

DYNARAD
ELECTRIC RESISTANCE
MELTING AND HOLDING FURNACE

INSTRUCTION MANUAL

Model Number EC-1500

Serial Number 1153 - *NPC #1*

**Electrical Schematic
Drawing Number D0179**

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DYNARAD ELECTRIC RESISTANCE FURNACE

INSTRUCTION MANUAL

DYNARAD MS, MG & EC SERIES

Version 1.5

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I INSTALLATION

A. Inspecting Shipment

1. Check for damage - Check all parts of the shipment for damage which may have occurred in transit. Carefully check the carton containing the crucible for obvious signs of damage such as fork lift holes, etc.
2. Report any Damage - Immediately report any damage to the freight carrier. Visible signs of damage to cartons or crates should be noted on the bill of lading and acknowledged by the freight carrier's driver or other representative.

B. Removal of Packing Materials

1. Move all containers and crates to a clear area near the installation site.
2. Open all crates and cartons and again inspect for any hidden freight damage which may have been previously missed. Immediately report any damage found to the freight carrier.
3. Unpacking furnace
 - a) Remove protective plastic sheeting and any crating materials from furnace.
 - b) Remove furnace cover - Loosen furnace cover hold-down lugs. MS Series only: Carefully lift furnace cover up at least 6 inches so that internal cover legs won't interfere with furnace refractory or wiring terminals. Set cover on clear space on floor, allowing the legs or cover rim to support the cover and protect the refractory materials underneath.
 - c) Remove internal packing - Carefully remove all internal bracing which protects the heating elements during shipment. Using a clean brush or compressed air, brush or blow away any residual styrofoam or packing materials which may have adhered to the elements.
Carefully inspect the heating elements for any damage which may have occurred in transit and report any damage to freight carrier.
Store all packing materials for later use if furnace is moved to a different location.
 - d) Open all other crates and cartons carefully and prepare for installation.

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C. Locating and Mounting Furnace and Controls

1. Place furnace - Set furnace in desired position on flat floor or platform using fork truck lifting from fork channels welded into the furnace base. Note that the furnace is supported by four plate steel pads welded to each end of the fork channels.

Furnace may also be set into pit using chains or other lifting means. Be sure to allow at least 2" clearance around perimeter of furnace to permit the furnace to run cool. Also allow room for adequately sized runout pan within pit area. Floor plate or heavy expanded metal may be used for pit cover after installation.

2. Leveling - Use a spirit level placed on a straight edge on top of the furnace body (with the cover removed) to be sure furnace is level. Add shim stock under pads to level as required.

Tilting furnace frames must be solidly anchored to floor or platform. It is not necessary to bolt a stationary furnace to the floor.

3. Control Panel - Mount control panel on wall or other support structure nearby furnace for operator's convenience. However, do not locate too close to furnace crucible opening to avoid possible damage from heat radiation when furnace cover is off.

4. Runout pan - The furnace should be provided with a runout pan of adequate capacity to contain the entire contents of a full crucible. The pan should be approximately 5" high and positioned so that the edge of the pan is behind the outlet of the furnace runout port. This will permit the collection of small amounts of metal "dribble" which might otherwise build up between the runout port and the runout pan.

D. Wiring and Checking - Refer to the electrical schematic and interconnection wiring diagram in the Appendix at the back of this manual.

1. Main Switch - Install a circuit breaker or disconnect switch in the vicinity (usually within 25 feet) and within sight of the furnace in conformance with local electrical codes. Refer to the serial number plate on the lower left side of the Control Panel to determine the correct operating voltage and maximum current. Please check with the factory if there are any questions regarding the furnace power requirements.

Run a conduit with properly sized wires from this breaker or switch directly to the Control Panel and connect incoming electric leads behind the protective barrier at the top of the panel as shown on the schematic diagram. **Be sure to replace this safety barrier before turning power on!**

2. Interconnect Control Panel and Furnace - Again referring to the electrical schematic diagram, run conduit and leads from the Control Panel to the furnace pull box at the rear of the furnace. Interconnect all identically numbered terminals in Control Panel and furnace pull box. Be sure leads are properly sized to handle currents shown on the electrical schematic.

3. Ground the furnace - Be sure to run a heavy gage ground wire from any suitable point on the furnace frame to a solid plant ground, such as a cold water pipe.

4. Connect thermocouple leads - Run a separate conduit for the low level thermocouple lead wires (provided by Dynarad) from the Control Panel to the small thermocouple junction box next to the pull box on the furnace.

Allow sufficient lead length to **directly** reach both temperature instruments inside the Control Panel from their respective thermocouples at the furnace without connection to any intermediate terminal strips or spliced connections.

Be sure the angle type crucible bath thermocouple is connected to the bath pyrometer instrument mounted in the Control Panel door. Then connect the furnace side wall mounted element temperature thermocouple to the Element Temperature Limiter, also mounted in the Control Panel door. Be sure thermocouple lead wires follow correct polarity as shown on schematic diagram (**red is negative** and magnetic).

5. Special lead wires provided - Dynarad has provided the thermocouple lead wire for both thermocouple pyrometers. The user will provide all conduits and all other interconnection wiring.

6. Check wiring - Again referring to the schematic diagram, use a low voltage "buzz tester" or ohmmeter to be sure all interconnections have been completed correctly. Also be sure that all connections are tightened securely.

7. Delay Power Test - **Do not turn on power until furnace is safe to operate.** If a Dynarad installation supervisor will be assisting with the furnace startup, **do not** turn power on until he arrives and performs a second

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wiring check prior to the initial power test. If a Dyanrad supervisor will not be assisting, wait until the furnace is closed up and all exposed wiring is covered and protected and otherwise completely safe for the initial power test which follows in Section I.

E. Accessories (Optional)

1. Pneumatically Operated Cover - Connect a 3/8" compressed air line to the small regulator prepiped to the inlet side of the manual operating valve mounted on the side of the furnace. Apply a minimum of 40 PSIG air pressure and open and close the cover using the manual valve. Adjust the speed as required using the exhaust port flow controls on the manual valve and the pressure regulator.

F. Installing Crucible

1. Check double glazing - Be sure crucible has been double glazed with oxidation retarding low temperature glaze by checking distinguishing crucible markings and/or supplier shipping documents to verify. Single glazed crucibles will have a shorter operating life so this is an important check.
2. Check crucible dimensions before installing the crucible in the furnace to eliminate the risk of having to remove it if the dimensions are not correct.

a) Inside diameter - Crucible ID should correspond with the ID of the furnace cover opening.

b) Crucible height

1) "MS" Series furnaces - With furnace cover removed, lay a straightedge across top of furnace frame and measure height from underside of straightedge (top of furnace frame) to top of permanent crucible pedestal in furnace refractory base. This dimension should be 1" greater than height of crucible.

2) "EC" Series furnaces - With furnace cover removed, lay a straightedge across top of furnace shell and measure height from underside of straightedge (top of furnace shell) to top of permanent crucible pedestal in furnace refractory base. This dimension should be 1-1/2" less than height of crucible.

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c) Crucible thickness - Check with crucible catalog or with Dynarad. Thickness varies with crucible size.

3. Installing crucible

a) Set crucible in furnace - Place refractory paper separation disk on pedestal and carefully place crucible and crucible spacer block (if required) on disk using a suitable crucible sling (see below), taking care not to strike the heating elements. Do not use clamps around crucible top except to remove a damaged crucible which will not be reused.

b) Crucible Sling - A simple sling can be assembled by taking a short, heavy chain with a chain hook attached to one end and forming a closed loop around the base of the crucible several inches smaller in diameter than the outside diameter of the crucible.

Then, tie a rope securely around the chain and bring it up and across the top of the crucible and down the other side and firmly attach it to the chain on the opposite side. Take another section of rope and attach it just like the first but at right angles to the first rope so that the two ropes are crossed at right angles at the crucible top.

Use a fork lift fork or a "cherry picker" to gently pick up the crucible. Test the sling to be sure the crucible is firmly cradled and then carefully set the crucible in position in the furnace. When the ropes are limp, simply reach inside and unhook the chain from itself, breaking the loop. The chain and ropes can then be easily removed from the furnace.

c) Center the crucible - Be sure the crucible is accurately centered. Use a tape measure to check that the crucible is equidistant from furnace shell on all sides.

G. Replacing Furnace Cover

1. Be sure the multi-component heat protection for the heating element wiring harness is properly in place. These consist of (a) heavy refractory blanket extending vertically up from the sidewall which protects both the harness and the nickel plated copper heating element terminals, (b) for "MS" Series only - rigid fiberglass angles with attached refractory blanket which overlap in front of (a) above, and (c) horizontal gasketing strips between furnace cover and sidewall.

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2. Place gasketing strips in place - The horizontal refractory gasketing strips should lay on the side wall lining and heating element top ends, in front of the heating element terminals. For the "MS" Series, this gasket is 2" thick and for the "EC" Series, 1" thick.

IMPORTANT: Be sure these strips butt up tightly against each other to prevent heat leaks. They should be replaced each time the furnace cover is removed because with heat over time they become compressed and lose their resiliency, and can cause damaging heat leaks if reused. The 2" thick refractory fiber blanket material is stocked by Dynarad under Part No. 520-0035 and the 1" thick blanket under Part No. 520-0010.

3. Check cover refractory for any missing pieces and replace where necessary. Be sure the furnace cover has an uninterrupted 2" thick layer of high temperature refractory blanket (Dynarad Part No. 520-0035) to tightly seal it against top of crucible.

4. Set cover in position taking care to keep refractory blanket undisturbed. If any of the refractory blanketing or gasketing is accidentally nudged out of position, reposition as required and reset the cover. Replace hold-down lugs on cover and tighten down gradually in rotation to compress refractory blanket uniformly.

5. Trim excess blanket from around inside top of crucible and inspect for gaps. Reset the cover again, if necessary, to insure a tight fit around the top of crucible to prevent internal metal leakage.

H. Installing Bath Thermocouple

1. **VERY IMPORTANT:** Only isostatically pressed silicon carbide thermocouple protection tubes with internal steel support tube (Dynarad Part No. 530-0100 for 18" length or Part No. 530-0105 for 24" length) should be used with aluminum, brass, or zinc to properly ground the metal bath and provide the longest operating life.

2. Position the thermocouple protection tube approx. 1" away from the side of the crucible and place the horizontal pipe section of the thermocouple assembly into the support clamp cradle. Place the U-bolt clamp over the thermocouple pipe and into the holes on either side of the cradle and thread the nuts onto the U-bolt.

VERY IMPORTANT: Use a suitable wrench to tighten the nuts so that the thermocouple support clamp is **very tight** to insure that the metal bath is electrically well

grounded. Also tighten the 90 degree elbow union on the thermocouple assembly to obtain the same result.

3. Polarity - Observe correct polarity when connecting T/C lead wires to junction block. **Red is negative (-)** and magnetic; **yellow is positive (+)** and non-magnetic.

I. Initial Electrical Check

1. With the furnace cover in position, close and screw shut the furnace pull box lid and check to be sure all high voltage connections are closed and protected in preparation for electrical checking.

