	1	1	1	1	1
P-20	STAINLESS STEEL BODY	1	1	1	1	1	1	1
P-21	HEAD	1	1	1	1	2	2	2
P-22	CAP	1	1	1	1	–	–	–
P-23	O-RING (STAINLESS STEEL BODY)	2	2	2	2	2	2	2
P-24	WAVE SPRING	1	1	1	1	2	2	2
P-25	RETAINING RING (TIE-TUBE)	2	2	2	2	2	2	2
P-26	ROD WIPER (W/O BUSHING) *	1	1	1	1	2	2	2
P-27	ROD WIPER BUSHING ASS'Y *	1	1	1	1	2	2	2
P-28	SPACER	1	1	1	1	2	2	2
P-29	RETAINING PLATE	1	1	1	1	2	2	2
P-30	SCREW (RET. PLATE)	4	4	4	4	8	8	8
P-43	CUSHION SLEEVE	–	1	1	2	–	–	–
P-58	PISTON/ROD ASSEMBLY	1	1	1	1	–	–	–

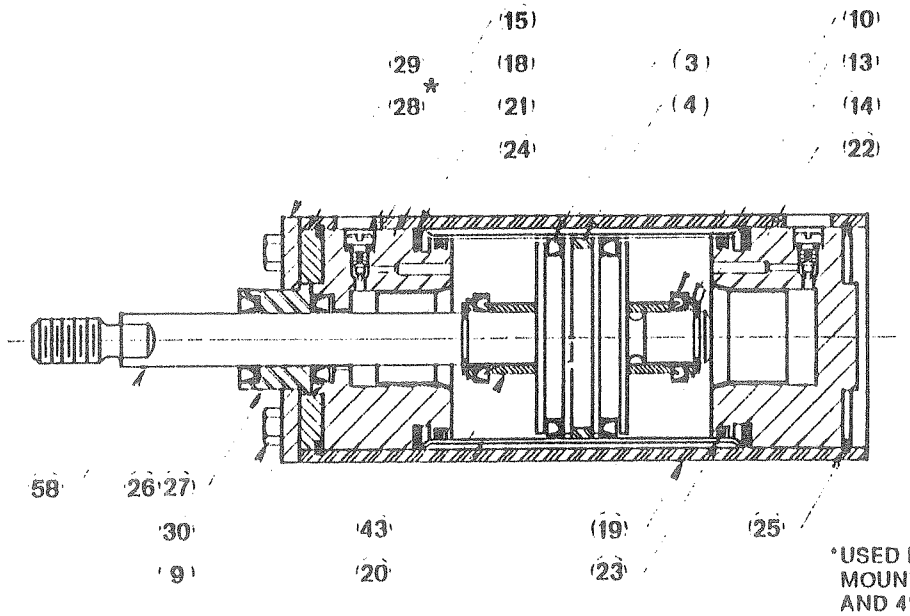
DOUBLE-WALL® REPAIR KITS

[illegible]		
P-25	RETAINING RING (TIE-TUBE)	2
P-23	O-RING	2
P-24	WAVE SPRING	1
P- 3	PISTON SEAL	2
P- 4	PISTON BEARING RING	1
[illegible]		
P-25	RETAINING RING (TIE-TUBE)	2
P-23	O-RING	2
P-24	WAVE SPRING	2
P- 3	PISTON SEAL	2
P- 4	PISTON BEARING RING	1

[illegible]		
P-10	CUSHION SEAL	1
P-13	CUSHION B/U WASHER	1
P-14	CUSHION RETAINING RING	1
P-15	CUSHION ADJUSTING SCREW	1
P-18	O-RING (CUSHION SCREWS)	1
[illegible]		
P-27	ROD WIPER BUSHING ASS'Y	1
P- 9	ROD SEAL	1

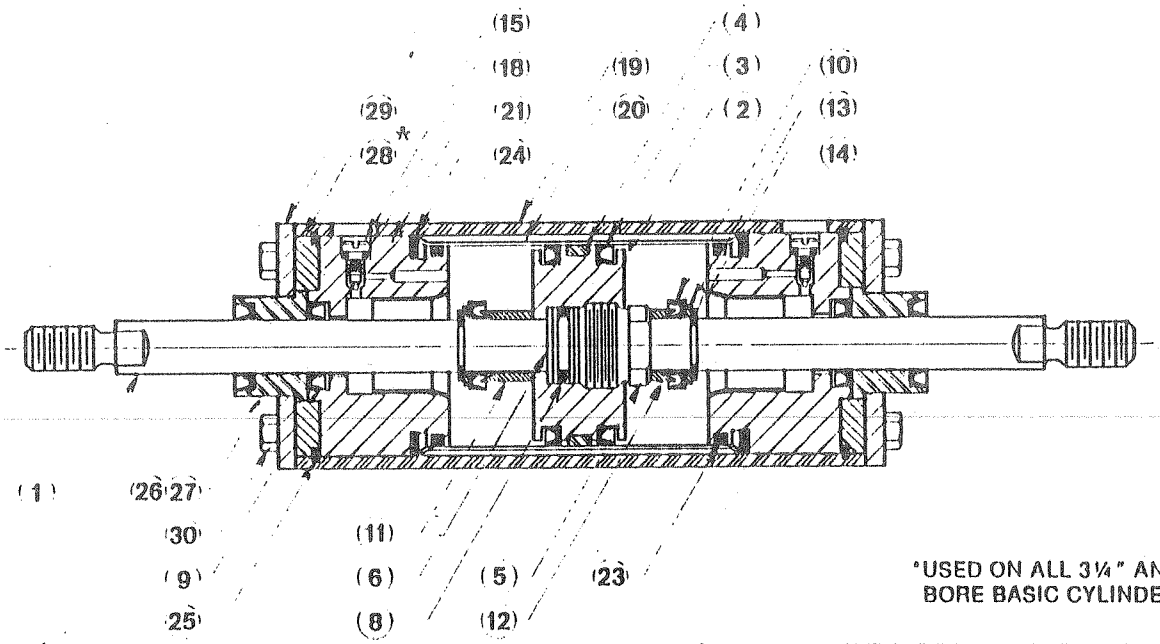
BASIC DOUBLE-WALL CYLINDER DRAWINGS

DW SERIES



*USED IN MOST MOUNTING KITS AND ON ALL 3¼" AND 4" BORE BASIC CYLINDERS.

DWD SERIES



*USED ON ALL 3¼" AND 4" BORE BASIC CYLINDERS.

