TraceFREE®

Electric Pipe Heating

INSTALLATION, OPERATING & MAINTENANCE INSTRUCTIONS FOR IMPEDANCE HEATING SYSTEMS

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1 – GENERAL

CAUTION:
Failure to follow recommendations could result in premature failure and/or serious equipment damage.

CAUTION:
Refer to these instructions for applicable warnings prior to installation, maintenance, operation, repair and/or modification.

Impedance Heating Systems are designed to provide years of trouble-free operation if properly installed and maintained. This system will maintain its design temperature in the piping whether the pipe is full or empty. The piping can be recovered to design temperature if allowed to cool for any reason. The process temperature controller automatically maintains the piping at temperature, and manual manipulation is not required at any time during normal operation or recovery. To ensure compliance with NEC or CEC and IEEE requirements, a person qualified in such systems should be available to oversee the design, installation and commissioning of the heating system.

1.1 - IMPEDANCE HEATING PRINCIPLE

In impedance heating, the wall of the pipe actually becomes the heating element. An automatic control loop monitors and adjusts alternating current to the pipeline through a step-down transformer that has been specifically designed for the installation. The rapid reversal of current and magnetic flux lines causes self-induction, and this opposition to current flow is called reactance.

Therefore, the impedance to the current flow is caused by the two in combination: Resistance and reactance. A third heat source is the alternating magnetic flux inducing eddy currents and hysteresis (molecular friction), attributed to the reluctance of the magnetic flux to reverse polarity.

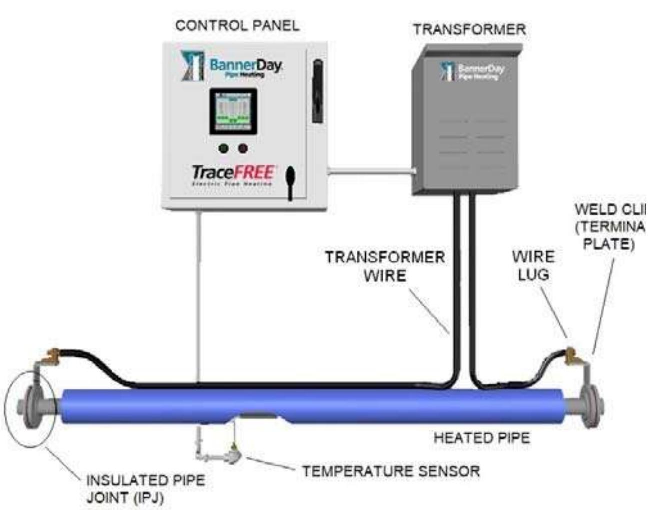
Uniform heating is produced both concentrically around the pipe circumference and along the entire pipe length since the current characteristics are uniform.

1.2 - SYSTEM TYPES

There are two systems types: End Feed and Center Feed. Specific application requirements determine which type of system is used. The distinguishing feature of each system is how the transformer secondary wires are connected to the heated pipeline.

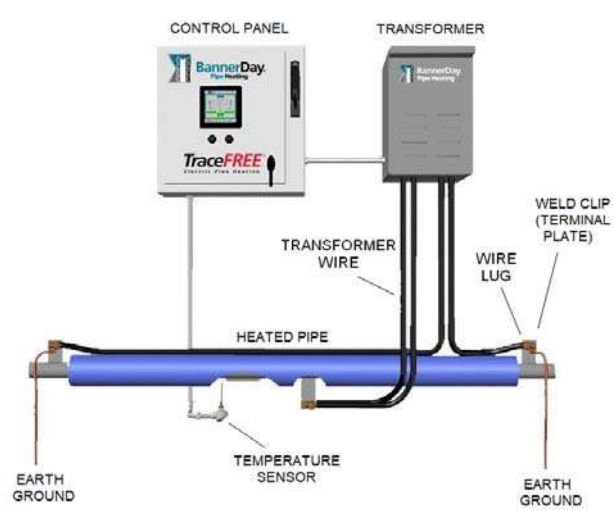
End Feed System

End Feed systems connect transformer secondary wire(s) to each end of the heated pipeline and require isolator flange assemblies at each end of the heated pipeline.



Center Feed System

Center Feed system transformers utilize multiple secondary wires. Transformer leg wires are applied to the electrical resistive center of the pipeline thereby enabling an even distribution of heat. Accordingly, outer transformer leg wires are evenly distributed to each end of the heated pipeline. At each end of a Center Feed system the pipeline is grounded to earth eliminating the need for isolator flange assemblies at the ends of Center Feed heated pipelines.



1.3 - EQUIPMENT

1.3.1 - Typical Control Panel

The Impedance Heating System is controlled using a UL listed control panel provided by the equipment provider. The panel is designed to safely receive external power, distribute it to system components within and provide circuit protection from ground faults or detected conditions harmful to personnel and equipment.

Panel components vary per application. For equipment detail refer to the wiring diagram included with the panel. Typical components may include:

- Disconnect Switch – Removes line voltage from the control panel for servicing and maintenance.
- Fusing – Protects wiring and controls from excessive current due to short circuit or overload.
- Power Controller – Magnetic definite purpose device or solid-state relay interlocked with the control circuit to isolate incoming power from the load for ON-OFF control methods or as a safety.
- SCR Power Controller – Accepts signal from the Process Temperature Controller and proportions heat output.
- Control Transformer – Provides low voltage power for control circuit.
- Ground Fault Device - Device used to de-energize each branch circuit when a ground fault is detected.
- Process Temperature Controller – Receives a temperature signal from a process sensor or remote input and adjusts system output to maintain required temperature setpoint.
- Control Circuit Switch – Pilot device allows the control circuit to be disabled while the main disconnect is on. This allows power to the process controller for configuration and setup.
- High Limit Controller (optional) – Over-temperature protection that breaks the control circuit when measured process temperature exceeds setpoint. Typically provided with manual reset.
- Control Relay – Defines control logic by interlocking safety devices to the system power or can provide remote alarm indication to the customer
- Programmable Logic Controller - PLC designs are available as an alternative to a process controller. They can be used as an ON/OFF system or they can provide control features due to their capacity to act on operational data.