2. Set the bath pyrometer at the desired operating setpoint temperature. Then set the heating element limit setpoint temperature not to exceed 2000°F. If provided, turn the optional "Seven Day Timer" switch "Off" and the optional "Power Level" switch to the lowest position.

3. Close the main disconnect or circuit breaker. The alarm horn should give a short chirp and the green "Main Switch On" lamp should light. The bath pyrometer and element temperature limiter should be on. The three ammeters should show current flow, though not necessarily all exactly equal, depending on furnace model.

Refer to the electrical schematic diagram to determine if the furnace is wired in a "wye" or "delta" configuration. In most cases, 480 volt furnaces are wye connected and 240 and 208 volt furnaces are delta connected.

a) "Wye" connection - The highest ammeter reading (with the optional Power Level Selector in the highest position) should approximately equal the current shown on the serial number plate (on the lower left side of the Control Panel), with allowance given for utility supply voltage variations.

b) "Delta" connection - The highest ammeter reading should approximately equal the current shown on the serial number plate (on the lower left side of the Control Panel) **divided by 1.73** (the square root of three), with allowance given for utility supply voltage variations.

4. Power Level Switch (optional) - Slowly turn the "Power Level" switch to the full right, maximum power position. As the switch is rotated through each position, the current shown on the ammeters should increase in all three phases.

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5. Ground fault interrupter (GFI) check - Loosen the keeper nut on the sensitivity adjustment on the front of the GFI relay inside the control panel. Using a small blade screwdriver, turn the sensitivity adjustment counterclockwise until it reaches the detented "Test Position."

The GFI should immediately trip causing the alarm horn to sound and the "Ground Fault" lamp on the front panel to light. The sensitivity adjustment should then be rotated clockwise, just out of the detented "Test Position", but otherwise at the maximum counterclockwise position which won't cause a test trip.

Tighten the lock nut to permanently retain this highest sensitivity adjustment. Reset the white circuit breaker on the GFI relay to silence the horn and reset the alarm circuit.

If the GFI does not operate per the above, shut off all power to the furnace and check that the two shielded leads are connected to the correct corresponding terminals on both the GFI relay and sensor with the proper polarity (refer to the schematic diagram).

6. Concluding tests - After completing all tests, turn off the main power switch. Furnace is now ready for regular melting operations.

II ROUTINE MELTING AND HOLDING OPERATIONS

A. Setting Instruments

1. Element temperature limit - As stated in the previous section, the element temperature limit should be set no higher than 2000°F. This represents a comfortable, conservative limit for the element wire (which has a melting point of 2750°F) consistent with long operating life. Higher operating temperatures will result in shorter element life which may not be cost effective even though higher melting rates will be attained.

2. Setting bath pyrometer - Through experience gained from many furnace installations, Dynarad can recommend the following starting settings for the 3-mode metal bath pyrometer which differ depending on whether the furnace is to be used for continuous or batch melting. Settings for holding use only follow in Section G below.

Refer to the temperature controller instruction manual in the Appendix at the rear of this manual for instructions on how to make these adjustments.

a) Continuous wet bath melting - In this melting mode solid charge material is continuously fed back into the furnace at the same rate that it is drawn out. Recommended starting settings are: Reset: 0.5 repeats per minute; Rate: 2.0 minutes; Proportional Band: 4; Cycle Rate: 60. Do not disturb any other tuning parameters.

b) Batch melting - In this mode, a larger quantity of charge material is placed in the furnace and brought up to tapping temperature, poured, and another batch is then charged. Recommended starting settings are: Reset: 0 repeats per minute; Rate: 0 minutes; Proportional Band: 10; Cycle Rate: 60. Again, do not disturb any other tuning parameters.

3. Setting Seven Day Timer (Optional) - The timer is provided with on and off trippers so that it can be set to turn on and off daily or over weekends, as desired. Refer to the instructions on the inside of the timer door for setting on and off times.

The timer motor will operate continuously (regardless of whether the "Seven Day Timer" switch on the front panel is off or on) as long as the main switch is closed and will require resetting if the main power is turned off. The "Seven Day Timer" coin switch on the front of the control panel must be turned on to enable the timer to operate. When this switch is turned on the yellow "Seven Day Timer On" lamp will be lighted.

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B. **WARNING!!** Please take note of the warning sign on the furnace which reads, "**EXPLOSION HAZARD - DO NOT PUT WET OR MOISTURE BEARING CHARGE MATERIALS OR TOOLS INTO THIS FURNACE AS EXPLOSION CAUSING DEATH, SERIOUS INJURY AND/OR PROPERTY DAMAGE MAY RESULT.** DO NOT REMOVE THIS SIGN."

This is a very serious warning which applies to all furnaces containing molten metals. Be sure that all charge material is completely dry and free of ice crystals, snow, absorbed moisture, etc. before charging into furnace. All charge material should be stored in a protected, dry area before use. Preheat ingots, scrap, and other charge material on top of the furnace before melting and inspect each individual piece of charge material for signs of moisture before placing in crucible.

Lower ingots in slowly. If "sputtering" from moisture should start, pull the ingot back out of the bath and let it dry out or set it aside until dry. Ingots should be lowered in slowly and carefully to insure against crucible damage as well. If "bubbling" should start following the submersion of any charge material in the crucible, all personnel should quickly move away from the furnace until it is clear that there is no danger of "popping," "sputtering," or explosions from moisture on the material.

C. First melt

1. Remove the manual crucible cover or open the optional pneumatic crucible cover and place sufficient charge material to develop a heel into the crucible. Always be careful not to wedge in any material which could expand faster than the crucible causing cracks to develop.
2. Close the main power switch or breaker to turn the furnace on and confirm that power is flowing to the heating elements by observing the ammeters.
3. Observe element temperature shown on the temperature limit pyrometer and look for a rise in element temperature.
4. Watch for steam - With the crucible cover still open, watch for any steam which may come out of the top of the furnace or through the refractory blanket material around the top of the crucible. If steam is seen, shut off the power and wait for it to disappear (20 to 30 minutes) and turn the power back on again.

Repeat this as necessary until the furnace reaches the melting point and a molten heel starts to develop in the

crucible. Then add more charge material to fill up the crucible and set the crucible cover in place (or close the optional pneumatically operated cover).

The amount of steam generated, if any, will depend on how much moisture was absorbed by the lining prior to furnace startup. If the furnace has been out of service for any length of time, the operator should watch for steam when it is again restarted.

D. Continuous Melting

1. Maximizing the melt rate - To maximize melting rate and temperature control accuracy, charge material should be charged back into the furnace at the same rate it is taken out, in increments as small as possible, preferably no more than one or two ingots at a time. The 3-mode fully time proportioning temperature controller will "anticipate" the addition of solid charge material and heat will be conducted through the crucible in time to melt each charge.

2. How to keep temperature constant - If the charge is not added, the heat which would have melted the charge will raise the temperature of the bath. But if charge material is added at the same rate molten metal is taken out, the furnace will come to equilibrium at that melting rate and the metal temperature will remain constant indefinitely, making it possible to continuously operate the furnace at a heavy melting output level.

3. Element temperature limit - If the temperature of the heating elements reaches the preset temperature limit, power to the elements will automatically be switched off and the white "Element Temp Limit" lamp on the control panel will be lighted. This is a normal limiting function and power will be switched back on as soon as the element temperature drops below the setpoint.

E. Batch Melting

1. Description of batch melting: Metal is added in bulk quantities, melted, and brought to the desired tapping temperature. It may then be treated and ladled out and the process repeated.

2. For maximum throughput the batch should be kept as small as possible and the crucible heel maintained as large as possible. This minimizes temperature drop and can prevent the heel from freezing which will promote faster melting.

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3. Furnace utilization - Increase furnace "utilization" to increase the average melting rate. Furnace utilization is defined as the time a furnace is actually melting metal during a given production period divided by the total time in that production period and is usually expressed as a percentage. The more time the furnace is doing something other than melting, the lower the utilization. If it is desirable to melt as much metal as possible, the time used to hold, recharge, and treat the metal must be minimized so that the furnace can melt more metal during the available time period.

4. Element temperature limit - If the temperature of the heating elements reaches the preset temperature limit, power to the elements will automatically be switched off and the white "Element Temp Limit" lamp on the control panel will be lighted. This is a normal limiting function and power will be switched back on as soon as the element temperature drops below the setpoint.

5. Close the cover! - The crucible cover should be replaced as soon as a charge is placed in the crucible to stop convective and radiation heat losses and improve efficiency. Several types of optional Dynarad pneumatically operated crucible covers have been designed to make it convenient for the operator to close the cover, particularly when frequent access to the furnace is required.

6. Controlling temperature overshoot

a) Why does temperature overshoot? - The large heat of fusion of aluminum has always made it a problem to batch melt. Forty percent of the heat energy required to melt aluminum is absorbed during the heat of fusion phase at the end of the melting cycle. During this phase, while 40% of the total energy is absorbed, the metal temperature does not rise one degree!

Temperature control instruments are designed to react to temperature changes and in the case of aluminum, when the Bath Temperature Controller calls for more power, it doesn't "see" much increase because it is "masked" by the heat of fusion. The controller thus continues calling for power, increasing the heating element temperature. Finally, when the metal is melted, the furnace has become hotter than necessary because the controller has been "fooled" and the excess heat raises the temperature of the bath above the desired setpoint.

b) How to control overshoot during batch melting

1) Keep the batch as small as possible and the heel as large as possible. Then the impact of the heat of fusion will be smaller as a percentage of the total energy contained in the entire bath.

2) Increase the proportional band setting on the Bath Temperature Controller. This will cause the controller to begin cutting back on the heat input sooner as the metal bath temperature rises. However, this means that the furnace's average melting rate will be reduced because when power is reduced, melt rate is reduced. If this is not a problem, increasing the proportional band is a good solution.

3) Add a predetermined amount of ingot to the furnace after the Bath Temperature Controller's indicated temperature has passed the setpoint. When this happens, the controller will stop all power input to the furnace and the extra ingot added at the end of the melt cycle will absorb the extra energy, keeping the temperature at the setpoint.

The exact amount of ingot to absorb this energy will depend on the batch size, the molten metal heel and the desired temperature but it can be easily determined experimentally during several melting cycles. When the right number of ingot is determined, sufficient space must be left in the crucible for them so the crucible isn't over-filled.

This method has the added advantage of maximizing average melting output because the furnace stays at full power longer and is brought to a "quick stop" by the ingot addition.

However, it is essential that the ingot be added after the setpoint is passed. Otherwise, the controller will just call for more power and the advantage of the ingot addition will be lost.

F. Power Level Control (Optional)

1. Reduce demand charges - This control can be effectively used to limit the input power and resulting utility demand charges whenever the furnace can be operated below its maximum power input level.

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When full power is required, the Power Level Control is turned to the highest setting. But if the melt rate for a given job is less than the maximum melt rate of the furnace, the Power Level Control may be used to reduce the input power to a level just above what is needed. In this way, power demand charges can be minimized.