HOW TO ORDER REPAIR PARTS & KITS

Individual Repair Parts and Kits are listed on page 11. When ordering, indicate the quantity desired, the part number or kit designation, and the cylinder model number on which the part is to be used. For example, a Cushion Adjusting Screw for a 1½" bore, 10" stroke, Double-Wall cylinder, Cushioned Both Ends, and a Small Male One Piece Rod End, would be ordered as follows:

QUANTITY	PART OR KIT NUMBER	MODEL NUMBER
(1)	P-15	DWC-1710-2

A Basic Repair Kit for the same cylinder would be:

(1)	K-B	DWC-1710-2

Please contact your BIMBA distributor for Repair Part & Kit prices.

TABLE OF CONTENTS

SPECIFICATIONS

INPUT

A. OPTIONS B,F,G,H

Milliamp Input: 4-20 mA input impedance - 510 ohms
10-50 mA input impedance - 220 ohms
0-5 mA input impedance - 2K ohms

Analog Input: 0-10 Vdc signal

Manual Control: 10K ohm, 2 watt potentiometer
Note: Manual potentiometer will override mA input signal unless external auto/manual switch is used.

B. OPTION K

Computer feedback 0-10 volt with options B,F,G,H

C. OPTIONS V,T

Voltage adjust potentiometer 10K ohm, 2 watt
Current adjust potentiometer 10K ohm, 2 watt
Voltage feedback signal 0 to 50 mV shunt

OUTPUT CURRENT RATING

25 to 600 amps

OUTPUT STAGE

Model 33P--Three SCR/Three diode Bridge
Model 36P--Six SCR Bridge

AC SUPPLY VOLTAGE

120, 208, 240, 277, 380, 480 or 575Vac +10% to -15%, 50/60 Hz

TYPE OF LOADS

Resistive, inductive, transformer, lamp and capacitive

SOFT START (OPTIONS B,F,G,H,V,T)

Set for initial half-second of operation of power on. Field adjustable by potentiometer from 0.2 seconds to 60 seconds. Ramp with DC signal change is factory set for 0.1 seconds. (Adjustable with capacitor change.)

HARD FIRING GATE PULSE

A combination of a high-potential gate pulse and a rapid rise time is used to prevent SCR damage due to di/dt stress.

INPUT ADJUSTMENTS (OPTIONS B,F,G,H,KB,KF,KG,KH)

Gain: 0-5mA, 4-20 mA, 0-50 mA and 0-10 Volts
Offset: 50% of gain maximum

REGULATION (OPTIONS B,F,G,H,)

Line voltage average regulation plus or minus 2% for +10% to -15% line change.

PROTECTIVE NETWORKS

Fusing: Integral I2t fuse protects against short-circuit overloads.

Transient Voltage Supressor: Integral MOV (Metal Oxide Varistor) protects against high potential transient voltage spikes.

SCR Peak Inverse Voltage (PIV Rating)

Line Voltage	Continuous SCR Rating
120 - 480	1200 Volts
575	1500 Volts

RC Snubber: RC snubber networks are used to prevent false firing due to dv/dt characteristics.

AMBIENT TEMPERATURE

Output rating decreases by 10% for each 5 degrees C rise (9 degrees F) in ambient temperature over 50 degrees C (122 degrees F) to a maximum of 60 degrees C (140 degrees F).

Ambient temperature Operating range 0 degrees C to 50 degrees C (32 degrees F to 122 degrees F).

Transportation and storage range -30 degrees C to 65 degrees C (-30 degrees F to 149 degrees F).

COOLING

Convection cooling 20 to 225 amps.
Fan cooling 300 amps and above. Fan cooled units have a normally open thermostat that will shut down unit on over temperature.

INSTALLATION

UNPACKING

Carefully unpack the SCR Power Controller from the shipping carton and inspect it for shipping damages. Immediately report any damages to the carrier.

MOUNTING

Select mounting location and make sure ambient temperature does not exceed operating range limits given in specifications. Mount units vertically so that heatsink fins are parallel to vertical mounting surface. Make sure that clearance on top and bottom of unit is at least six (6) inches.

WIRING

Connection Diagrams illustrate typical wiring connections for given controller models.

Note: All wiring must comply with local codes, regulations and ordinances.

****** WARNING ******

DO NOT SERVICE EQUIPMENT WITH VOLTAGE APPLIED. UNIT CAN BE THE SOURCE OF FATAL ELECTRICAL SHOCKS.

CONTROL OPTIONS

OPTION LETTER	DESCRIPTION
B	MILLIAMP SIGNAL (ADJUSTABLE GAIN AND OFFSET POTENTIOMETERS, MANUAL CONTROL, SOFT START, LINE VOLTAGE REGULATION). Two potentiometers adjust Offset and Gain. This allows the adjustment to most milliamp signals. A Manual Control can be added externally with a potentiometer. An external switch can be added to provide manual-automatic operation. Soft start is adjustable with a potentiometer. This unit also includes line voltage regulation.
F	OPTION B WITH THE ADDITION OF CURRENT TRIP Adjustable from 75-200% of controller rating for instantaneous trip if current exceeds preset level.
G	OPTION B WITH THE ADDITION OF CURRENT LIMIT This option will limit the output current at a preset level, adjustable from 10 to 125% of controller rating. (Current limit will override control input signal to limit current output).
H	COMBINATION OF OPTIONS B,F AND G
V	VOLTAGE AND CURRENT REGULATION FOR DC LOADS Feedback signal from a 50 millivolt shunt provides 0.5% voltage and current regulation. Logic provided for independent voltage and current adjustments with automatic crossover.
T	OPTION V WITH THE ADDITION OF CURRENT TRIP Adjustable from 75-200% of controller rating for instantaneous trip if current exceeds preset level.
K	COMPUTER INTERFACE (AVAILABLE ONLY IN COMBINATION WITH OPTIONS B,F,G AND H)

CONNECTIONS (OPTIONS B,F,G AND H)

MANUAL CONTROL (Manual potentiometer does not have to be connected)

1. If manual potentiometer is not used proceed to automatic control.

2. Connect manual potentiometer to terminal 3,6 and 9 on TB1 per connection diagram for options B,F,G and H.

3. Manual potentiometer is 10K ohm, 2 watt.

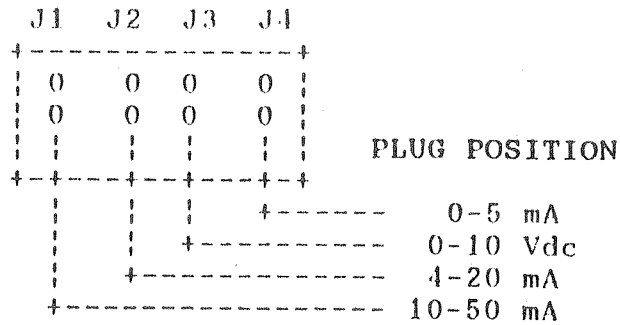
4. If you are using only manual control, proceed to power connections.