For additional information on these components see individual manufacturer data sheets and instructions.

1.3.2 - Transformer

A step-down transformer has been specifically designed for the operating conditions. Transformers for heating systems are typically provided with secondary voltage up to 30 volts but can be designed up to 50 volts when subject to equipment ground fault protection and when access to equipment is only by qualified persons. The transformer should be placed within a specified distance from the pipeline, as indicated on the layout drawing.

1.3.3 - Typical Field Equipment

Equipment typically provided by manufacturer includes:

- Insulated Pipe Joint (IPJ) – Impedance heating produces even heat throughout the circuit. To achieve this, each heating circuit must be electrically uniform from end to end. Since grounding will cause stray currents, and branch circuits at tees will cause currents to divide, IPJs are used at tees and equipment connections. The IPJ positions are typically shown on an outline drawing. These should be located as close as possible to the tees or equipment to prevent any section of piping from being unheated.
- Temperature Sensors – sensors are used to monitor pipe surface temperature. The pipe surface temperature will be very close to the fluid temperature in the pipe.
- Wire – The transformer secondary wire carries current to the pipe and should be sized for normal current imposed on the heating system.
- Wire Lugs and Weld Clips – Wire lug design should be adequate to pass current through structural attachment plates or brackets, commonly referred to as weld clips or terminal plates, welded to the pipe. Note optional weld clip guards are also available per document ENM-3848.

Equipment supplied and installed by end user:

- Pipe – The size, schedule and material of the piping for which this system was designed are specified on the outline drawing. All piping should be installed as specified since mixed piping will result in uneven heating. In addition, all piping being heated must be within same ambient temperature. The limits of pipe length should also be kept, or the system will not operate as designed. The pipe in an Impedance Heating System will carry a low voltage current; therefore, it must be isolated from all electrical grounds. Care must be taken at support points to ensure that pipe expansion will not cause accidental grounding of the circuit.
- Thermal Insulation – Thermal Insulation should be installed to prevent heat loss from the pipe and to protect against accidental contact. The integrity of the thermal insulation must be maintained in order to have the most efficient and maintenance-free system.

1.4 - CONTROL METHODS

Control methods for electric heating systems can either be:
- ON / OFF
- Proportional, Integral, and Derivative (PID).

1.4.1 - ON/OFF Systems

On/off systems utilize a process similar to a thermostat that operates a home furnace. A typical Control Panel is provided with a digital indicating process controller which accepts a sensor input from the process. The controller is configured to an SSR output to pull power contactors in and out, to cycle the load.

The process controller must be configured to limit the cycle rate to avoid quickly wearing out the power contactors. Contactors are typically rated for 100,000 cycles of operation.

Two methods can be used: “Hysteresis” or “Cycle Time”.

Hysteresis (also known as “Dead Band”) defines a temperature range around the setpoint where the process controller will not change the state of the power contactor. A hysteresis value of 5°F would define the “error” or tolerance from setpoint that the user can accept. This is sometimes referred to as deadband. This method of control is typically recommended for ON/OFF impedance systems to prolong the life of the electrical components.

Cycle Time is a method to define the minimum time that the controller must wait between de-energizing and re-energizing the power contactor. A Cycle Time of 3-5 minutes on equipment operating continuously would wear out power contactors in about 2 years. If the Cycle Time is set for 3 minutes, but the temperature has not yet dropped below the setpoint, the heater will not come on until the temperature drops low enough.

1.4.2 - PID Control

PID control utilizes Proportional, Integral, and Derivative control methods to scale the output from a process controller (typically 4-20mA) to an SCR Power Controller. Note that reverse acting signals are used with heating systems where the system is OFF at 4mA and fully on at 20mA.

SCR Power Controllers are phase-angle fired units that linearly control, with respect to the process controller command signal, the RMS value of the load voltage.

For further details about PID control, refer to the process controller instruction manual.

1.4.3 - Factors Impacting System Control

Many factors affect the setpoint tolerance and control of heating systems. Control Method (noted above), Heat Load Fluctuations, and Fluid Properties are all significant factors.

<u>Heat Load Fluctuation</u>**,** or changes in the process, can cause wide temperature fluctuations. Some typical changes to a heating process loop are:
- Adding fluid at a temperature below process temperature
- Opening or closing tank access covers
- Starting or stopping fluid agitators
- Ambient temperature changes
- Fluid flow rate changes
- Insulation thickness
- Power available can be affected by user voltage fluctuations

<u>Fluid Thermal Properties</u> can greatly impact temperature control. Fluids such as water, with high thermal conductivity, are easy to heat without experiencing large temperature gradients. Fluids such as wax or tar pitch have such low thermal conductivity that the system must be designed with a much lower pipe watt density than with most fluids. Solids buildup on the pipe wall can also reduce the heat transfer.

To obtain optimum control, the use of SCR control is recommended.

2 – INSTALLATION

CAUTION: It is recommended for installation to be performed by qualified personnel familiar with the National Electrical Code (NEC), Canadian Electrical Code (CEC), IEEE and all local codes and standards. It is the responsibility of the installer to verify the safety and suitability of the installation.

WARNING: DO NOT mount Control Panels in an atmosphere containing combustible gases, vapors, dusts, or fibers unless properly marked as suitable for the condition.

WARNING: Hazard of electrical shock. Lock out and tag the branch circuit disconnect switch before working on the Control Panel.

2.1 - Control Panel

2.1.1 - Storage and Handling

Care must be taken to avoid damage to the Control Panel and system components during storage and handling.

Protect the Control Panel from weather damage during storage. It is recommended to store the Control Panel in a cool, dry area when possible. Ensure all openings are tightly sealed if stored outdoors.