2. Multiple furnace installations - This control is particularly helpful for multiple furnace installations where some furnaces are needed to melt at lower rates than others. The correct power setting is chosen for each furnace and excess power demand is readily and positively curtailed.

3. Low level for holding - The lowest power level should be chosen when the furnace is to be used for holding purposes only. The power available will be more than enough to maintain holding temperature but the power demand will be just a fraction of the full power available so that utility demand charges will be minimized.

G. Holding Use Only

1. Production holding - When the furnace is to be used for holding purposes only, no special preparations are required. The Bath Temperature Controller on the front of the control panel is simply set for the desired holding temperature and the furnace will maintain that temperature indefinitely.

2. Bath Temperature Controller Tuning Constants - If the furnace will not be used for melting, Dynarad recommends a different set of tuning constants for holding use only as follows: Reset: 0.05 repeats per minute; Rate: 0 minutes; Proportional Band: 2; Cycle Rate: 60.

3. Idling at night or other off shift periods

a) Reduce holding temperature - The bath temperature pyrometer should be set at the lowest practical holding temperature for the metal alloy used but not below 1200°F. For example, the usual overnight holding temperature for most aluminum alloys is 1200°F.

Keep the metal molten. The metal should not be allowed to solidify whenever refractory crucibles such as silicon carbide are employed to avoid risk of cracking when the metal is remelted.

The temperature must not be allowed to drop below 1200°F in silicon carbide crucibles to prevent low temperature oxidation which can drastically shorten crucible life.

- b) Fill the crucible - Keep the crucible full during off shift periods. This will extend crucible life by reducing oxidation and resulting cracking around the top. It will also insure the furnace will be ready for production with a full pot of metal.
- c) Close the cover! - The crucible cover should be placed in position over the crucible so that heat losses are minimized during off shift periods.

H. Don't Overfill Crucible - Do not permit the metal level in the crucible to exceed the top of the pot. Molten metal can soak through and eventually penetrate the refractory fiber gasket at the top of the crucible and run down into the heating chamber. If the metal penetration is heavy enough, heating elements might be damaged.

I. Using Fluxes in Electric Resistance Furnaces

1. Introduction - Because of the nature and purpose of reactive chemical fluxes, their use in electric resistance furnaces can potentially cause severe problems with furnace internal electrical components.

By understanding how adverse reactions can take place, the electric resistance furnace user can weigh the benefits of using reactive fluxes against risk of damage and can minimize the risk if their use is essential. He can also consider using nonreactive fluxes which pose no danger to electric furnace components.

2. Definition - Reactive fluxes are defined as solid, liquid or gaseous chemical agents which, when brought into contact with molten metal, cause chemical reactions to take place either spontaneously by themselves or in conjunction with metallic components of the metal bath.

Non-reactive fluxes function strictly in a physical or mechanical manner and do not take part in chemical reactions.

3. Use of Fluxes - Reactive and non-reactive fluxes are used for many purposes; for example, to cleanse molten metal of suspended oxides or dissolved gas, to separate liquid metal from dross on the metal surface, or to carry out silicon modification or grain refinement.

4. Examples of reactive fluxes include exothermic surface dross treatment "cover" fluxes which typically contain halide salt mixtures such as potassium and sodium chlorides, cryolite or sodium fluoride;

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submersible volatile halides in the form of tablets or "doughnuts" which generate halide gases; chlorine, fluorine, and Freon gases used for hydrogen degassing; compounds of titanium, boron, and zirconium used for grain refining; metallic sodium or sodium containing salts used for silicon modification or grain refinement.

5. Examples of non-reactive fluxes include nitrogen, argon, and helium gases used principally for hydrogen degassing and the removal of entrained aluminum oxide or dross.

6. Chemical Reactions - The risk of problems with reactive fluxes is simply understood. If fluxes or any flux derivative (such as chlorine or fluorine) are an effective chemical agent in fluxing the molten metal in the furnace, they can be equally effective in chemically fluxing (corrosively attacking) furnace components (and other nearby objects) which they contact.

All electrically conductive components including heating elements, lead wires, cables, bus bars and metal framework together with sheet metal roofs, steel building girders, etc. are especially susceptible to chemical attack from reactive fluxes. In electric furnaces, these include commonly used resistance materials such as nickel-chromium alloys, iron-chrome-aluminum alloys, and silicon carbide. Anything which will conduct electricity contains metallic components and is subject to attack from reactive chemical fluxes.

7. How these reactions take place - In electric resistance crucible furnaces, the crucible acts as an effective barrier between the metal and the heating elements. A refractory seal is employed between the top of the crucible and the underside of the furnace cover to prevent metal splashing from causing internal damage to the furnace.

However, this seal must accommodate crucible expansion without stressing the crucible and is generally made of a material such as ceramic fiber refractory which is resilient at higher temperatures. These materials effectively prevent damage from metal splashing but cannot be made gas tight. Thus, if a cover is placed over the crucible while reactive fluxes are present, any gases generated cannot rise freely but can pass through the crucible seal and enter the interior of the furnace and do serious damage.

8. How to minimize risk of damage

- a) Eliminate the use of reactive fluxes - This is the simplest solution. Much of today's foundry practice

has evolved from the use of fuel fired furnaces and the metallurgical problems they generate. By eliminating water vapor which is a product of combustion in fuel fired furnaces, electric resistance furnaces eliminate the largest source of dross and dissolved gas. Thus, it may be possible that reactive fluxes are not even necessary but may be just a carryover from previous fuel fired furnace practice.

b) Use only non-reactive fluxes - Dry, inert, non-reactive gases such as nitrogen, argon, and helium can act as effective degassers and suspended dross removers in electric resistance furnaces where the presence of water vapor has been dramatically reduced. The driest non-reactive gases are the most effective and come from a liquified gas source.

c) Use reactive fluxes with great care - If reactive fluxes are absolutely necessary, the gaseous types are the best to use in an electric resistance furnace. **The furnace cover must always be kept off** so the gases can rise freely. Nitrogen/chlorine, nitrogen/Freon or nitrogen/SF₆ mixtures can be used with good results if they are not allowed to be trapped inside the furnace where they can do damage.

Dynarad's ChemClean aluminum degassing system automatically blends nitrogen or argon with SF₆ or Freon 12 for safer, more effective aluminum degassing. ChemClean's single-knob flow control design simplifies operation by eliminating troublesome dual flow controls. ChemClean maintains a constant mixing ratio for improved consistency. It is safer than risky chlorine or chemical tablets and is smokeless with low toxic gas emissions and won't harm furnace equipment. ChemClean is used by many aluminum foundries and die casting plants around the world. Dynarad will gladly furnish complete information about its ChemClean system upon request.

The next best choice are the submersible tablet or "doughnut" ring degassers which can be used effectively, particularly the type which leaves no reactive residual. As with the gaseous types, the furnace cover **must be kept off during the treatment**.

Solid powdered or granular "cover" fluxes should be used **only with extreme care**. They present the highest risk because flux material left behind on the molten metal, the crucible or thermocouple protection tube can continue to react when the crucible cover is closed causing extensive damage.

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If they must be used, the furnace operator should apply them **only when the crucible seal is intact and the furnace cover is off**. The minimum "dosage" should be used and, following treatment, all traces of granular or liquid (melted) flux must be carefully removed, with the operator paying particular attention to less accessible areas such as behind the thermocouple protection tube.

Also, the operator should wait until all gas generating reactions are complete before removing the residue and replacing the cover to insure that no further adverse reactions can take place.

9. Ask First - Always contact Dynarad before attempting to use reactive chemical fluxes in a Dynarad furnace. Obtain the commercial name and number of the flux in question and, if possible, find out from the supplier if corrosive gases are generated and what compounds are included. A few moments taken to check could prevent possible major damage from an adverse reaction.

J. Furnace Shutdown - The shutdown procedure is very simple. Metal is ladled or poured out of the crucible until very little is left at the bottom and then the furnace is shut off. It can later be restarted following the instructions above.

The optional Seven Day Timer may then be employed to restart the furnace (see instructions in paragraph A (3), page 11).

K. Power Failures - If furnace power should be interrupted, the furnace will automatically restart itself upon restoration of power **without** requiring a manual reset. Since the furnace is highly insulated, it can sustain a power failure of several hours duration with the crucible cover in place.

If a power failure of long duration is anticipated, the furnace should be emptied and shut down in an orderly manner.

The user may wish to consider equipping the furnace with a central station alarm if power failures can be expected and the furnace is idled during off shift periods. This will help prevent crucible and thermocouple damage which can occur if metal is allowed to solidify in a non-metallic crucible.

III FURNACE MAINTENANCE

A. Crucibles

1. Scraping

a) Why crucibles should be scraped - The crucible should be scraped on a regular basis to prevent the buildup of oxides on the side walls. Oxide buildups will reduce heat flow through the crucible and reduced heat flow will cause a reduction in melting rate and an excessive increase in the temperature of the outside surface of the crucible. Abnormal temperature differences between the inside and outside surfaces will result in higher internal stresses which will contribute to shorter operating life.

b) How to scrape a crucible - Make up a "half moon" shaped piece of metal such that its outside curvature matches the inside curvature of the crucible. Weld it to a piece of solid rod with a handle at the opposite end.

With the crucible full of molten metal, carefully scrape the inside surface of the crucible up and down, all around the full perimeter to loosen and free any oxides attached to the side wall. Then skim the oxides off the top surface.

Bubbling dry nitrogen through the bath with a suitable lance will aid in bringing loose oxides to the surface.

c) Repeat as needed - Crucibles should be scraped on a regular basis, usually once a week. More frequent scrapings may be required if oxide buildup is more rapid due to increased oxides in the charge material.

2. Crucible inspection - Non-metallic (e.g. silicon carbide) crucibles should be inspected on a regular basis, usually daily, to watch for the development of cracks or other signs of wear. Crucible cracks quite commonly develop around the top and may increase in length and begin to approach the metal line. The furnace runout pan should also be checked for evidence of metal dripping which might indicate that the crucible will need to be changed.

Once suspicious cracks or dripping are detected, the crucible should be changed as soon as possible to prevent the occurrence of larger spills.

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3. Crucible Replacement

a) Remove old crucible - The crucible should be ladled out and the furnace power shut off and the main switch locked off as a safety measure. The hold-down lugs on the furnace cover can then be loosened and released and the cover lifted off.

If the crucible is to be permanently retired, heavy duty C-clamps can be firmly attached in three or four places around the top of the crucible. Chains looped through the clamps can be used to remove the crucible, taking care not to attach clamps too close to cracks which could result in pieces of the crucible splitting away.

b) Install new crucible - A new refractory paper crucible separation disk (see Parts List) should be set in place on the crucible pedestal and the new crucible installed following the instructions in Section I (Installation), Paragraph F, page 6.

c) Replace runout membrane - If the foil runout membrane in the furnace runout port was damaged, it should be replaced with a single thickness of ordinary aluminum foil.

B. Thermocouples

1. Type K Elements - Both furnace thermocouple assemblies use heavy gage Type K, Chromel/Alumel thermocouple elements. Both thermocouple pyrometers are calibrated to accept millivolt outputs from Type K thermocouples so other types will not provide correct readings and should not be substituted.