AUTOMATIC CONTROL

1. Connect DC voltage or milliamp input signal to terminals 1 and 2 on TB1 with terminal 1 positive and 2 negative.

2. If manual and automatic control are both used, consider using an external auto/manual switch to stop the manual setting from overriding the automatic signal. See wiring diagram for connections.

3. Check J1 plug for correct position to match control signal. (see Control Sense board on page 10). Move J1 plug to the correct position to match the input signal. Plug is shipped in the 4-20 mA position.



POWER CONNECTIONS (Refer to Wiring Diagram)

1. Connect line 1 and load to power terminals.

2. Connect line 2, 18-22 gauge wire to printed circuit board terminal 7 on TB2.

START-UP PROCEDURE

MANUAL CONTROL

1. If the unit has a milliamp or voltage input and a manual control potentiometer is also used, set the milliamp or voltage input signal to zero.

2. Slowly rotate manual control potentiometer in a clockwise direction. Output voltage should slowly increase with potentiometer rotation.

3. If output voltage appears to be normal, turn the manual control fully counterclockwise (OFF).

   Note: If unit is connected for manual control only and optional current limit is provided, proceed to current limit start-up procedure. If operating under manual control only, you have completed start-up.

AUTOMATIC CONTROL

1. Gain and Offset adjustments - Factory calibrated for 4 to 20 mA dc input signal.

2. Apply milliamp or voltage input signal and observe output. Unit output should be proportional to control input signal. If a different milliamp input range is desired, or you want to check calibration, proceed as follows: (Note: it is recommended that the actual load be disconnected and replaced with a resistor or light bulb load while performing these adjustments.)

   a. Apply minimum desired input control signal (example: 4 mA).
   b. Adjust Offset potentiometer (R12) until output voltage is at zero. CCW rotation will decrease output.
   c. Apply maximum desired input control signal (example: 20 mA).
   d. Adjust Gain potentiometer (R15) until output voltage is full on. CCW rotation will increase output. If required, repeat steps a through d to obtain specific output levels.

3. If both automatic and manual inputs are used, the manual control will override the automatic input signal unless a manual/automatic switch is used and placed in automatic position.

CURRENT LIMIT

Note: Current limit is typically adjusted for full rated current, therefore, appropriate load must be used for this adjustment.

1. Apply input control signal to achieve full output.

2. Adjust Current Limit potentiometer (R63) to obtain desired output level. CCW rotation of potentiometer will decrease output level.

CURRENT TRIP

Current trip is independent of current limit. When the current set point is reached, the controller will go to zero instantaneously (less than 8 milliseconds). Current trip is adjustable (R42) from 75-200% of controller rating. CCW rotation will increase current trip set point.