2.1.2 - Site Selection

Review the expected installation temperatures and environmental rating of the Control Panel noted on the nameplate. Do not install a Control Panel in an area inconsistent with its rating

Allow sufficient free space around panel installation site. Working space for panel maintenance should be at least the width of the panel or 30 inches, whichever is greater. Height must be the height of the panel or 78 inches, whichever is greater. The depth in front of the panel shall not be less than 3 feet. In all cases, the working space shall permit at least a 90-degree opening of the equipment doors or hinged panels (per NEC Article 110.26).

2.1.3 - Mounting

Control panels are provided with either wall or floor mounting. Mount the panel with structural quality bolts matching the size of the holes provided in the mounting feet.

Do not weld to Control Panel to avoid damage to electronic components.

2.1.4 - Wiring

The system is furnished with a main disconnect switch and individual circuit fusing. A disconnect switch with fusing can be used in conjunction with either an on-off system (magnetic contactor) or with SCR control. A circuit breaker should not be used with an on-off system due to high inrush, typical of impedance heating systems, which could cause nuisance tripping. The same conditions in combination with a SCR control would not trip a circuit breaker because the “Phase Angle” or “Soft Start” SCR used has a built-in capacity to absorb the inrush, thus preventing a breaker from tripping.

If not provided with the panel, the electrical installation should include a service disconnect switch in sight of the panel, as well as branch circuit over-current protection and over-temperature protection.

The size and type of incoming and interconnecting field wiring will depend upon system current draw and wire insulation rating. The control panel temperature can be assumed to be 130^{o}F max. Field supplied conductors must be sized for at least 125% of the circuit current. All wiring must conform to National Electrical Code or Canadian Electrical Code as required and all local codes of authority.

The control panel is completely wired internally. Refer to the wiring diagram for wiring recommendations. A copy is provided inside the panel. Review the field wiring requirements carefully. Select instrument wiring to properly match the required signal. Shielded wire is recommended for low voltage and temperature sensor signals, to minimize 60Hz noise. Shields must be grounded at one end only to prevent a ground loop.

When temperature sensors are used, check the wiring diagram for the correct wire type. Be careful to note thermocouple connections, unlike RTDs, are polarity sensitive and “Red” wire is negative. Failure to connect properly may result in an uncontrolled heater.

Wiring to the panel should be permanently installed in metallic or non-metallic electrical grade conduit in accordance with all applicable electrical codes, and should include a grounding conductor if non-metallic conduit is used.

Field supply wiring must be rated for 600Vac. Use copper conductors.

WARNING: Retighten all electrical connections that may have loosened during shipment. Failure to do so may result in damage to the Control Panel or risk of fire. The most critical are the power circuit conductors.

Confirm all unused conduit holes in the panel are sealed with plugs suitable for the environment.

Attach a ground conductor to the mounting lug provided, or by other appropriate means, per NEC or CEC along with all local codes and standards as applicable.

The impedance heating system shall be connected to ground as indicated on the wiring diagram, either at the isolation transformer secondary terminals or at the end flange of the workpiece, but not at both places. The ground connection should also be independent of the secondary conductor connection,

Be sure the panel doors are properly closed and sealed to ensure personnel protection. Also, contaminants can create leakage, (shock) hazards, permanent damage, or failure to the Control Panel and should be avoided.

If performing a dielectric test to confirm wiring insulation, test the power circuit at no more than two times the rated voltage plus 1000 volts after isolating the control transformer. If the control circuit is tested, pull out the process controller, remove secondary ground(s), and disconnect any High Limit Controllers. Test control circuit at 1200V max.

2.2 - Impedance System Components

CAUTION: When performing Dielectric or Meg Ohm tests, remove transformer primary fusing to isolate control circuit electronic equipment. Failure to do so may result in damage to the control components.

2.2.1 - Transformer

It is important that the temperature in the area where the transformer is mounted does not exceed 104°F (unless marked otherwise on the transformer) and that the air circulation is not impeded. The transformer should be reliably secured to the mounting surface. Depending on application, the transformer enclosure may be environmentally rated Type 3R or 4X.

CAUTION – When working on the transformer, disconnect power and follow all lockout procedures.

Also, take note of transformer nameplate ampacity and which should be confirmed that secondary current draw is not exceeded.

IMPORTANT - Ground connections depend on system type. End Feed Systems should be earth grounded at the X2 transformer leg, transformer electrostatic shield, transformer case, and control panel equipment ground. Similarly, Center Feed Systems should be earth grounded at the transformer electrostatic shield, transformer case, and control panel equipment ground, but NOT at the X2 transformer leg. Instead Center Feed Systems are to be earth grounded at the ends of the heated pipe.

The wire in the heating circuit is connected to the transformer and to each of the weld clips. Care should be taken to insure the connectors are clean and free from foreign material before the connections are made. Apply electrical antioxidant compound to all wire ends and secondary wire lugs connecting to weld clips.

Primary leads must be connected according to the wiring schematic found inside the control panel. If the transformer has multiple primary taps, the primary jumper should result in the lowest secondary voltage output. Final primary tap selection is made during the initial Startup.

Additional information for the installation and maintenance of dry transformers can be found in the American National Standards Institute publication C57-94

The correct location of the transformer relative to the system's pipe length is as follows:

End Feed Systems
When a single circuit hookup is used, the transformer can be located anywhere along the pipeline, but within the specified distance away from the pipe.

Center Feed Systems
When a center feed hookup is used, the transformer must be located at the electrical midpoint of the length of pipe to be heated and within the specified distance away from the pipe.

Typical transformer wiring connections are shown in Appendices A and B. Specific wiring details are found in the Control Panel and System Wiring Diagram (supplied with and located in system control panel)

INSTALLATION

When a ground fault device is required, component arrangement depends on system type:

End Feed Systems

- Monitoring Relay located in the control panel.
- Current transformer located in the transformer enclosure.
- Ground Fault Test Point located along the heated pipeline.

Center Feed Systems

- Monitoring Relays located in the control panel.
- Current transformers located at each end of the heated pipeline.
- Ground Fault Test Point located along the heated pipeline.