2. Metal Bath Thermocouple Replacement - Disconnect the thermocouple lead wires at the junction block inside the thermocouple head at the end of the horizontal pipe. Then remove the U-bolt clamp from the horizontal thermocouple pipe and remove the thermocouple assembly. Replace it with a spare thermocouple bath assembly (Dynarad Part No. 140-0001 for 18" assembly, Part No. 140-0010 for 24" assembly) taking care to follow the instructions in Section I (Installation), paragraph H, page 8.

CAUTION: Be sure to use only isostatically pressed silicon carbide protection tubes for melting and holding aluminum, brass, or zinc. Tighten the U-bolt clamp and the 90 degree elbow union to be sure the thermocouple provides an adequate ground for the metal bath.

INSTRUCTION MANUAL

3. Dynarad recommends that the element temperature limit thermocouple (Dynarad Part No. 380-0015) be replaced annually to reduce the possibility of a failure which could affect production operations. The Inconel protection tube will rarely need replacement.

4. Polarity - Observe correct polarity when connecting T/C lead wires to junction block. **Red is negative (-)** and magnetic; **yellow is positive (+)** and non-magnetic.

C. Heating Elements

1. Description - Dynarad electric heating elements are constructed from high temperature iron-chrome-aluminum alloys which have a very high melting point (2750°F). Dynarad recommends they be operated at a conservative maximum temperature of 2000°F (which is well below the maximum operating temperature of 2500°F recommended by the alloy suppliers) to insure long life and trouble free operation.

Dynarad elements are supported from individual free standing ceramic panels and the elements are separately wired and fused so they will operate independently.

2. Replacement of heating elements - Problems with cracked or broken crucibles can occur in metal casting plants and usually spell disaster in conventional electric furnaces. Fortunately, the damage they can cause in a Dynarad furnace is usually quite minor. This is because Dynarad uses many individual heating elements and such damage is usually limited to one or two elements while the others continue in operation.

Using methods described in Section IV (Troubleshooting), Paragraph D (4), page 31, the user should determine which heating element(s) require replacement and proceed as follows.

a) Cold replacement - The furnace power should first be switched off and locked out for protection of maintenance personnel. Then the cover hold-down lugs can be loosened and the cover lifted off and set aside. The element(s) to be replaced should be located and the lead wires detached from the copper terminals using a pair of 7/16" end wrenches. The top ceramic stud and support washer can then be lifted aside and the heating element lifted vertically out without removing the crucible.

The replacement heating element can then be vertically lowered into place with its base resting on the element support pad in the furnace floor. Using a

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pair of heavy duty pointed nose pliers, grip the heating element lead wire close to the point where it comes out of the ceramic panel at the top of the element and bend the lead wire back at a 90 degree angle just **above** the point gripped by the pliers.

Thread the lead wire through the hole in the protective refractory blanket and, with the heating element firmly in place and supported at the top by the ceramic stud and washer, bend the lead wire 90 degrees toward the terminal screw, just in front of the face of the copper terminal.

Then, while pressing the lead wire into the ceramic fiber blanket in a fashion similar to the other lead wires, bend a hook completely around the stainless steel bolt in the front of the copper terminal and cut off the excess lead wire.

Use only the special stainless steel bolts, washers, and nuts provided by Dynarad (Part Nos. 270-0120, bolt; 270-0230, washer; and 270-0040, nut) and assemble just like the other connections. (Please note that the use of substitute hardware or any other deviation from factory design could lead to junction failures.) Tighten the hardware firmly with the end wrenches and the installation is complete.

b) Hot replacement - Heating elements may be replaced from a Dynarad furnace containing molten metal by following all of the above directions with these additional instructions.

Equip personnel with high temperature gloves and protective insulating clothing. When the furnace cover is removed, place the crucible cover or a suitable piece of ceramic fiber board or blanket over the crucible and lay a two foot wide, five foot long strip of high temperature ceramic fiber blanket (Dynarad Part No. 520-0010) over the gap between the heating elements and the crucible to eliminate glare and heat radiation from this area.

Additional strips may be used to cover this gap all around the furnace to minimize the overall temperature loss during the element change. Using high temperature gloves and the tools described above, the element(s) can be quickly replaced. One element should be replaced in about one-half hour.

D. Tightening Electrical Connections

All conductors of electric current such as cables, connectors, terminals, etc. generate a small amount of heat which, in turn, causes these conductors to expand and contract. This expansion and contraction can cause electrical junctions and connections to loosen. In addition, vibration during shipment can also loosen electrical connections. Loose electrical connections are highly undesirable because they increase the resistance to current flow, generating hot spots at loose joints which can damage or destroy the connectors and any components to which they are connected such as contactors, fuse blocks, terminal blocks, etc.

To avoid electrical hot spots, Dynarad recommends the user regularly turn off and lock out all electrical power and tighten all electrical connections at the power source, inside the control panel, and in the furnace junction box. This should be done immediately after the furnace is put in service (to catch any loose junctions caused by shipping vibration) and thereafter on a quarterly basis. A "tug test" consisting of pulling firmly on the attached wire or cable to check for looseness should be performed after tightening each junction. Regularly tightening electrical connections is a sound maintenance practice for all electrical equipment including electric furnaces which will pay dividends in time and money saved.

DYNARAD ELECTRIC RESISTANCE FURNACE

IV TROUBLESHOOTING

A. Control Panel Electrical Safety

1. **DANGER - HIGH VOLTAGE!** - Turn power off before opening the Control Panel door. The fused disconnect switch or circuit breaker which supplies power to the Control Panel should always be opened and locked out before opening the Control Panel door and particularly before performing any maintenance work inside the panel.

2. Do not rely on the door switch - While the Control Panel is equipped with a safety door switch which opens all high voltage contactors and shuts off all low voltage (120 VAC) control power, it is still possible to sustain dangerous and potentially lethal electrical shock if personnel should touch any terminals behind the protective barrier, or if the barrier should be removed and not replaced, or if any components such as contactors should become defective and remain closed when they are turned off and expected to be open.

Don't rely on the door switch! Shut off and lock out incoming power before opening the Control Panel door.

B. Thermocouples

1. Metal Bath Thermocouple

a) Thermocouple failure - If the bath thermocouple protection tube is worn out or damaged, molten metal can enter the tube and damage the thermocouple element. This usually results in an open circuit condition which drives the bath pyrometer temperature indicator to the maximum or full upscale position causing the pyrometer to turn off power to the furnace.

However, if any metal leakage through the protection tube is slow and gradual, the thermocouple element may not immediately go into an open circuit condition but, instead, may degrade slowly and provide an incorrect millivolt output (usually a low output). The bath pyrometer will then give an incorrect reading which can be checked with a separate (perhaps a portable) temperature sensing instrument.

A bath thermocouple short circuit condition, usually caused by a loose connection somewhere in the thermocouple or lead wire circuit, will result in the pyrometer driving to the **low** end of the scale which will call for power to the furnace. This can result in overheating of the bath with the highest tempera-

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ture ultimately determined by the setting of the Element Temperature Limiter. Thus, care must be taken to avoid short circuits in thermocouples or lead wires.

b) Replacement - A defective thermocouple should be replaced. Refer to Section III (Furnace Maintenance), Paragraph B (2), page 22, for thermocouple replacement instructions.

2. Element temperature limit thermocouple

a) Thermocouple failure - The element temperature limit thermocouple is not subject to constant submersion in molten metal so this is not a normal cause of failure. However, the element will slowly deteriorate as a result of time and temperature and will eventually fail, usually by an open circuit.

b) Result of failure - An open circuit thermocouple failure will result in the element temperature limit pyrometer indicator being driven fully upscale which will turn off power to the furnace. This could result in a freezeup of the metal bath if the furnace is not supervised.

c) Replacement - A defective thermocouple should be replaced. Refer to Section III (Furnace Maintenance), Paragraph B (3 & 4), page 23, for thermocouple replacement instructions.

C. Alarms

1. Ground Fault Alarm

a) Description of operation - The Ground Fault Interrupter (GFI) senses current flow into and out of the furnace. If inflowing current above the GFI's set sensitivity adjustment finds a path to ground instead of returning through the normal supply cables, the GFI will detect the fault to ground and instantly shut off power to the furnace, sound the alarm and light the "Ground Fault" lamp. However, the GFI is designed to ignore very low level leakage currents, which are normal, to avoid nuisance tripping.

b) Possible causes - Any ground fault above the GFI's low level minimum sensitivity (which is adjustable, but factory set at the most sensitive setting) which occurs anywhere in the furnace power circuits beyond the GFI sensor (located inside the furnace pull box) can trip the GFI.

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For example, metal leakage from the crucible of sufficient quantity to complete a path from the metal bath to a heating element should cause the GFI to trip. Thus the isostatically pressed silicon carbide bath thermocouple protection tube must always be tightly clamped in its U-bolt clamp with its 90 degree union similarly tight to adequately ground the metal bath so that the GFI can operate properly.

Similarly, any other such path to ground caused by any metallic object contacting any current carrying cable or component in the furnace should trip the GFI.

c) Reset - Open the Control Panel door and locate the ground fault relay inside the panel. Switch the white circuit breaker lever upward to the reset position. If the fault is clear, this will silence the alarm.

d) Find the cause - If the GFI successfully resets, the furnace should be closely inspected for the cause of the original trip. For example, the runout port should be inspected for evidence of dripping metal which might have resulted in a GFI trip.

If the GFI will not reset, the fault has not been cleared and the furnace must be shut off and checked for the cause of the ground fault. Use the following procedure:

- 1) Be sure the ground fault relay sensitivity adjustment has not been left in the "test" position which would cause continuous tripping. Refer to page 10, paragraph 5 for directions on how to check this.
- 2) Open the main disconnect and check inside the control panel **and** the furnace terminal box to be sure that the neutral terminal has **not** been connected to ground. If it has, remove this ground connection.
- 3) With all power off, remove all of the heating element fuses and disconnect the neutral lead going to the furnace at the junction terminal inside the control panel. Then close the door and restore power and see if the ground fault relay trips. If it does, the ground fault relay or sensor is causing the problem.
- 4) If the ground fault doesn't trip, the fault is somewhere "downstream" of the heating element

fuses. To find it, connect one lead of an ohmmeter to ground and touch the other lead to each of the lower fuse terminals where the wires going to the heating elements in the furnace are connected. Also touch this ohmmeter lead wire to the neutral lead going to the furnace which you just removed.

If you find resistance ranging from a dead short to several thousand ohms between any of these wires and ground you have found the ground fault. Trace it out and locate the exact point of the fault which could be in the wiring going to the furnace or somewhere inside the furnace, perhaps caused by a recent metal spill. When the fault is cleared, you're back in business.

NOTE: A new furnace which has been operated less than two or three weeks or an older furnace which has been placed back into service after several months of inoperation may contain moisture which can register resistance readings, usually in excess of ten thousand ohms, which is normally insufficient to trip the ground fault. Resistance readings caused by moisture also tend to give "erratic" readings which seem to constantly change. These readings will increase up to the megohm and higher range, effectively disappearing, after the furnace dries out fully.