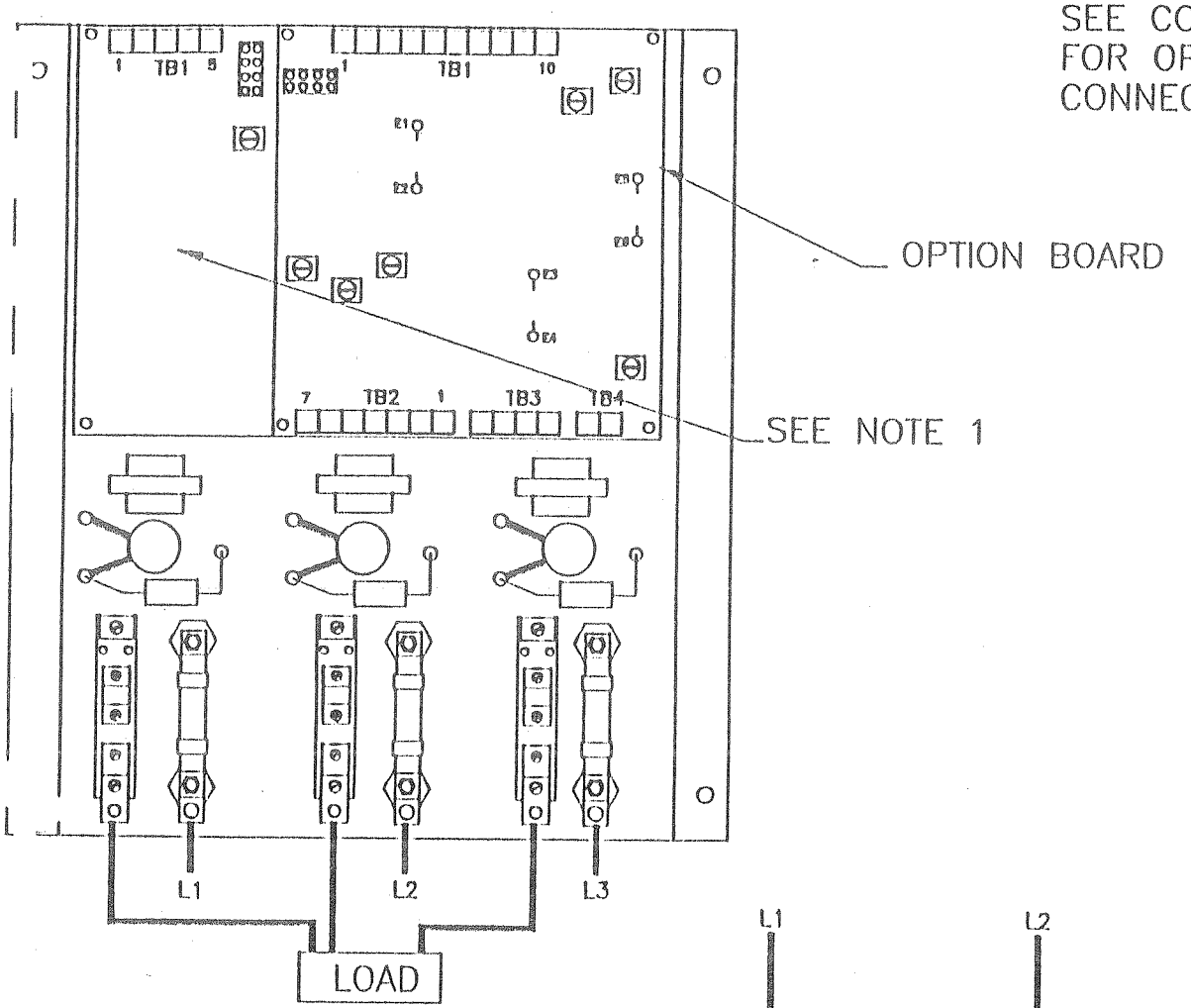
SOFT START

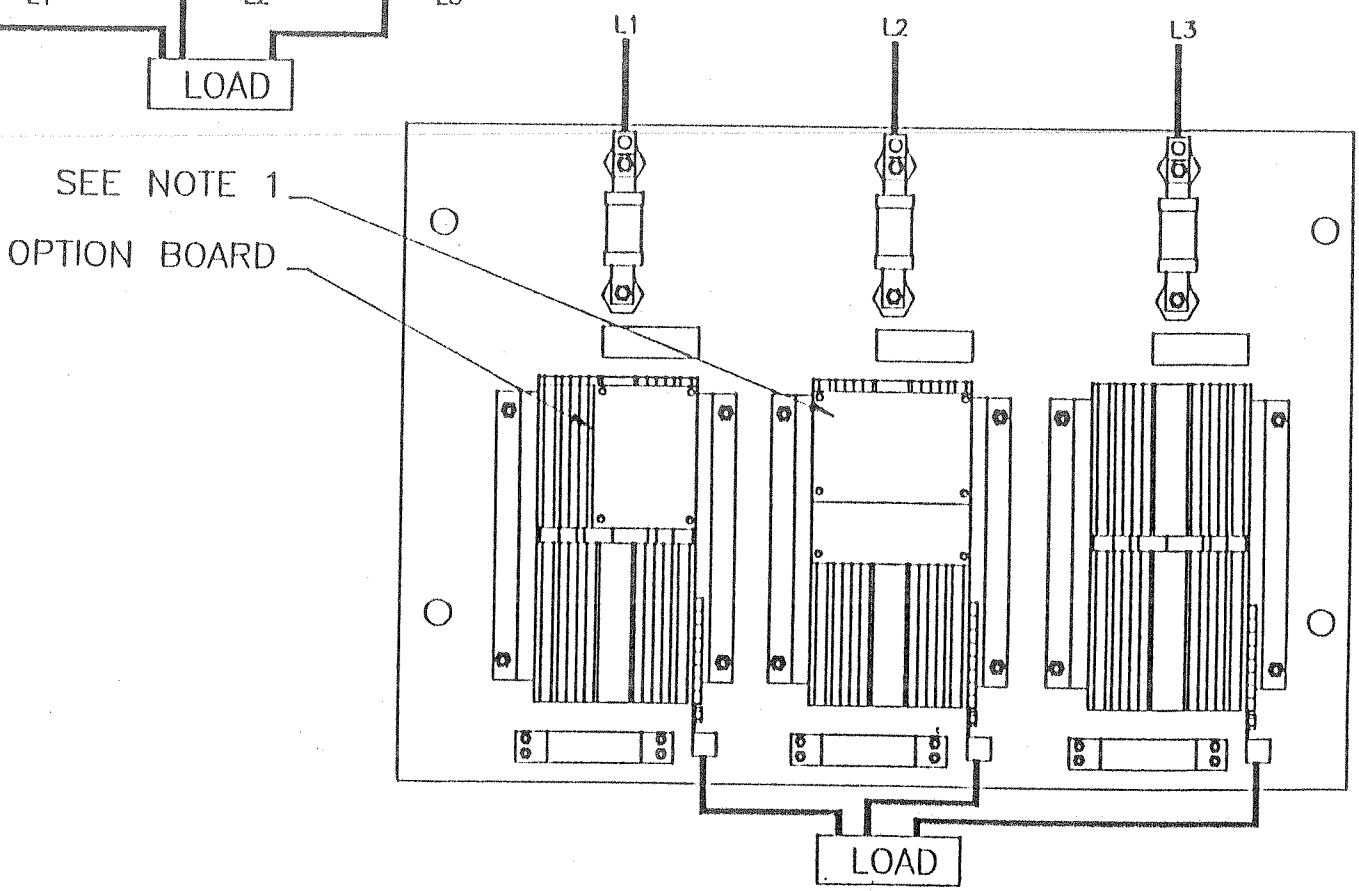
Soft start adjustment is factory set (R46) for 0.5 seconds. Soft start can be increased to a maximum of 60 seconds by adjusting R46 in a CW rotation. Note: Soft start is active only when initial power is applied and has no effect on control signal change. If a longer ramp with respect to control signal input is desired, add capacitor at terminals E1 and E2 on top board (E2 is positive). Contact factory for capacitor value.