Ground fault devices by design are tripped by detection through a current transformer typically located inside the transformer and wired to the control panel. Refer to the wiring diagram in the control panel for verification of terminations and type of wire to use.

The Ground Fault Test Point must be mounted to the pipeline (Appendix C) at the location indicated on the Piping Layout drawing. The Ground Fault Test Point is connected to the Control Panel using 14/2 SO cable. For terminations inside the control panel refer to the wiring diagram.

<u>2.2.2 - Piping and IPJs</u>

Piping should be of continuous weld construction, fabricated according to applicable piping standards. Flanges should be used at branch connections and at heated section separations with IPJs installed between as required.

Impedance heating produces the same even heat throughout the pipe, which will carry a low voltage current isolated from electrical grounds. To achieve this, each heating circuit must be the same electrically from end to end. At points where the heated line is connected to a tee, vessel or other line, either heated by another method or not requiring heat, the pipe must be electrically isolated using IPJs, available from the manufacturer. These should be located as close as possible to the tees or equipment to prevent any section of piping from being unheated. Pipe supports and hangers must also be electrically isolated from the impedance heated pipelines (Appendix D). Care must be taken at support points to ensure that not only pipe expansion but also bolt looseness at the isolator flanges may not be the cause of accidental circuit grounding.

Recommendations concerning threaded joints include:

- Apply graphite paste or equivalent to threaded pipe joints. Do not use Teflon based or non-electrically conductive pipe joint compound.
- Current passes through flange joint fasteners at the IPJs. Apply electrical antioxidant compound or equivalent to all fastener threads to ensure good electrical conductivity. Also use star washers underneath all nuts connecting with the flange.
- For proper assembly and tightening of IPJs see Appendix E.
- Do not use IPJs as unions because disassembly may damage electrical insulation.

IMPORTANT – When welding a slip-on or weld neck flange to the pipeline for an insulated pipe joint, remove all IPJ components (gasket, bushings, washers, etc.) to avoid damage during the welding process.

Non-isolated valve handles and all other exposed metal parts on the pipeline that are or could be electrically energized should be electrically insulated with glass tape and waterproofed.

Any air lines such as for pneumatic valve actuators must be electrically non-conductive.

For lower temperature applications, transparent shield designs over the IPJ flanges are also available. In addition to helping reduce the risk of accidental shock, the covers eliminate the need to insulate the IPJs, thereby making it easier to verify the IPJ is isolating properly.

<u>2.2.3 - Weld Clips</u>

Clips should be welded to the piping to provide the best possible electrical connection between the pipe and the clip. Welds are to be full circumferential. Just be aware of clearances needed for weld clip guard installations where applicable (see Appendix F2). Remember that the location of the weld clips defines the electrical circuit and clips should be located on flanges where available to provide the greatest length of heated pipe. High temperature applications may require the use of perforated clips in order to dissipate the heat before the wire connections are made. The weld clips must have unobstructed air circulation to allow cooling.

Center Feed Systems require determination of where the electrical resistive center of the pipe is located. This can be accomplished by temporarily routing the X2 power wires to the ends of the pipe. Pipe temperature must not be elevated; attach the wires using nonconductive straps or clamps. Place weld clips by temporary means at the estimated center, apply lowest tap voltage available using the X1 power wire. Check current in both X2 wires. When variance is 5% or less, that should be the center tap. Permanently weld the clips.

<u>2.2.4 - Wire</u>

Reference the wiring diagram for the proper hookup wire size. The wire is to be run in free air and strapped externally to the thermal insulation jacket, equally spaced around the circumference of the pipe and held in place every 6 to 9 feet, using aluminum or similar strap of non-ferrous material. The wire is not to be run in conduit, unless specified by the System Designer.

2.2.5 - Wire Lugs

Wherever possible, wire connections should be of the permanent type. Compression type wire lugs are recommended. See Appendix F1 through F3 for typical designs.

Wire lugs must be installed with a minimum Grade 5 hex head bolt, lock washer, and nut. Tighten to the following torque specification:

- 27 ft-lbs for 3/8”-16 bolts
- 55 ft-lbs for 1/2"-13 bolts

If supplied, wire lug set screws must be tightened to the following torque specification:

- 25 ft-lbs for wire sizes 8 to 3/0
- 50 ft-lbs for wire sizes 4/0 to 500 MCM

Wire connections shall be marked with identification tags supplied by the factory within 1 foot of the pipe connection points.

Also note when operating temperatures are at or below 140 °F, there is an option available for a self-vulcanizing tape that can be wrapped around the wire lugs and weld clips. The tape helps reduce the risk of accidental shock and eliminate possible spark.

2.2.6 - Thermal Insulation

Optimal performance of an impedance heating system requires consideration of two key features of thermal insulation design: (1) properly sized insulation material such as fiberglass, mineral fiber or comparable electrically nonconductive material affixed to the pipeline, and (2) an aluminum outer jacket (or other non-ferrous material) to protect the insulation. Note fixtures such as valves and flange joints along the pipeline are heatsinks. At such locations either add extra insulation to compensate for the higher heat loss, or consider jumpering the current flow.

For outdoor installations, it is very important that the insulation be properly installed so as to create a weather barrier and help establish a reliable heating system. The aluminum jacket is to be trimmed back approximately 1/2" to prevent jacket from being electrically energized. The void created by trimming the jacket back is to be sealed with a caulk that is not electrically conductive. At areas where insulation can be damaged, the insulation should be protected. Should the insulation become wet, broken or crushed, it should be repaired with materials like those used on the original installation. Wire or straps used to band insulation or the power wires around the pipe shall be aluminum or other non-ferrous material. Keep in mind the need to avoid ferrous materials such as steel because they would induce a current through the jacket due to the magnetic field present.