Should GFI tripping continue without obvious cause, the user should contact Dynarad's Service Department for assistance.

2. High temperature limit - The element temperature limit pyrometer is equipped with a second high temperature alarm setpoint which actuates approximately 125°F above the normal adjustable high limit setpoint (which should not be set above 2000°F). If actuated, this high temperature alarm will open the power contactor, sound the alarm, and light the red "Element Over Temp" lamp.

Should this alarm be tripped, the user should shut off power to the furnace and permit it to cool down below the normal high limit setpoint and then investigate the cause of the alarm and correct the problem.

D. Heating elements

1. Using ammeters to monitor the heating elements

- a) Introduction - This Dynarad furnace is equipped with ammeters which continuously indicate current

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flow to the heating elements. These ammeters provide helpful information about the condition and performance of the heating elements.

b) Independent readings - Each ammeter independently reads the current in just one phase regardless of furnace voltage or whether the furnace is wired in a "delta" or "wye" configuration.

c) Element grouping - A group of elements is wired across each phase, the exact number depending on the size of the furnace. In some furnace models the number of elements in each group may vary, but never by more than one element. Thus, all meters will read close to each other but may not read exactly the same.

d) Separately fused - Each heating element is separately wired and individually fused. Heating element fuse blocks are located inside the Control Panel. The Control Panel should never be opened without shutting off all power to the furnace.

e) Determine elements per group - The user should refer to the electrical schematic diagram for his particular Dynarad furnace model and determine the number of heating elements connected in each phase group. Then he can divide the number of elements in each group into the ammeter reading for that group to determine the current flowing through each individual heating element. This information will be useful for checking elements following instructions in Paragraph 3 below.

2. Normal current variations

a) Voltage fluctuations - Most electric utilities are obligated to maintain their customers' voltage to no better than plus or minus five percent of the nominal supply voltage. Since the current flow to the heating elements is proportional to the supply voltage, ammeter readings can vary by this amount as well.

The supply voltage normally follows grid wide as well as local demand patterns. It will drop during periods of heavy use and rise during off-peak periods.

b) New elements - When Dynarad heating elements are brought to full operating temperature for the first time, aluminum in the resistance alloy oxidizes at the surface, forming a protective coating of aluminum oxide. This effectively stops further oxidation and gives Dynarad heating elements a decided advantage

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over other types, such as nickel/chrome elements, which form no protective coating and continuously oxidize until they are no longer useful.

When Dynarad elements form this protective oxide coating, the electric resistance rises slightly causing the current to drop slightly. Then the resistance remains relatively constant throughout the operating life of the element.

c). Temperature changes - As with most resistance heating alloys, the elements will draw slightly more current when the furnace is cold than when it has reached operating temperature. This is normal.

3. Abnormal ammeter readings

a) Element out of circuit - If the current reading of any ammeter should drop by an amount equal to the current required for a single heating element, then one element is out of the circuit for that group. A current change of this type can be distinguished from a normal voltage fluctuation by noting that the change is larger than most normal fluctuations and appears in just one meter while voltage fluctuations usually affect all three phases at once.

b) Causes - An individual heating element can drop out of the circuit because of an open fuse, an open wire or junction, or an open heating element.

4. Checking individual element circuits - The following procedure may be used to troubleshoot heating element circuits.

a) Shut off all power to the furnace. Lock out the breaker or disconnect to be safe. However, it will not be necessary to empty the furnace since the checking procedure can be completed quickly.

b) Open the Control Panel and remove all fuses from the element fuse blocks. (It will not be necessary to remove the two fuses which protect the step-down transformer which provides low voltage instrument power.)

c) Use a continuity checker or ohmmeter to check the fuses. If any are open, obtain replacements of the same size and rating.

d) Refer to the electrical schematic and determine whether the furnace is "wye" or "delta" connected.

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Most 480 volt furnaces are wye connected and the return leads of all heating elements are connected to "neutral".

Most 240 and 208 volt furnaces are delta connected and the return leads of the heating elements are connected to the incoming three phase power legs designated "A", "B", and "C".

Referring to the connection lugs on the main contactor and the heating element return terminals to the left of the element fuse blocks, the left lug or terminal is leg "A", the center lug or terminal is leg "B", and the right lug or terminal is leg "C".

e) Checking "wye" connected furnaces - Connect one probe of an ohmmeter to the furnace neutral terminal. This will be the red colored stand-off insulator terminal to the left of heating element fuse blocks. Then, with the fuses still out of the fuse blocks, measure the electrical resistance of each heating element by contacting the other ohmmeter probe in turn to each of the **lower** fuse block terminals.

All elements should read approximately the same resistance (this resistance will depend on the furnace operating voltage). If any circuits are open (the ohmmeter reads infinity) or read much lower than the others (including a direct short), note the element number for later checking.

If all elements read approximately the same resistance, and a fuse was previously found to be open, the problem is the fuse. Replace it and place the furnace back in operation.

f) Checking "delta" connected furnaces - Note that each fuse is labeled with a number followed by two phase leg designation letters separated with a slash mark. For example, a fuse might be labeled, "3 C/A."

To check each element, first connect one probe of an ohmmeter to the appropriate furnace return terminal lug (to the left of the heating element fuse blocks) corresponding with the **second** letter on the fuse label. (Remember, the left lug is "A", center lug is "B", and right lug is "C".) Then connect the other ohmmeter probe to the **lower** terminal of that fuse holder and read the element resistance.

Similarly, determine the resistance of each of the other heating elements, carefully following the above procedure. Just like the "wye" connected furnace, all elements should read approximately the same

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resistance (this resistance will depend on the furnace voltage). If any circuits are open (the ohmmeter reads infinity) or read much lower than the others (including a direct short), note the element number.

If all elements read approximately the same resistance, and a fuse was previously found to be open, the problem is the fuse. Replace it and place the furnace back in operation.

5. If any of the heating element resistance readings show an open circuit (the ohmmeter reads infinity), or if they are much lower or even a direct short, the furnace must be opened and the element(s) checked.

However, it is not necessary to do so immediately. If the user would prefer to check the element(s) later, all fuses may be replaced except those which protect the element circuits in question and the furnace may be placed back in operation. The element(s) can then be checked at the convenience of the user.

6. Element numbering system - Looking down at the furnace in plan view, the heating elements are numbered in consecutive clockwise order starting with the element closest to the element protection thermocouple. These numbers correspond with the numbers shown on the individual element fuse holders.

7. Replacement of heating elements - Follow the instructions in Section III (Furnace Maintenance), Paragraph C (2), page 23.

E. Temperature Control Instruments

1. Fine Tuning - The bath thermocouple pyrometer may require "fine tuning" adjustment(s) of the Reset, Rate, Proportional Band, or Load Line settings to improve temperature control performance in a particular installation. The element temperature limit pyrometer requires no internal adjustment.

2. Refer to manuals - Please refer to the individual operating and servicing manuals for "fine tuning" or other information concerning the pyrometer instruments which are found in the Appendix at the back of this manual.

Spare Parts List for Dynarad EC-1500 Furnace, Job # 1153

	Dyn. Part No.	UM
Thermocouples and Accessories		
Bath T/C Protection Tube,	530-0105	ea
Bath T/C element,	380-1030	ea
Replacement 12" high limit T/C Assy.	140-0012	ea
Refractories & Ceramic Components		
Blanket 1/2"	520-0030	sf
Blanket 1"	520-0010	sf
Blanket 2"	520-0035	sf
Patching cement for floor	501-0010	lb
Ceramic studs 2 1/2"	530-0020	ea
Ceramic pink washer	530-0010	ea
Heating Elements:		
Heating element 28" 277V flex lead (inc. hardware)	301- 00 75RP	ea
Misc. Furnace Components		
Hat ring	220-0250	ea
Element Terminal Assy. Ec-Series	103-0025	ea
High Temp Stand-off Assy	103-0100RP	ea
Pedestal 3" x 34"	530-0124	ea
Separation disk	530-0138RP	ea
Wire harness	116-0050	ea
Heater Hangar Replacement (Element restraint)	270-0032	ea
Instruments, Relays, etc.		
Relay, contactor control	320-1120	ea
Fuses, ATM 30	360-5230	ea
High power plug, 4W4P	360-2535	ea
High power plug receptable, 4W4P	360-3624	ea

DYNARAD ELECTRIC RESISTANCE FURNACE

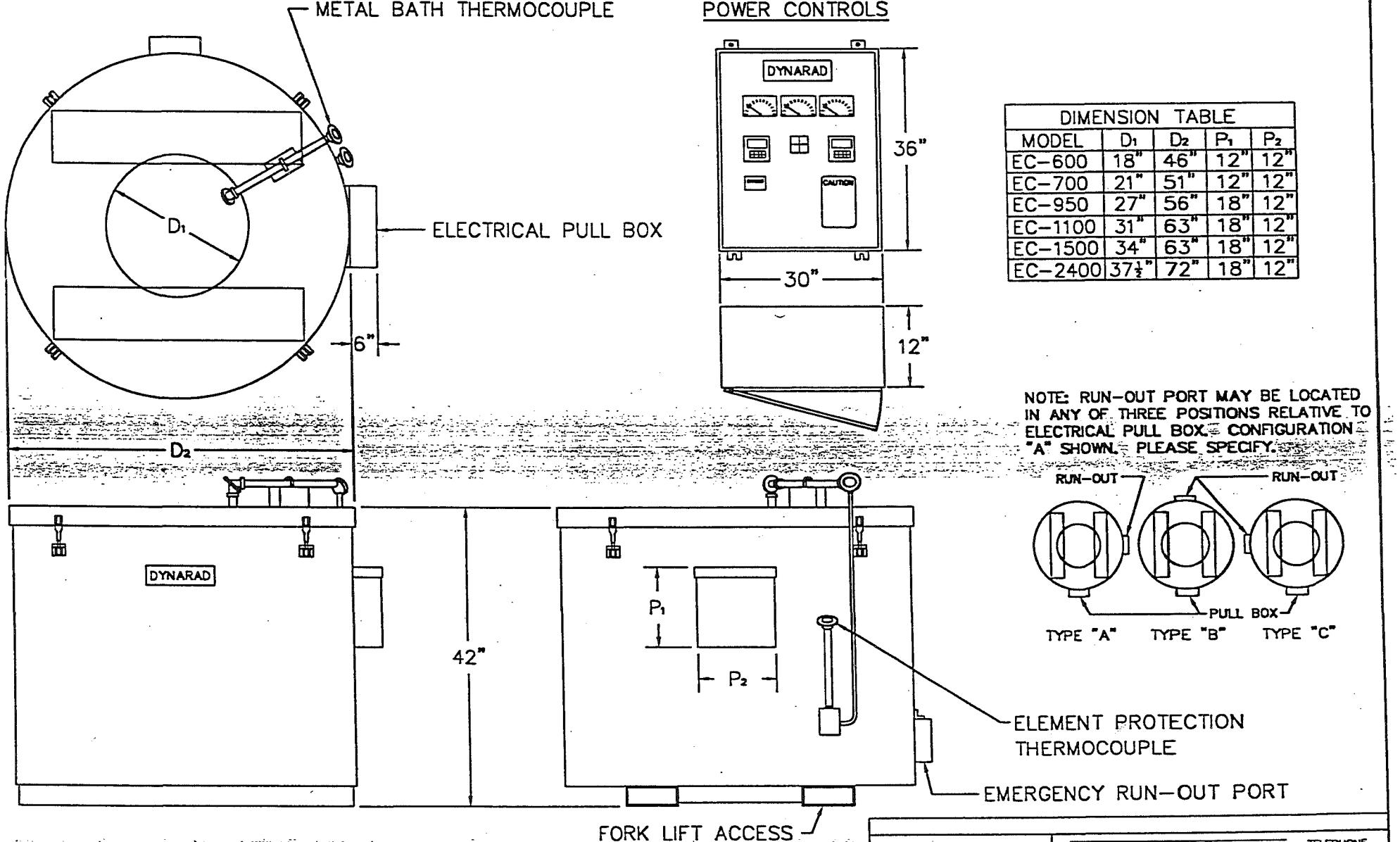
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CRUCIBLE MAKE & MODEL:

SUPPLY VOLTAGE: _____ VOLTS, _____ HERTZ,

WITH OR WITHOUT NEUTRAL

START-UP SERVICE REQUIRED? YES NO

SHIP VIA? _____

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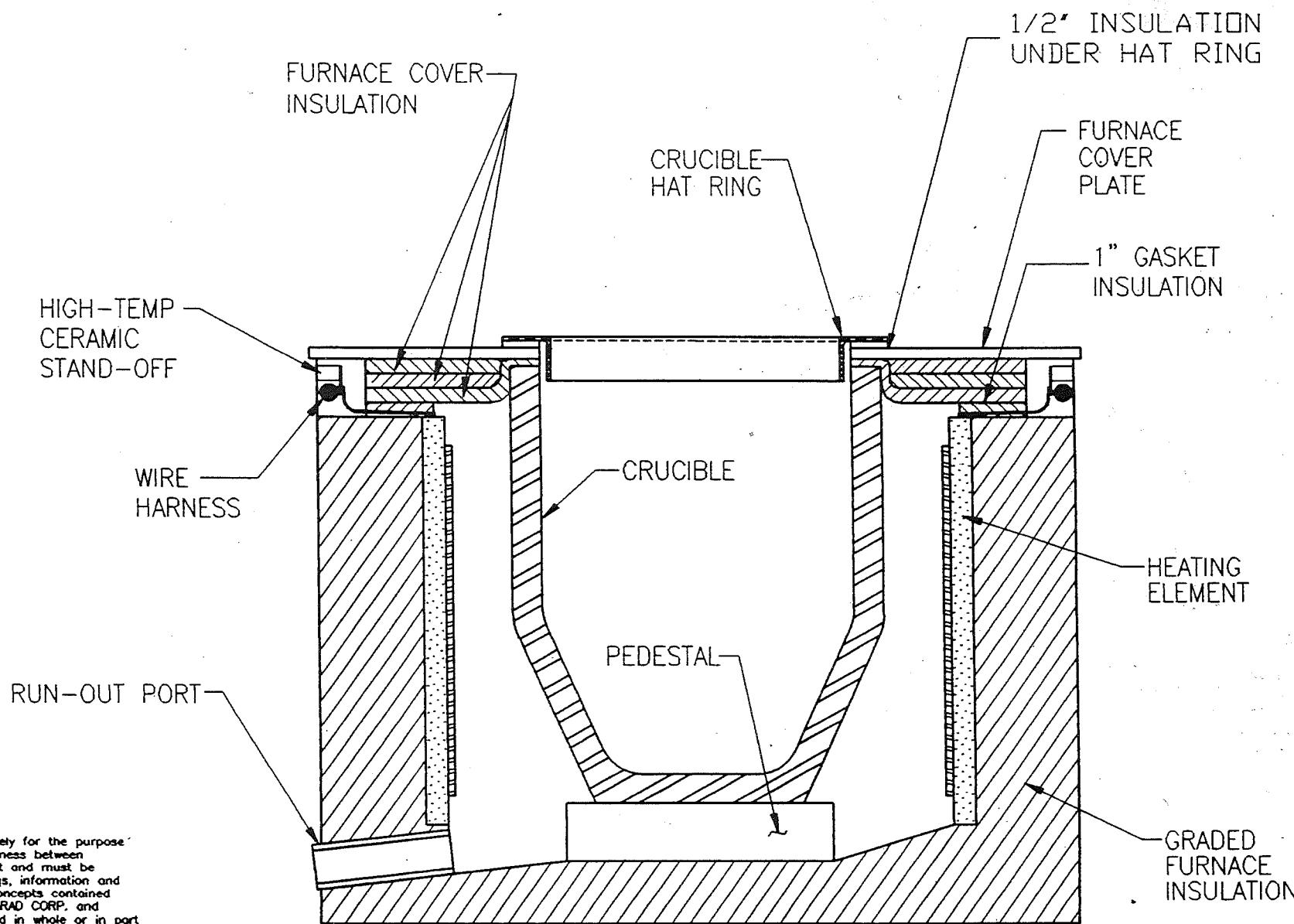
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EC SERIES
ELECTRIC RESISTANCE
WELTING FURNACES

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SHEET 1 OF 1



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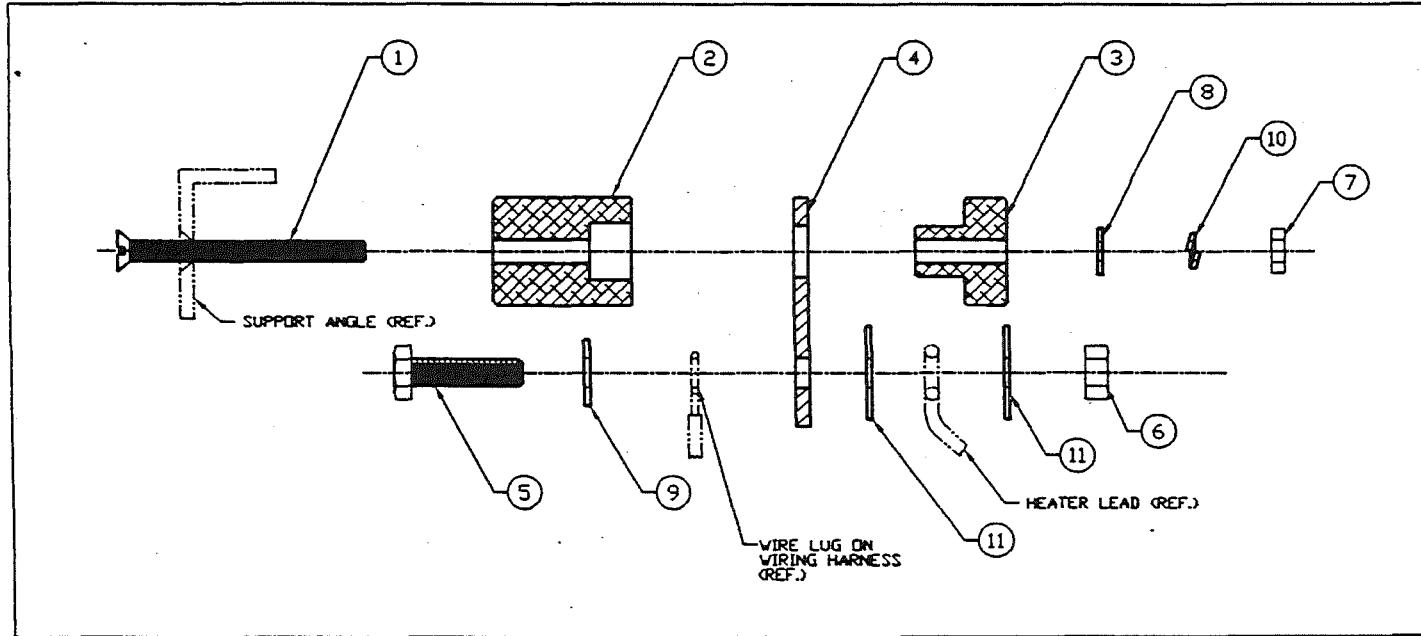
DYNARAD

TELEPHONE: (510) 638-2000
FAX: (510) 639-4564

**INSULATION DETAILS
EC FURNACES**

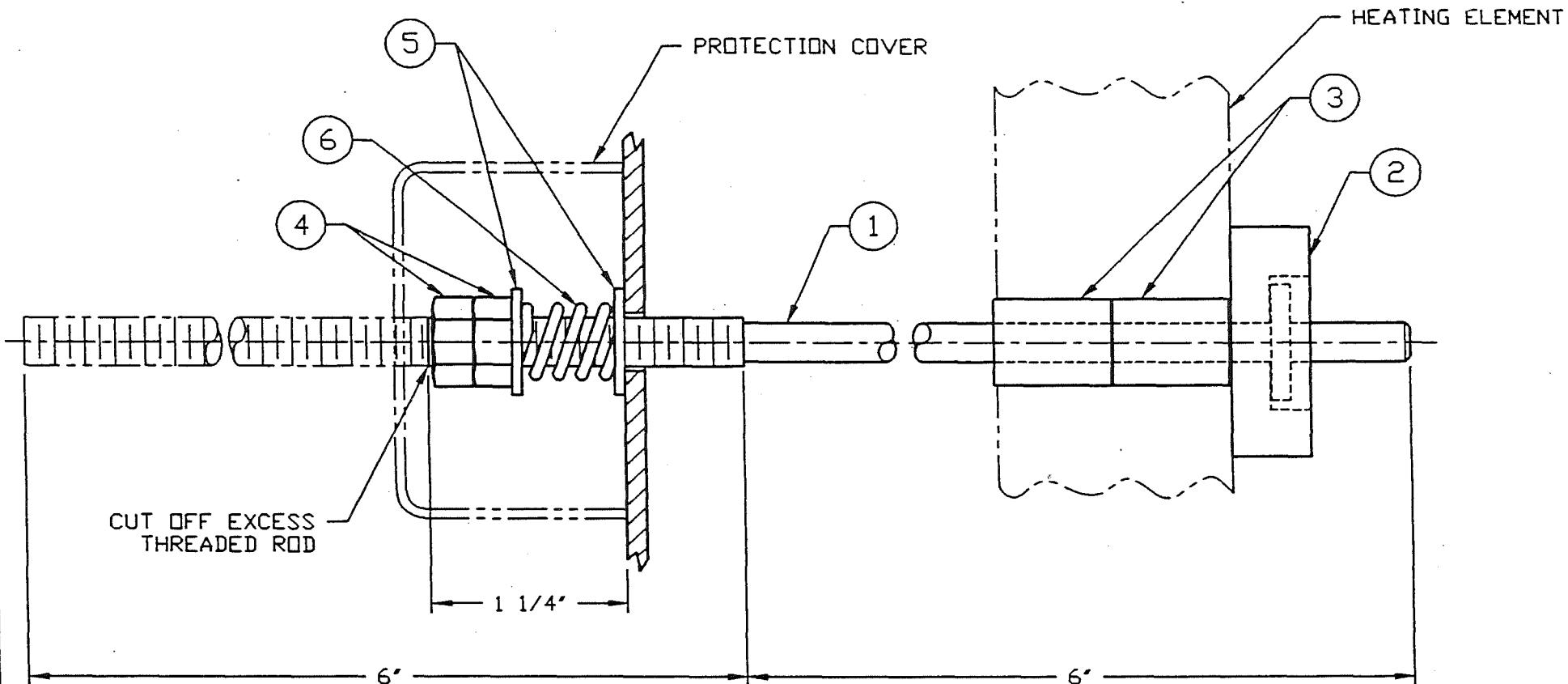
A0132

FILE: A0132B-1.DWG



EDIT	EDIT		EDIT	EDIT
REV	ZONE	DESCRIPTION	BY	DATE
TOLERANCES: UNLESS OTHERWISE SPECIFIED				
FRACTIONS =	DEC =	ANGLES =		
\pm EDIT	\pm	\pm		
DIMENSIONS ARE IN INCHES				
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DYNARAD ELECTRICAL STAND-OFF				
DRAFTSMAN	DHT	DATE	1-20-98	DRAWING NO.
CHECKED BY		DATE		A0168
USED ON	DYNAFLEX	SCALE	4 / 7	A0168A-1.DWG
SHEET 1 OF 1				