POWER CONNECTIONS

25, 50, 75 AMP UNITS

NOTE 1:
SEE CONTROL DIAGRAM FOR OPTION CONTROL CONNECTIONS

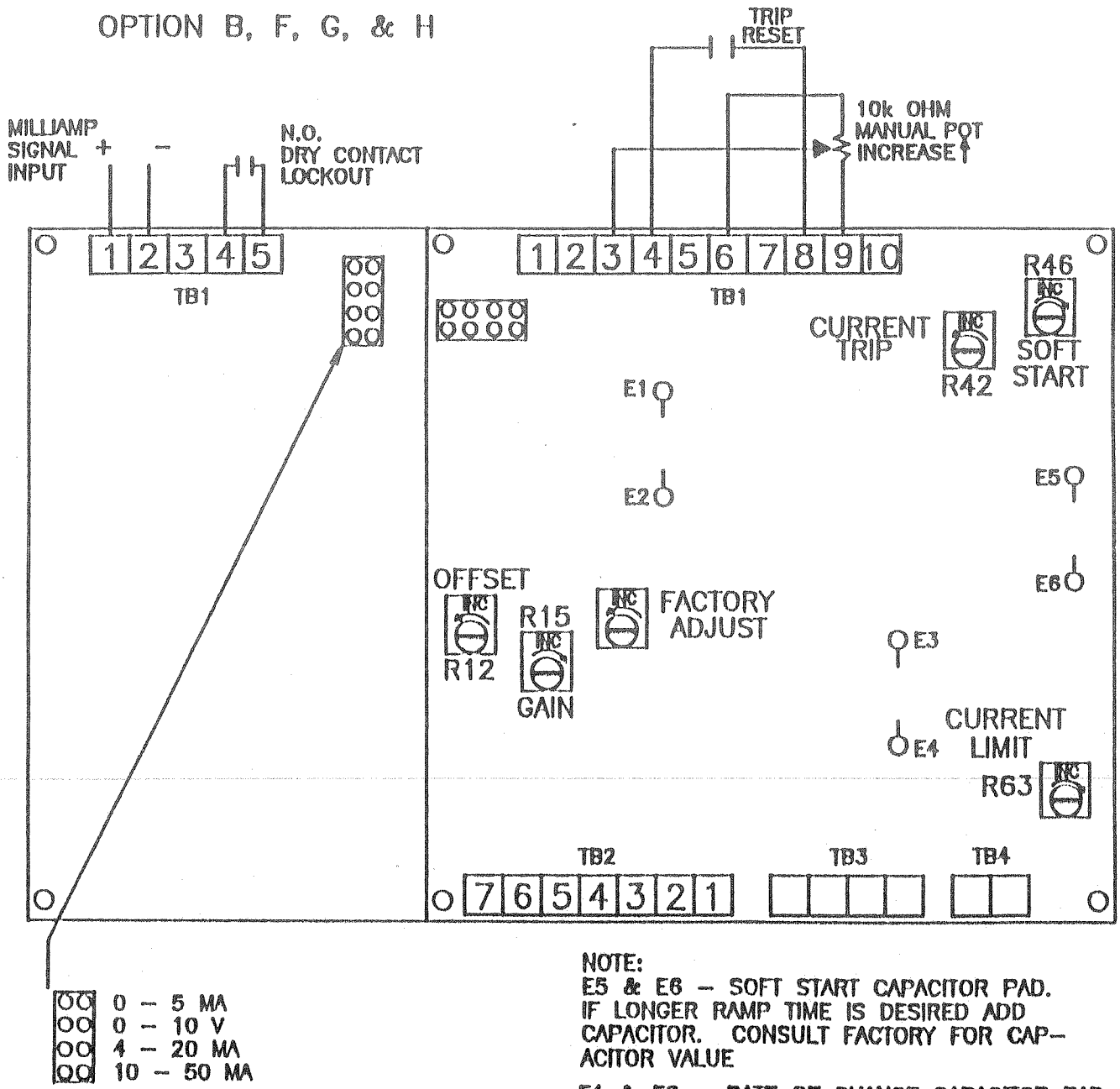




110, 140, 175, 225, 300, 400, 500, 600 AMP UNITS

CONTROL CONNECTIONS

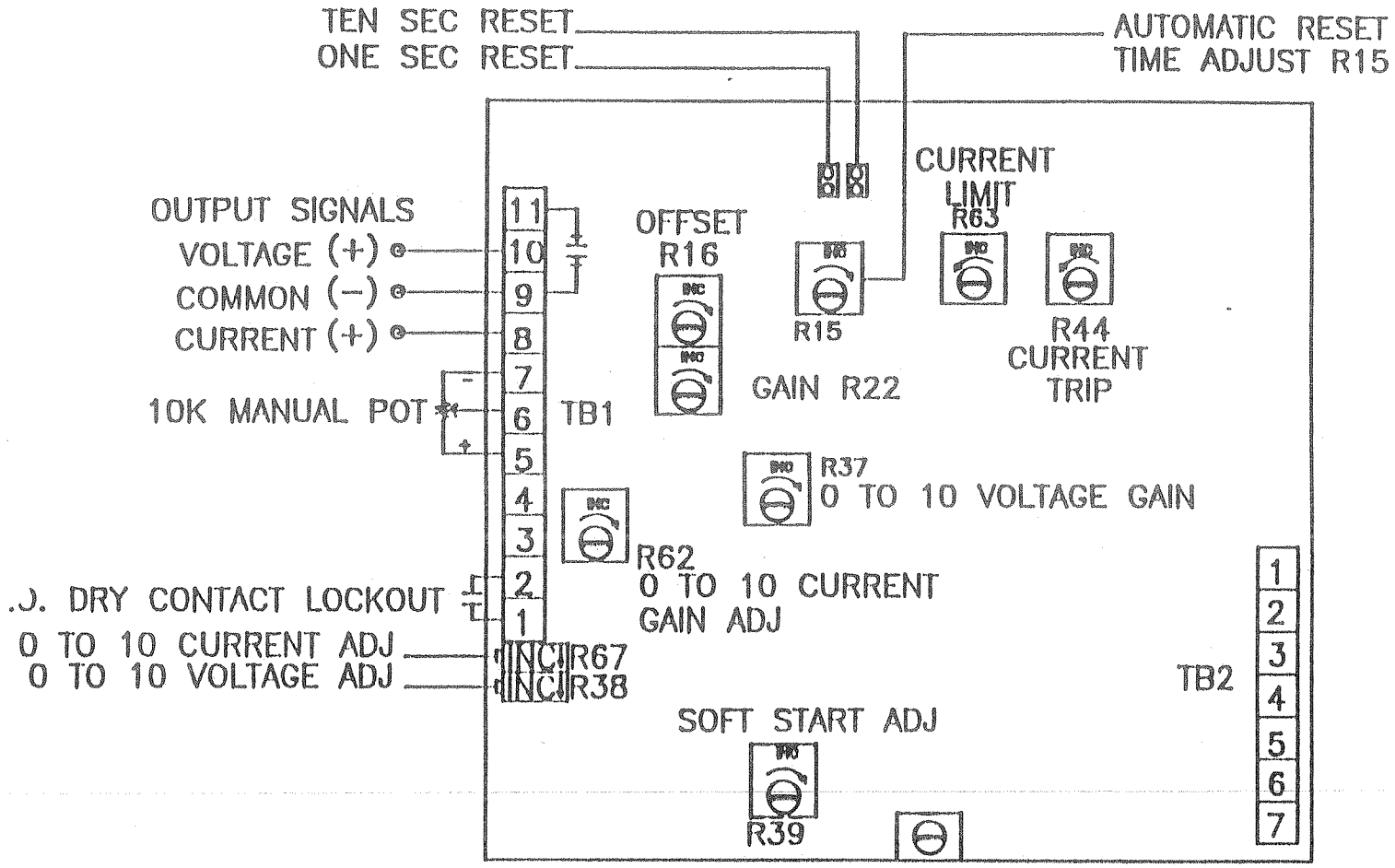
OPTION B, F, G, & H



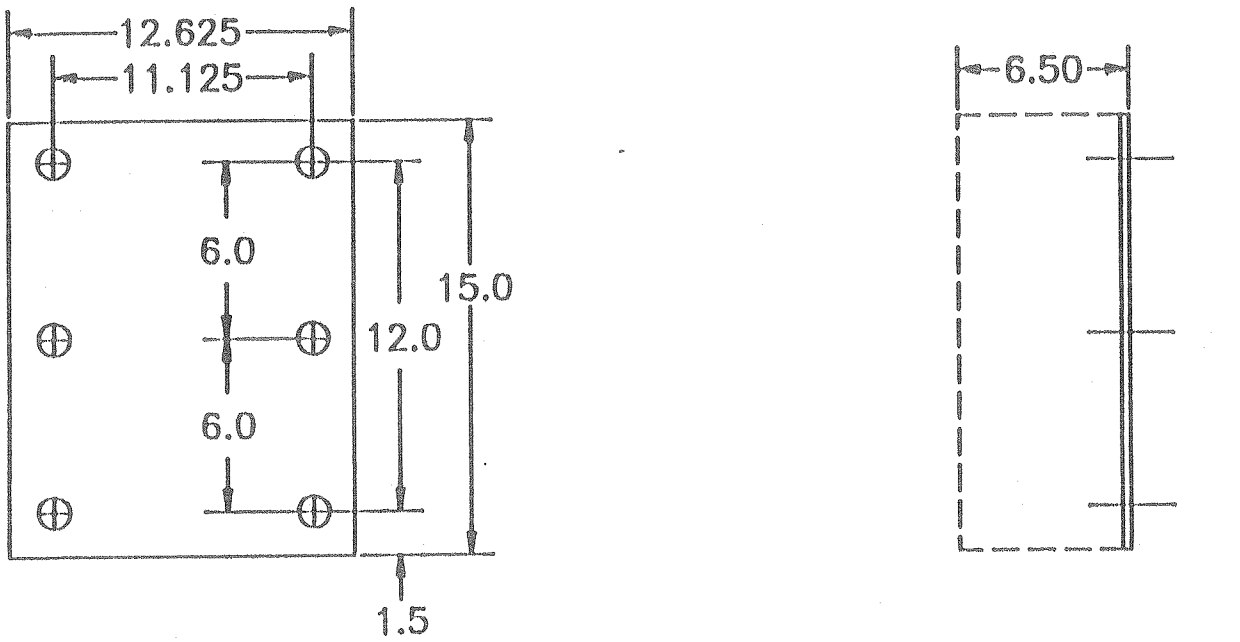
NOTE:
E5 & E6 – SOFT START CAPACITOR PAD. IF LONGER RAMP TIME IS DESIRED ADD CAPACITOR. CONSULT FACTORY FOR CAP–ACITOR VALUE

E1 & E2 – RATE OF CHANGE CAPACITOR PAD. ADD CAPACITOR TO INCREASE RESPONSE TIME WITH RESPECT TO CONTROL SIGNAL INPUT CHANGE. CONSULT FACTORY FOR CAPACITOR VALUE

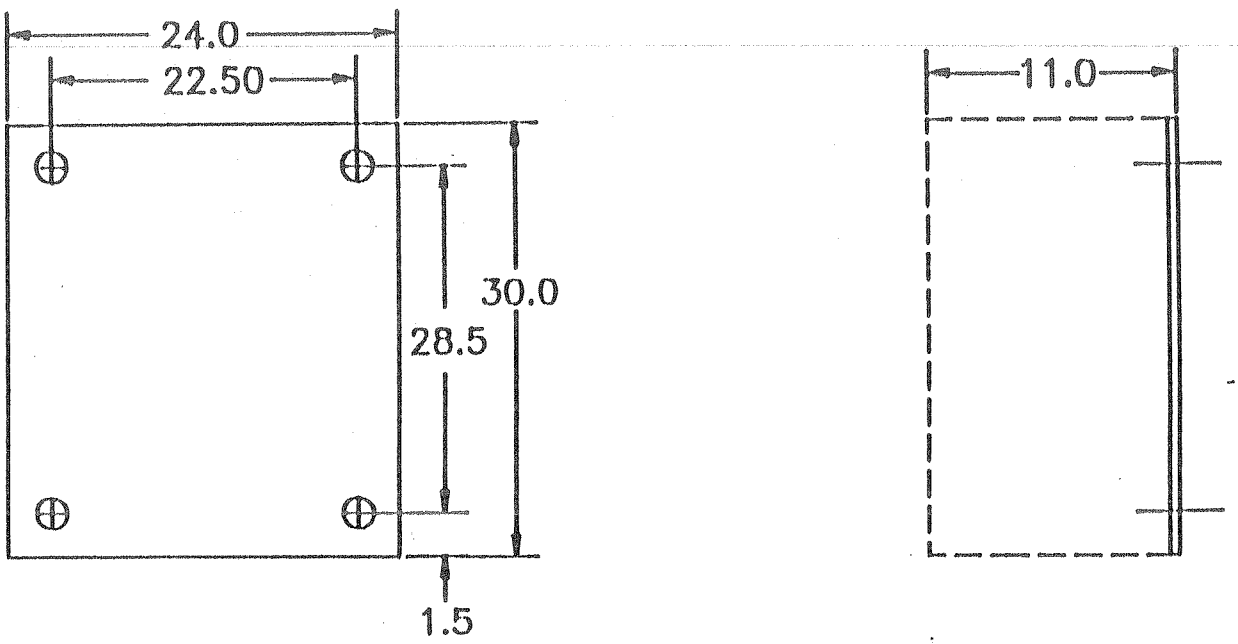
K OPTION CONTROL CONNECTIONS (KB–KH)