2.2.7 - Temperature Sensors

Sensors should be securely affixed to the pipe using thermowells or weld pads as shown in Appendices G1 and G2. For best results installation recommendations include:

- Sensors should be located a minimum of ten feet from any terminal plates, flanges, tees or any other item which may act as a heat sink and alter the temperature reading. On center feed systems, one sensor should be installed on each side of the midpoint terminal plate connection a minimum of ten feet from the terminal plate.
- Wells should be skip welded to the pipe so as not to warp the tubing;
- Upon completion of assembly, insulate the well with the same insulation type and thickness as the main pipeline.

When using thermocouples, it is recommended that minimum 16 AWG shielded and grounded thermocouple extension wire be used. It is essential that the correct type of thermocouple extension wire be used.

When using RTD’s, connections to the control panel should be done using Belden 8772 or equivalent wire (20 AWG, 3-conductor, shielded). One other recommendation when installing RTDs is to apply thermal grease to the probe tip when inserting into the well to help with better temperature sensing.

2.2.8 – Marking Requirements

The weather jacket of the impedance heating system shall be clearly marked with warning labels, “Warning: electrically heated and energized pipe under the thermal insulation”. These labels are to be spaced at intervals not to exceed 20 feet.

When the impedance heating system is designed for greater than 30 volts ac additional wording is included, “WARNING: Energized equipment up to 80 volts ac” shall be placed near any intermediate guarded pipe junction points or related guarding, where equipped.

Additional warning labels are available from the factory as needed per application.

3 – OPERATION

3.1 - Cautions and Setup

CAUTION: Equipment should be operated by qualified personnel only to prevent equipment damage or failure.

Carefully review all instructions and become familiar with the equipment, safety interlocks, and process temperature controller provided before energizing the equipment.

DO NOT operate system at voltages in excess of that marked on the panel nameplate. Excess voltage can overload the power circuit components and wiring.

Temperature regulating devices and temperature limiting controls are recommended to control the heating process and safeguard the system from excessive temperatures that can cause damage. Also, damage to fluid could occur if the pipe is allowed to exceed the maximum film temperature recommended by the manufacturer.

Ensure power ahead of the panel is off and perform the following steps:

1. Exercise all switches, circuit breakers and operating mechanisms to confirm they operate freely.
2. Conduct an insulation resistance test to ensure the system is free from short circuits or grounds.

Manufacturer recommendation is that all safety interlocks be tested during initial startup to ensure they properly disable the system.

For solid state non-indicating controllers, it is recommended to dial the high limit controller setpoint down below the normal operating temperature either during initial startup operation or with only the control circuit on, and verify that the contactor opens, disconnecting power to the transformer. Return the controller to the desired setpoint.

3.2 - System Checkout

Check the primary voltage and compare with transformer design voltage.

Walk along the pipeline and look for obvious mechanical grounds on the piping, pipe supports and possible contact between the aluminum cover of the pipe insulation and protruding pipe supports, temperature sensors, etc. Pipe insulation jacket seams should be down.

Check all temperature sensors for good contact between sensor and pipe surface (surface should be clean). It is essential to verify that the sensors have been connected per wiring diagram and especially where polarity and wire color is of concern.

Make certain that all IPJs are installed properly, all bolts to be in the same direction.

Check connections between terminal plates/angles and piping; the cross-sectional area of the welds should be at least equal to the cross-sectional area of the plate or angle.

Check all electrical connections for tightness.

Check for wet insulation. If there is wetness, some of the aluminum covering should be removed in order for the moisture to escape during heat up.

If a center feed connection is used, measure to verify the midpoint location is correct. When energized, the current readings to each end of the pipe should be within 5% of each other. **Uneven heating will occur, on either side of the connection, if the connection is not made at the actual electrical midpoint.**

Make certain that the return wire runs in free air, and is strapped externally to the thermal insulation, equally spaced around the circumference of the pipe.

Check to see that primary connections are made to the lowest voltage tap on the transformer.

Check panel fusing. Fuses should be of the same class, voltage and amperage noted on the wiring diagram.

Verify that all exposed metal parts on pipeline, such as valve handles and wire connections, that are energized are properly electrically insulated.

See Appendix for Startup Checklist.

3.3 - Initial Operation

Review the setup of the process controller. Manufacturer configures the controller inputs and outputs unless the user specifies a special controller.

Turn the Control Circuit Switch to the OFF position.
Turn on power ahead of the panel and close panel main disconnect switch.

Connect primary lines from the control panel to the power transformer at the lowest voltage tap.

Turn the Control Circuit Switch to the ON position.

Inspect for alarm pilot lights. Push any red illuminated reset pilot lights to attempt resetting. All alarm lights should be reset.

Gradually increase the control setpoint and observe the system for proper operation.

Check the total secondary current. If the current reading is below the system design, change the tap selection at the transformer primary progressively upward until the proper current is reached.

Check the operation of all controlling instruments.

After the design temperature of the pipe has been reached, check the secondary current again and compare with the design current at that temperature.

Check again for grounds, which are possibly caused because of expansion of the piping.

Retighten all electrical connections and tighten again after a 24-hour period.

If applicable, adjust high limit temperature controllers by setting as close to the operating conditions as possible without nuisance tripping.

3.4 - Shut Down

The heating system may be shut down by reducing the process setpoint to ambient. It is recommended to continue circulating the process fluid until temperatures are reduced to a safe temperature.

Turn the control circuit switch to OFF. Turn off main power disconnect switch.

3.5 - Normal Operation

Turn on disconnect switch.

Adjust process controller to the desired setpoint.

Turn control circuit switch to ON.

Note: Be sure to use the Standby mode if the above steps cannot be accomplished quickly.

For systems with a high limit controller: If the process temperature exceeds the high limit temperature controller setpoint, the power controller will deenergize and shut off power to the transformer. The OVERTEMP pilot light will energize.

In case fuses are blown, the first thing to check, is the piping. The areas where the piping could be grounded are usually at hanger and support points. Your preventive maintenance should include a periodic check of these points.

After any alarm condition, the system should be investigated and the problem remedied. Do not operate the equipment with safety devices disabled or serious damage to the system may result.