10-17-97



ITEM	PART No.	QTY	DESCRIPTION
1	291-0032	1	HANGER ROD
2	530-0005	1	CERAMIC WASHER
3	530-0002	2	CERAMIC SLEEVES
4	270-4250	2	5/16-18 HEX NUTS
5	270-1140	2	5/16 FLAT WASHERS
6	270-9426	1	SPRING

TOLERANCES:
UNLESS OTHERWISE SPECIFIED

FRACTIONS = $\frac{1}{16}$ INCHES = $\pm \frac{1}{16}$ ANGLES = $\pm \frac{1}{16}$

DIMENSIONS ARE IN INCHES

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PART No. 270-0032

DYNARAD

ELEMENT HANGER ROD
INSTALLATION DETAILS

DRAFTSMAN	DHT	DATE 5-16-97	DRAWING NO.	REV.
CHECKED BY		DATE	A0128	B
USED ON DRAWING		SCALE	FULL	A0128B-1.DWG

SHEET 1 OF 1

UDC 2000 CONFIGURATION RECORD SHEET

GROUP DESCRIPTION	FUNCTION DESCRIPTION	VALUE OR SELECTION	FACTORY SETTING	GROUP DESCRIPTION	FUNCTION DESCRIPTION	VALUE OR SELECTION	FACTORY SETTING
TUNING	GAIN	1.0		CONTROL	SP SRC	1LOC	
	PB	0.1			RATIO	1.0	
	RATE T	0.01	0.00		BIAS	0.0	
	I MIN		1.0		PWR UP	ALSP	
	I RPM	0.02			SP HI	2000	2400
	MANRST		0		SP LO	0	
	GAIN 2		5.0		ACTION		REV
	PB 2				OUT HI		100
	RATE2T		0.0		OUT LO		0
	I2 MIN		0.2		DBAND	0.5	2.0
	I2 RPM				HYST	0.0	0.5
	CYC TI	120	20		FAILSF	0	
	CYC2TI		20		PB or GN	PB	GAIN
	* LOCK	CONF	CAL		MIN RPM	RPM	MIN
	AT KEY		ENAB	OPTIONS	AUXOUT		NONE*
	RH KEY		ENAB		0 PCT		0
					100 PCT		1000
					REM SW		NONE*
ALGORITHM	CTR ALG		PIDA	ALARMS	A1S1VA	125	90
	INPUT 2		ENAB*		A1S2VA	0	10
	OUT ALG	RLY	"		A2S1VA	0	95
SP RAMP	SPRAMP		DISABL		A2S2VA	0	5
	TI MIN		0		A1S1TY	DE	PROC
	FINLSP		0		A1S2TY		PROC
	SP PROG		DISABL		A2S1TY	OE	PROC
A TUNE	AT ENB		DISABL		A2S2TY		PROC
	OUT STP		10		A1S1HL		HI
	AT ERR		NONE		A1S1EV		BEGN
INPUT 1	DECIMAL	8888			A1S2HL		LO
	UNITS	°F	NONE		A1S2EV		END
	IN1TYP		K H		A2S1HL		HI
	IN1 HI		2400		A2S1EV		BEGN
	IN1 LO		0		A2S2HL		LO
	BIAS 1		0		A2S2EV		END
	FILTR1	3	0	Note:	Fixed Alarm		
	EMISS		1.0		Hysteresis of 0.5% of (PV) Input Span		
	BRNOUT		UP				
	FREQ		60				
	DISPLAY		PR N				
INPUT 2	IN2 HI		1000				
	IN2 LO		0				
	FILTR2		0				

*Appears only if model number allows

**Selected according to model number

* CALIBRATE ALL SETTINGS IN UNIT BEFORE LOCK. DO LOCK LAST OR
YOU WON'T BE ABLE TO ACCESS OTHER PARAMETERS.

JUMPERS J4 = N.C. J5 = N.C. J6 = N.O.

Configuration Record Sheet

Keep a record

Enter the value or selection for each prompt on this sheet so you will have a record of how your controller was configured.

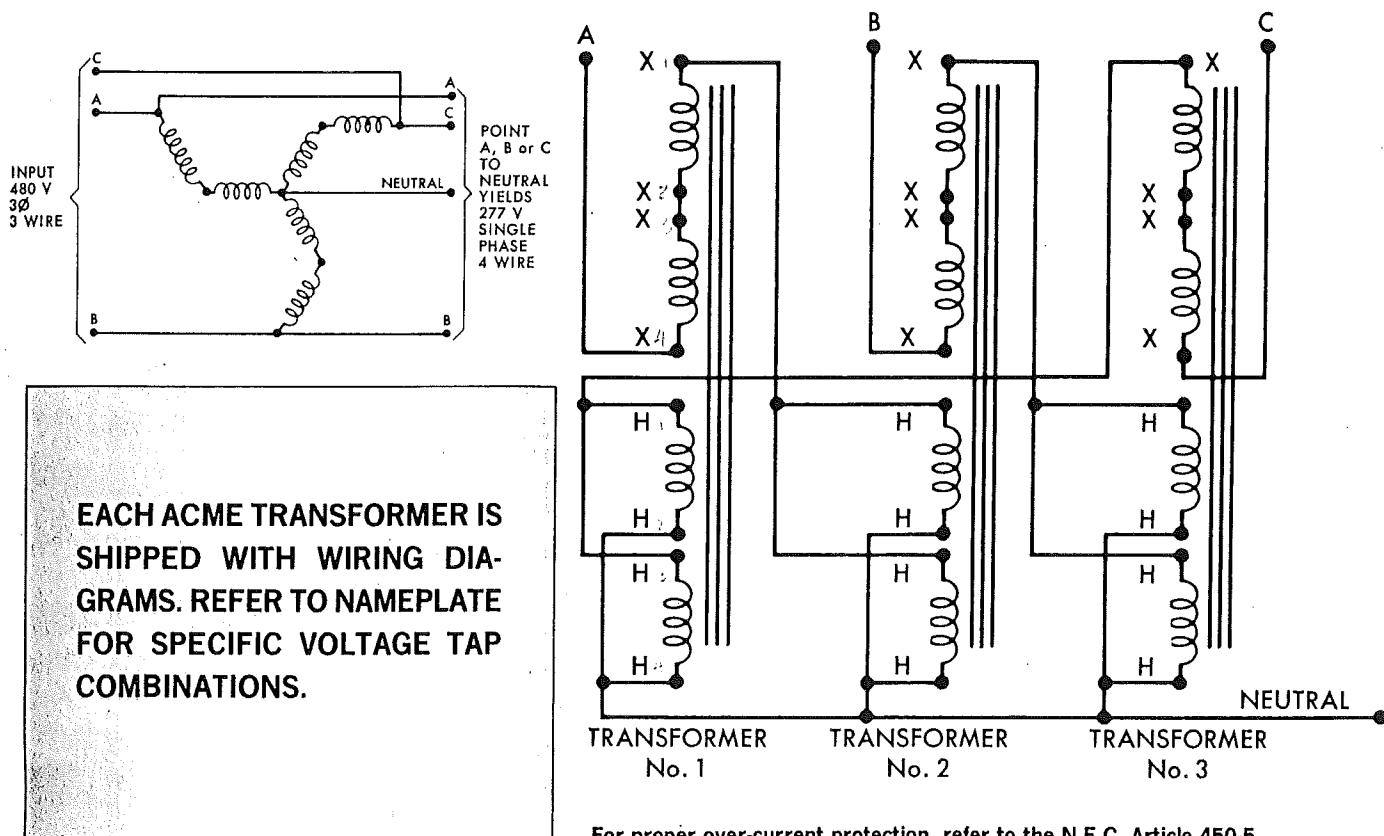
Group Prompt	Function Prompt	Value or Selection	Factory Setting	Group Prompt	Function Prompt	Value or Selection	Factory Setting	
TUNING	PROP BD or GAIN	4.0	1.0	CONTROL	PID SETS SW VALUE SP SOURC RSP SRC RATIO BIAS SP TRACK POWER UP SP HILIM SP LOLIM ACTION OUT RATE PCTM UP PCTM DN OUT HILIM OUT LOLIM DROP OFF DEADBAND OUT HYST FAILSAFE MAN OUT AUTO OUT PBorGAIN MINorRPM		1 ONLY 0.00 1 LOCAL NONE 1.0 0 NONE ALSP 1600 0 REVERSE DISABL 0 0 100.0 0 0.0 2.0 0.5 0.0 0.0 0.0 0.0 GAIN MIN	
	RSET MIN	2.0	0.00					
	RSET MIN		1.0					
	RSET RPM or MAN RSET	0.5	1.0					
	PROP BD2		0.0					
	RSET2MIN		1.0					
	GAIN 2		1.0					
	RATE2MIN		0.00					
	RSET2MIN		1.0					
	RSET2RPM		1.0					
	CYCSEC	120	20.0					
	CYC2SEC		20.0					
	SECURITY		—					
*	LOCKOUT	+VIEW	CALIB					
	AUTO MAN		ENAB					
	SP SEL		ENAB					
	RUN HOLD		ENAB					
SP RAMP	SP RAMP		DISABL	OPTIONS	AUX OUT		DISABL	
	TIME MIN		3		4mA VAL		0	
	FINAL SP		—		20mA VAL		0	
	SP RATE		DISABL		DIG IN 1		NONE	
	EUHR UP		—		DIG IN 2		NONE	
	EUHR DN		—					
	SP PROG		DISABL					
ADAPTIVE	ADAPTIVE		DISABL	Com	ComSTATE		DISABL	
	SP CHANG		10		Com ADDR		0	
	KPG		1.0		SHEETIME		0	
					PARITY		ODD	
ALGORITHM	CONT ALG		PID A		BAUD		300	
	INPUT 2		DISABL		DUPLEX		—	
	OUT ALG	TIME	—		LOOPBACK		DISABL	
	4-20RNG		50PCT		SHEDMODE		LAST	
	FLY TYPE		—		SHED SP		TO LSP	
					UNITS		PERCNT	
INPUT 1	DECIMAL UNITS	°F	XXXX	ALARMS	A1S1 VAL	50	90	
	IN1 TYPE	K TC H	NONE		A1S2 VAL	0	90	
	XMITTER		0-10mV		A2S1 VAL	50	90	
	IN1 HI	2400	LINEAR		A2S2 VAL	0	90	
	IN1 LO		1000		A1S1TYPE	DEV	NONE	
	BIAS IN1		0		A1S2TYPE	DEV	NONE	
	FILTER 1	3	0		A2S1TYPE	DEV	NONE	
	BURNOUT	NP	1		A2S2TYPE	DEV	HIGH	
	EMISSIV		NONE		A1S1 HL		—	
	PWR FREQ		0		A1S1 EV		HI	
			60HZ		A1S2 HL		—	
INPUT 2	XMITTER 2		LINEAR		A1S2 EV		HI	
	IN2 HI		1000		A2S1 HL	Lo	—	
	IN2 LO		0		A2S1 EV		HI	
	FILTER 2		1		A2S2 HL		—	
					A2S2 EV		HI	
					AL HYST		0.1	

* CALIBRATE ALL SETTINGS IN UNIT BEFORE LOCK. TO ACCESS OTHER PARAMETERS.