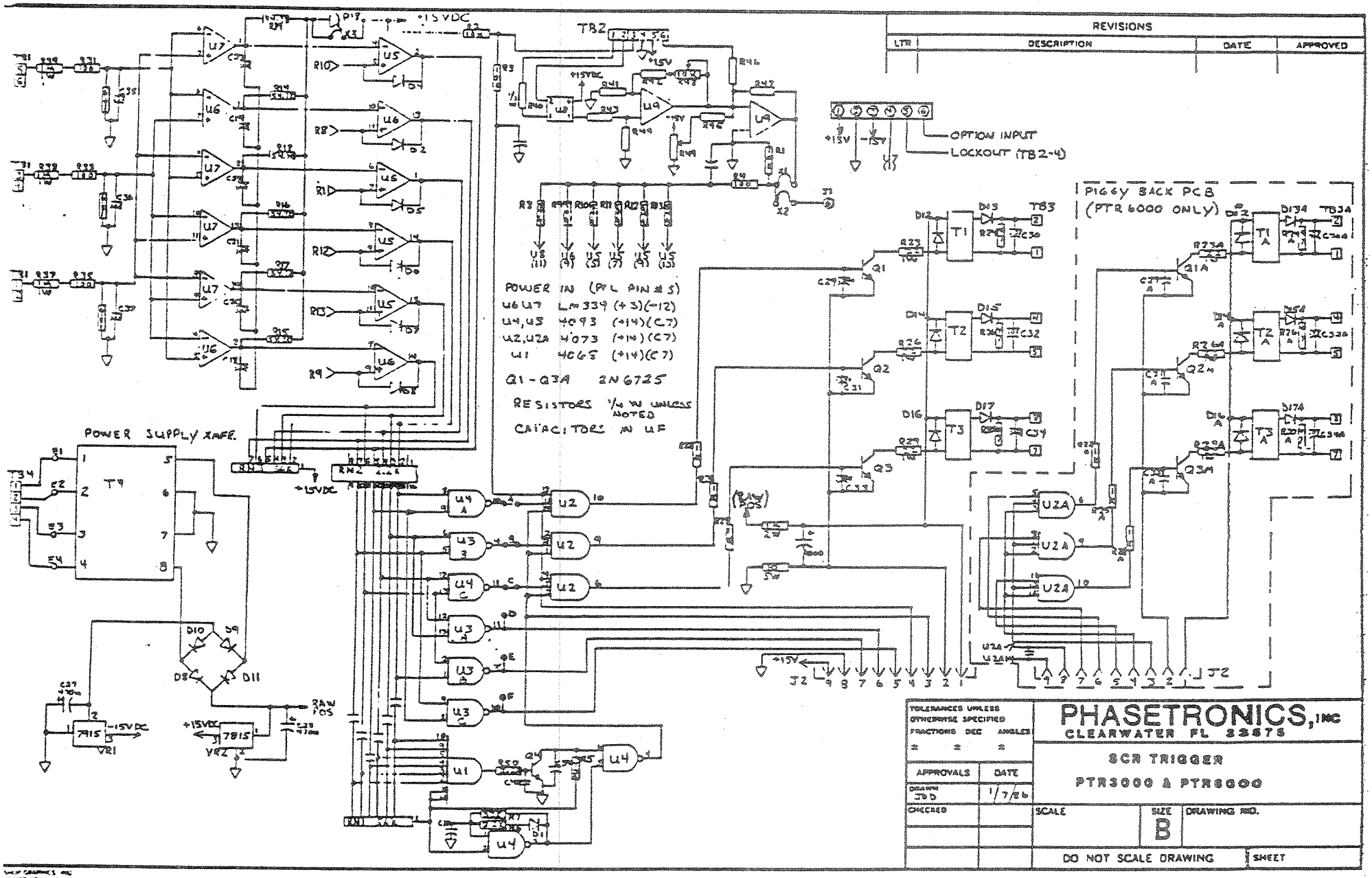
DIMENSION CONFIGURATIONS

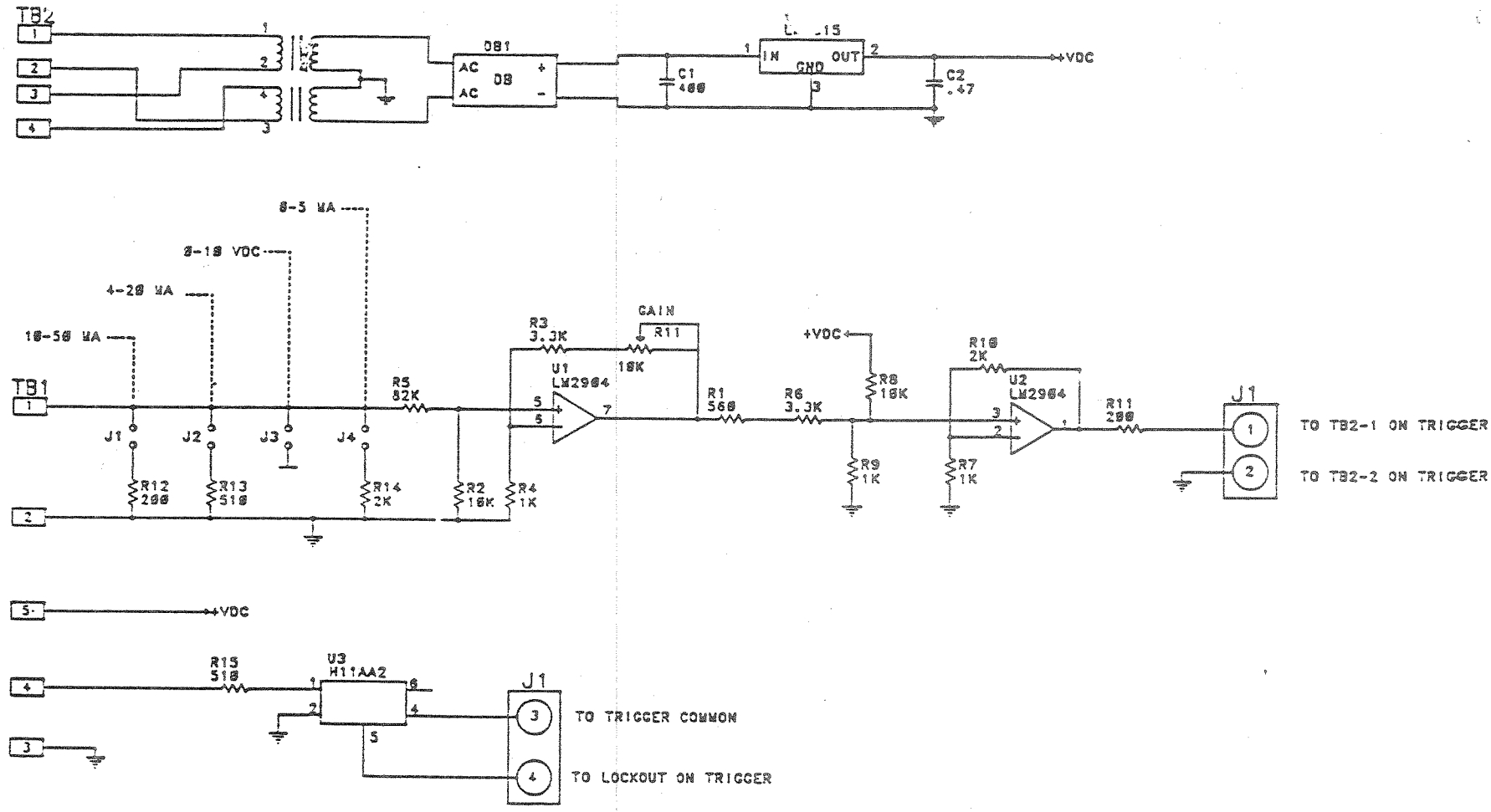


ALL MODELS THRU 75 AMPERES

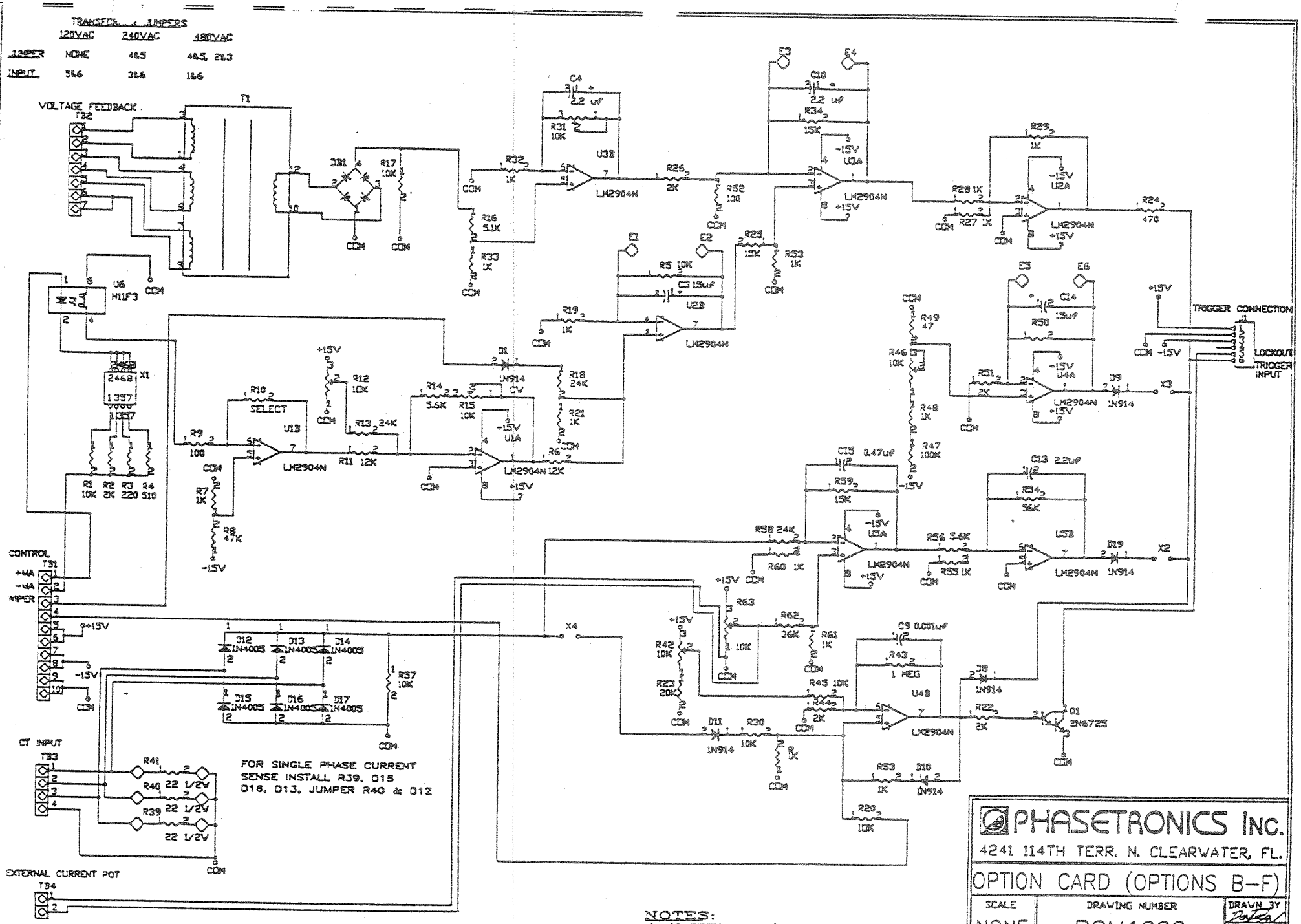


ALL MODELS 110 THRU 600 AMPERES


REVISIONS
LTR
DESCRIPTION
DATE
APPROVED
+15VDC
TB2
OPTION INPUT
LOCKOUT (TB2-4)
PIGGY BACK PCB
(PTR 6000 ONLY)
POWER SUPPLY XMFR.
POWER IN (PC PIN # S)
U6 U7 LM339 (+5)(-12)
U4,U5 4093 (+14)(C7)
U2,U2A 4073 (+14)(C7)
U1 4069 (+14)(C7)
Q1-Q3A 2N6725
RESISTORS 1/4 W UNLESS NOTED
CAPACITORS IN UF
PHASETRONICS, INC
CLEARWATER FL 33575
SCR TRIGGER
PTR3000 & PTR6000
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
APPROVALS DATE
DRAWN JDD 1/7/86
CHECKED
SCALE
SIZE B
DRAWING NO.
DO NOT SCALE DRAWING
SHEET



PHASETRONICS	
1989 CALUMET ST. CLEARWATER, FL. 33575	
CONTROL SENSE BOARD	
	REV 2
DATE: 11/25/86	SHEET 1 OF 1



NOTES:
1) ALL RESISTORS 1/4W
2) ALL CAPS IN uf
3) ALL DECOUPLE CAPS 0.1uf TO COMMON

PHASETRONICS INC.
4241 114TH TERR. N. CLEARWATER, FL.

OPTION CARD (OPTIONS B-F)

SCALE	DRAWING NUMBER	DRAWN BY / CHK'D BY
NONE	PCM1200	
SHEET	REV. No.	DATE
1 OF 1	1	08-21-89

REPLACEMENT PARTS

SCR DEVICES

UNIT RATING (AMPS)	120-480 VOLTS PHASETRONICS PART #	575 VOLTS PHASETRONICS PART #