3.6 - Documentation

Upon confirming that the impedance heating system is fully operational, an authorized employee should also be responsible for periodically checking system operation, documenting it, signing and dating such information. The “Preventive Maintenance Record” located in the Appendix may be used for such purpose.

Note data recorded should be taken when the system is operating at 100% output from the process

This checklist should be retained for future reference when conducting Preventive Maintenance.

4 - MAINTENANCE

CAUTION: Troubleshooting and repairs should only be attempted by qualified maintenance personnel.

Impedance Heating Systems are essentially permanent fixtures. They are designed to provide effective heating of the pipe for as long as the pipe and/or process is installed. However, like any equipment, preventative maintenance is required.

Maintenance should be performed on an annual basis. This includes the equipment mounted to the pipe (terminal plates, secondary wires, etc.) as well as the transformer and control equipment.

4.1 - Transformers and Pipeline Assembly

The transformer and pipeline assembly require periodic checks to ensure that all mechanical and electrical connections are tight and free of corrosion.

Take a voltage reading between the terminal plate and the copper conductor. Voltage drop should be less than .125 volt for each wire in parallel. Loose or corroded connectors create high resistance connections, system imbalances and possible system failures. If voltage drop is too high, replace compression lug.

Visually inspect the secondary wire insulation at the pipe connection. Excessive heat from the terminal plate, pipe or vessel will cause cracking and degradation of the wire insulation. Damaged wire should be replaced. Determine the cause of the excessive heat and rectify the problem by cleaning or replacing wire compression lugs, installing high temperature terminal plates, installing additional piping insulation or whatever is required to decrease the amount of heat at the wire connection.

Replace or thoroughly dry and clean any insulation that is damp or wet or shows an accumulation of deposited material from previous moisture. The performance of the heating system is dependent on the integrity of the thermal insulation system.

Visually inspect the entire piping system. Look for new equipment mounted to the pipe. Ensure pipe supports are properly installed and centered over the beams. Remove any external equipment that could cause grounding.

Finalize inspection of the transformers and pipeline by verifying present data in the System Operation Checklist documented previously. As a reminder, the readings should be taken when the system is operating at 100% output from the process controller. Such information may be useful in evaluating overall system performance over time.

4.2 - Control Panel

WARNING: Hazard of electrical shock. Lock out and tag the branch circuit disconnect switch before working on the Control Panel.

Periodically check all electrical connections, including field and factory-made connections, for tightness, and all wiring for deterioration at least once a year or after any electrical fault. Inspect for signs of overheating, corrosion, or pitting of electrical joints. Dress up and clean all contact surfaces.

Mechanical wire connections should be checked periodically to see that they have not vibrated loose. Since impedance heating uses low voltage in the heating circuit, a poor connection can be detrimental. The easiest check is to measure the temperature of the connection. If it is excessive, these connections should be taken apart and the mating surfaces cleaned and reassembled

Exercise all switches, circuit breakers and operating mechanisms to confirm they operate freely, making sure that they quickly and securely throw the contacts fully open and fully closed. Wherever possible, check all devices for missing or broken parts, proper spring tension, free movement, rusting or corrosion, dirt, and excessive wear. Adjust, clean, lubricate and/or replace parts as required.

Inspect the enclosure and conduit connections for evidence of water leaks or moisture collection. Tighten connections as required. Do not continue using a panel with signs of damage.

Clean any appreciable accumulation of dust and dirt. Attempt to seal source of dust entry.

Check fuses to make sure they are consistent with the wiring diagram, having the proper ampere rating and interrupting rating. Make sure that non-current-limiting fuses are never used as replacements for current-limiting fuses. Never attempt to defeat rejection mechanisms that are provided to prevent the installation of the wrong type of fuses.

Check insulation resistance:

- If a severe electrical fault has occurred.
- If it has been necessary to replace parts or clean insulating surfaces.

Replacement parts must be of equal or higher ratings. Contact the factory for recommended spare parts.

5 - TROUBLE SHOOTING

CAUTION: Troubleshooting and repairs should only be attempted by qualified maintenance personnel.

Your Impedance Heating System has been designed as a simple series or parallel circuit. When the system is initially installed and operating, there should be little or no downtime due to malfunction.

PROBLEM	CAUSE	SOLUTION
° Process temperature is below setpoint.	° Proper heat up time has not been allowed.	° Verify heat up/recovery time for system.
	° Additional piping has been added to the system.	° Isolate all additional piping using IPJs as required.
	° Temperature controller is not set to proper temperature.	° Verify setpoint. Check controller output LED to verify status.
	° High limit controller has tripped.	° Allow system to cool and reset high limit.
	° Low line voltage.	° Confirm supply power is no more than 3% low.
	° Insufficient insulation.	° Insulate exposed piping to reduce losses.
° Panel will not energize.	° No power to panel.	° Supply power.
	° Disconnect switch is not turned on.	° Turn disconnect switch to the ON position.
	° Control circuit fusing is blown.	° Check and replace fusing if necessary.
	° Remote interlock is open.	° Close remote interlock.
	° Component failure.	° Check and replace component if required.
° System does not energize	° High limit controller has tripped.	° Allow system to cool and reset high limit.
	° Ground Fault Device has tripped.	° Check pipeline for ground condition and repair accordingly.
	° Interconnecting wire between panel and impedance transformer is broken or connection is loose.	° Check wire continuity and repair if necessary.
	° Power fusing is blown.	° Check and replace fusing if necessary. ° Confirm supply voltage is no more than 7% high.
	° Component failure.	° Check and replace component if necessary.
° Pilot light not operating when system is operating correctly.	° Bulb burnt out.	° Replace bulb.
° Nuisance over-temperature tripping.	° High limit setpoint temperature too low.	° Consult this manual for the proper setpoint.

GENERAL TROUBLESHOOTING GUIDE

IF PROBLEM PERSISTS, PLEASE CONSULT FACTORY.