Auto Zig-Zag Grounding Transformers

For Developing a Neutral from a Three Phase, 3-wire Supply

Refer to page 13 for Dimensional Data



For proper over-current protection, refer to the N.E.C. Article 450-5.

**PRIMARY (INPUT): 480 VOLTS
3Ø, 3 WIRE**

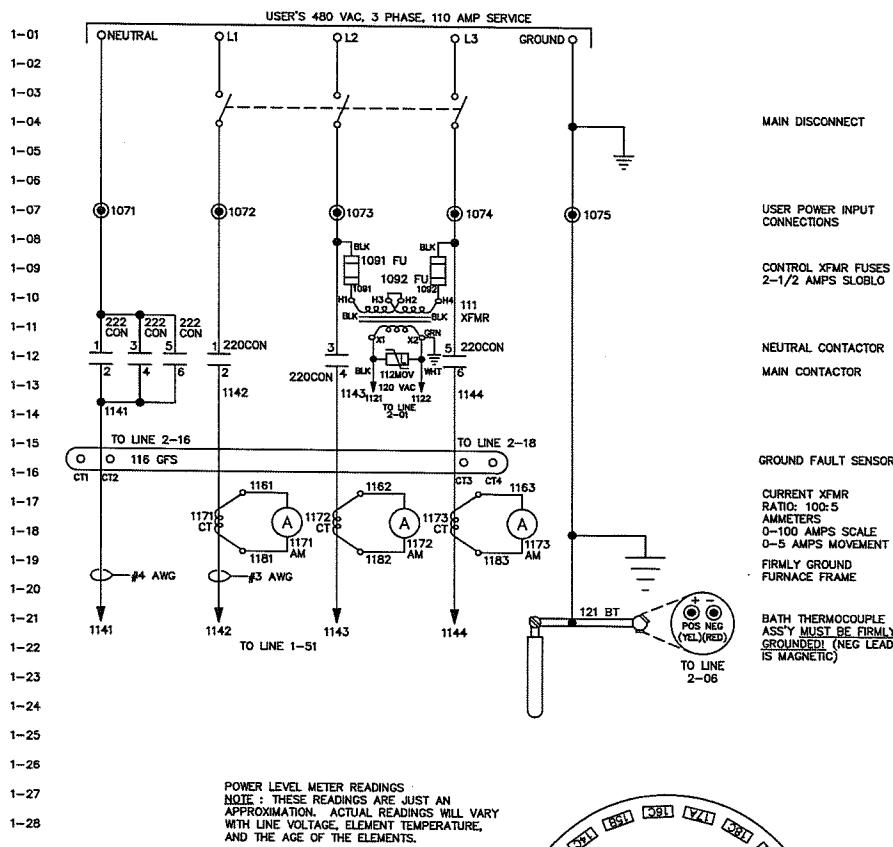
50/60 Hz

**SECONDARY (OUTPUT): 480Y/277 VOLTS
3Ø, 4 WIRE**

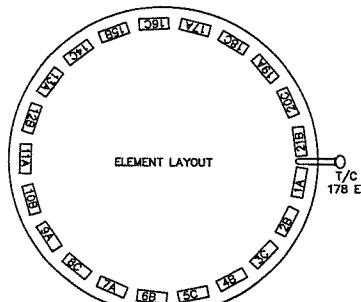
Use 3 Pieces of Type No.	Avalable to	Nameplate KVA per Each Trans.	No. of Trans. Required	Three Phase KVA	Max. Continuous App. Load Per Phase (277 Volts)
T-2-53010	No Taps Only	1	3	10.8	12.5
T-2-53014	No Taps Only	1.5	3	15.6	18.75
T-2-53012	No Taps Only	2	3	20.7	25
T-2-53018-4	Taps & No Taps	3	3	31.2	37.5
T-2-53014-4	Taps & No Taps	5	3	51.9	62.5
T-2-53515-3	With Taps Only	7.5	3	78.0	93.8
T-2-53516-3	With Taps Only	10	3	103.8	125
T-2-53517-3	With Taps Only	12.5	3	136.0	157.5
T-2-53518-3	With Taps Only	25	3	259.5	312
T-2-53019-3	With Taps Only	30	3	390.0	468
T-1-53020-3	With Taps Only	50	3	519.0	625
T-1-53021-3	With Taps Only	75	3	780.0	935
T-1-53022-3	With Taps Only	100	3	1038.0	1250
T-1-53023-3	With Taps Only	125	3	1294.0	1562.5

NOTE: Units having no taps are recommended for this Zig-Zag connection. When only transformers with taps are available, refer to factory for proper connection diagram.

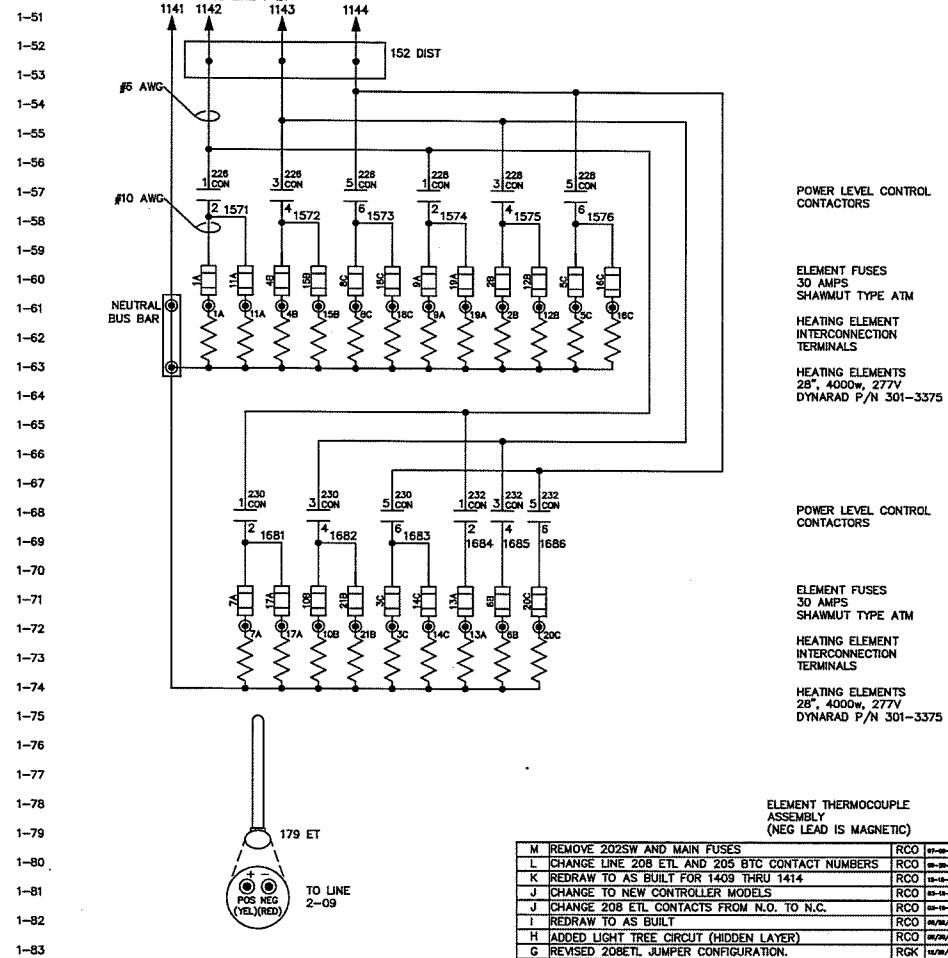
Connection diagram (using 3 pieces of 1 phase, 60 hertz transformers connected zig-zag auto) for developing a neutral (4th wire) from a 3 phase, 3 wire supply. Dimensional information on page 13.



	1171 AM	1172 AM	1173 AM
POWER LEVEL 1	29 AMPS	29 AMPS	29 AMPS
POWER LEVEL 2	58 AMPS	58 AMPS	58 AMPS
POWER LEVEL 3	87 AMPS	87 AMPS	87 AMPS
POWER LEVEL 4	101 AMPS	101 AMPS	101 AMPS



1-38



M	REMOVE 202SW AND MAIN FUSES	RCO
L	CHANGE LINE 208 ET. AND 205 BTC CONTACT NUMBERS	RCO
K	REDRAW TO AS BUILT FOR 1409 THRU 1414	RCO
J	CHANGE TO NEW CONTROLLER MODELS	RCO
I	CHANGE 208 ETL CONTACTS FROM N.O. TO N.C.	RCO
H	ADDED LIGHT TREE CIRCUIT (HIDDEN LAYER)	RCG
G	REVISED ZOBEL JUMPER CONFIGURATION.	RGK
F	REVISED TITLE BLOCK, REVISED ALARM HORN CKT.	RGK
REV	DESCRIPTION	BY DATE
TOLERANCES: UNLESS OTHERWISE SPECIFIED		
IN "	MM	MM
DIMENSIONS ARE IN INCHES		
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FURNACE AND CONTROL PANEL ELEC SCHEM		
EC-1100/1500/2000DS		
480VAC, WITH POWER LEVEL CONTROL		
CHANGED BY	DRAWN BY	REV.
DATE	NAME	M
USED ON	REMA	
SHOOT 1 OF 2		

STRIKO
DYNARAD

501 E ROSEVELT AVENUE • 49400 •
Telephone (510) 772-2775 Fax (510) 772-2771

FURNACE AND CONTROL PANEL ELEC SCHEM

EC-1100/1500/2000DS

480VAC, WITH POWER LEVEL CONTROL

H.I. DRAWN 6/24/87 DRNING NO. D0179 M