25	25-0040-1200SD	25-0040-1500SD
50	25-0055-1200SD	25-0050-1500SD
75	25-0090-1200SD	25-0090-1500SD
110	25-0940-1200	25-0940-1500
140	25-0940-1200	25-0940-1500
175	25-0940-1200	25-0940-1500
225	25-0940-1200	25-0940-1500
300	25-0940-1200	25-0940-1500
400	25-0940-1200	25-0940-1500
500	25-2170-1200	25-2170-1500
600	25-2170-1200	25-2170-1500

MOV DEVICES

UNIT RATING CURRENT	VOLTAGE	PHASETRONICS PART NUMBER
25-75	120,208,240	50-040-0250
	277	50-040-0510
	380,416,480	50-040-0510
	575	50-080-0600
110-600	120,208,240	50-130-0250
	277	50-190-0510
	380,416,480	50-190-0510
	575	50-250-0660

SCR TRIGGER

VOLTAGE	PHASETRONICS PART NUMBER
208	PTR6000-208
240	PTR6000-240
277	PTR6000-277
380	PTR6000-380
416	PTR6000-416
480	PTR6000-480
575	PTR6000-575

I2T FUSE DEVICES

UNIT RATING (AMPS)	FUSE RATING	PHASETRONICS PART NUMBER
25	30	52-0030-0600
50	60	52-0060-0600
75	80	52-0080-0600
110	125	52-0150-0600
110	150	52-0150-0600
175	200	52-0200-0600
225	250	52-0250-0600
300	350	52-0350-0600
400	450	52-0450-0600
500	600	52-0600-0600
600	800	52-0800-0600

OPTION BOARD

OPTION LETTER	PHASETRONICS PART NUMBER
B	PCM1200-B
F	PCM1200-C
G	PCM1200-D
H	PCM1200-E
T	PCM1200-T
V	PCM1200-V

CONTROL SENSE BOARD OPTION I	
33P1	PTR3000-I
36P1	PTR6000-I