425 Hanley Industrial Court
St. Louis, MO 63144
www.bannerdaypipeheating.com

6 - APPENDIX

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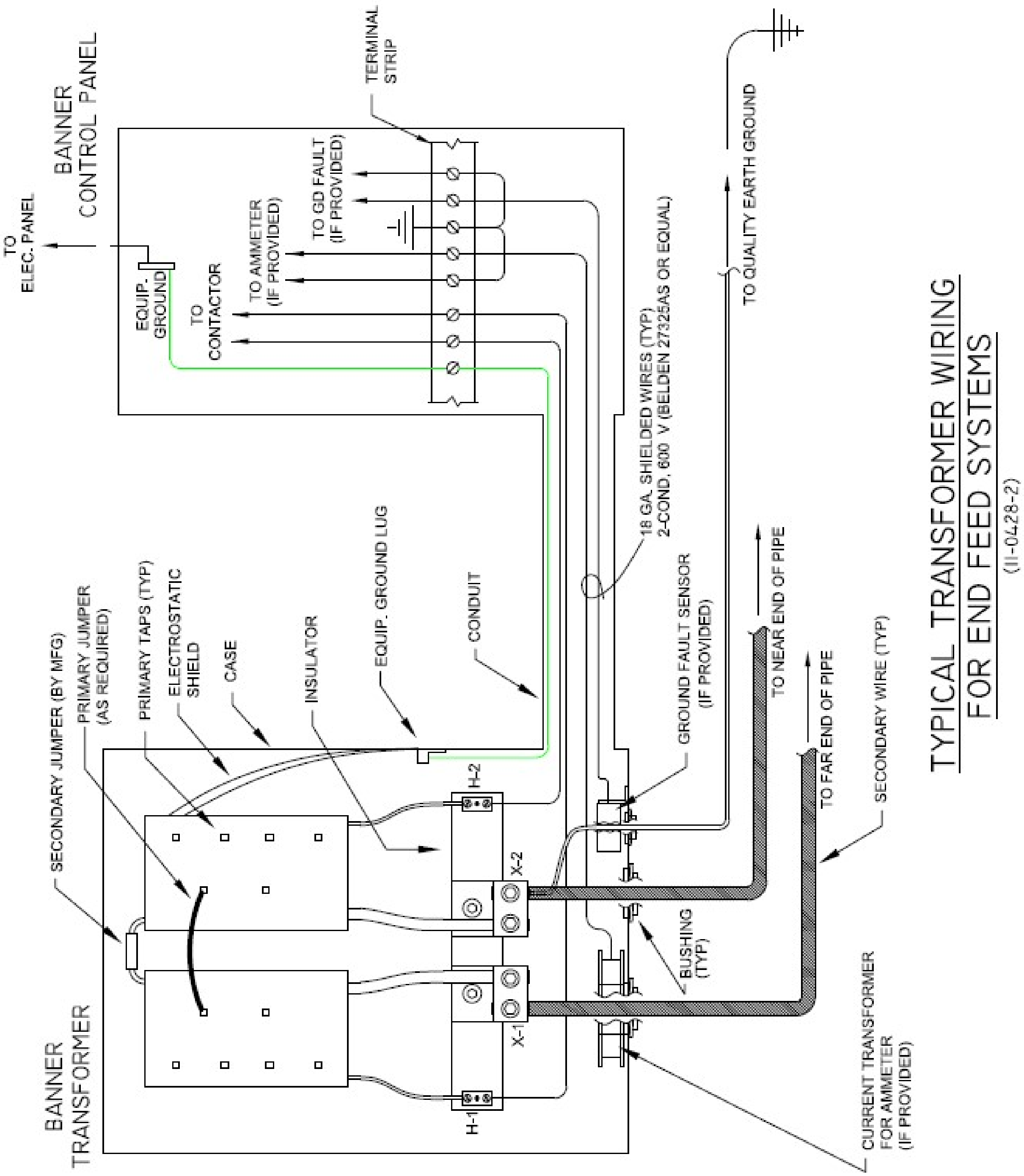
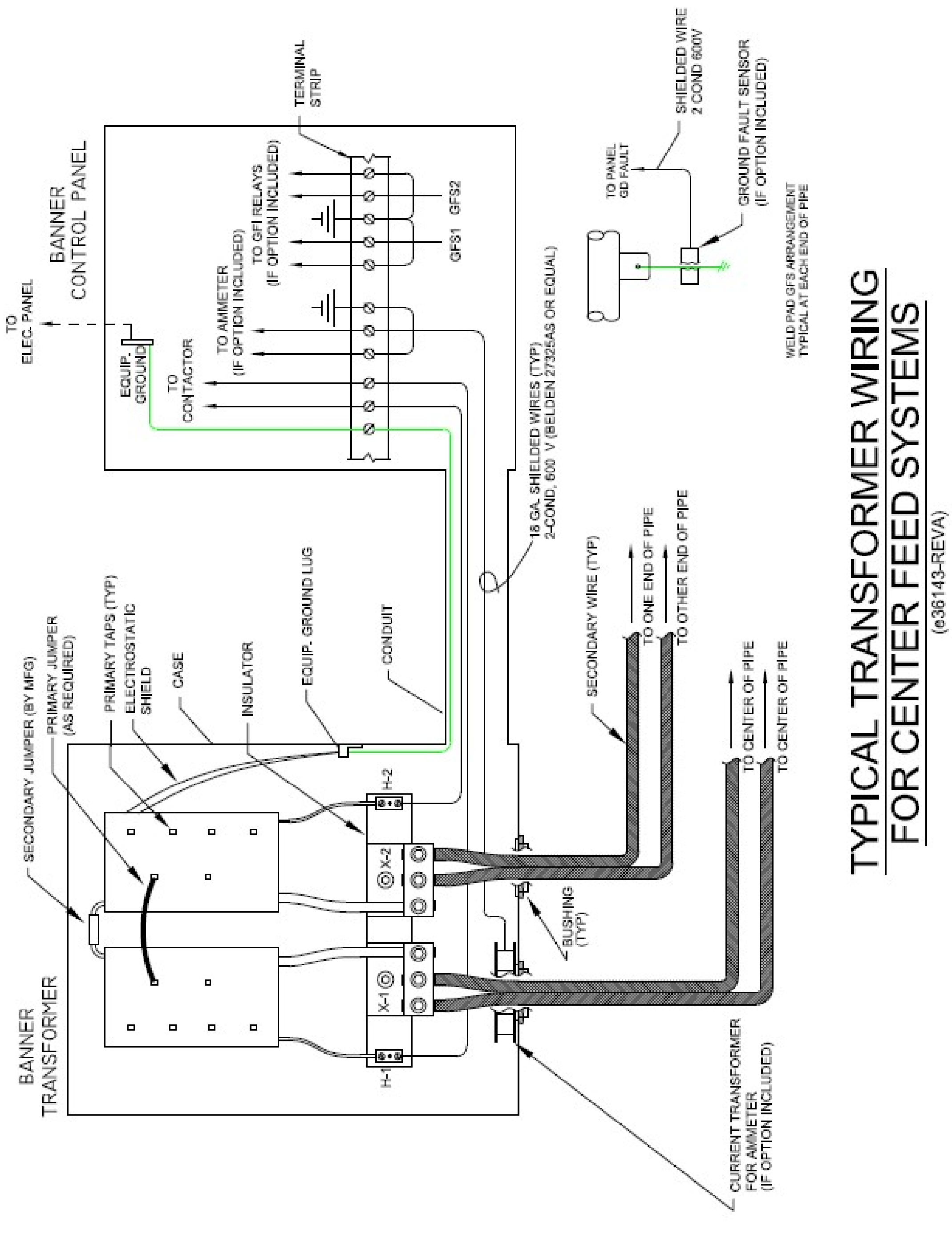
Appendix A

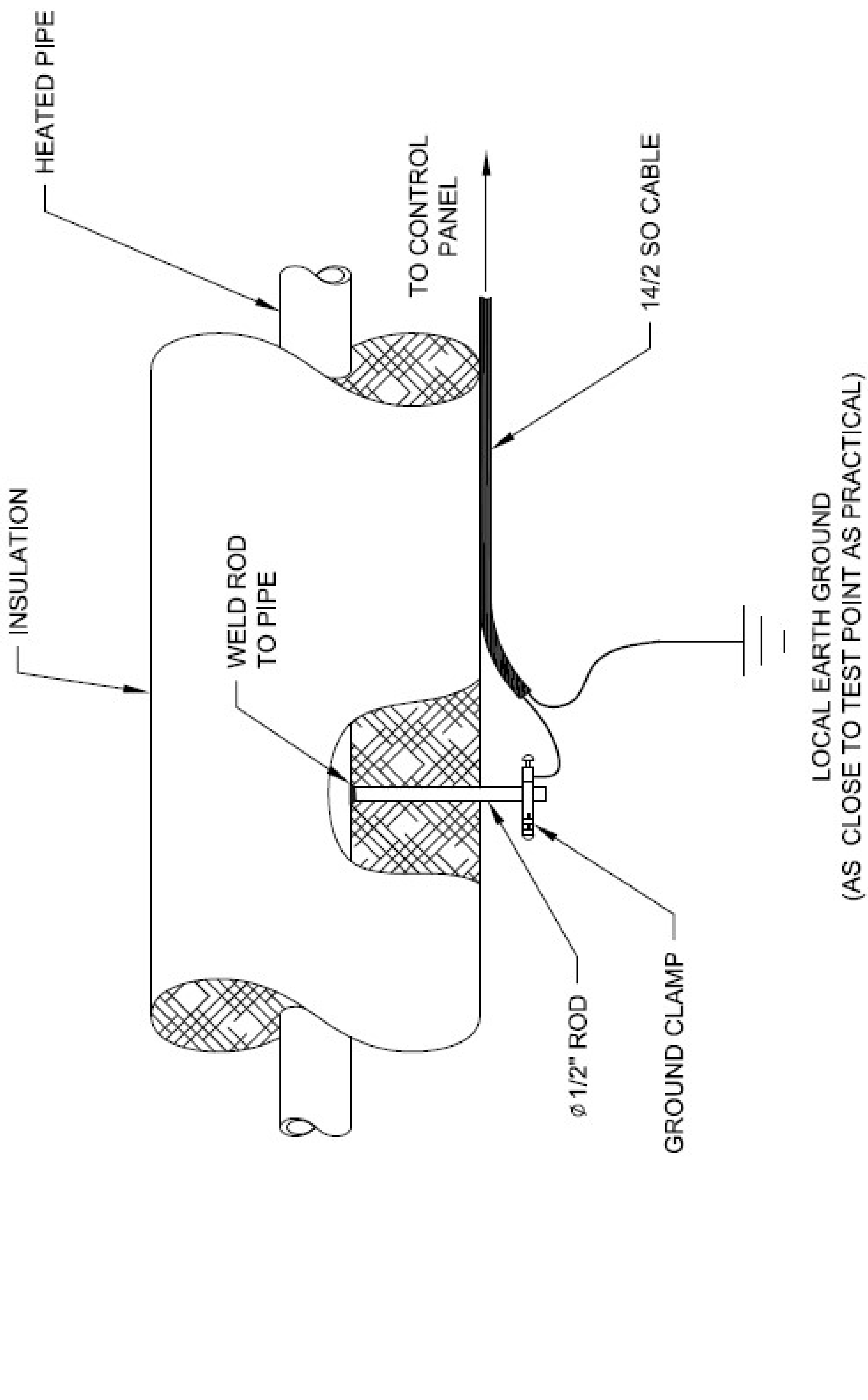


TO ELEC. PANEL
BANNER CONTROL PANEL
TERMINAL STRIP
EQUIP. GROUND
TO CONTACTOR
TO AMMETER (IF PROVIDED)
TO GD FAULT (IF PROVIDED)
TO QUALITY EARTH GROUND
18 GA. SHIELDED WIRES (TYP) 2-COND. 600 V (BELDEN 27325AS OR EQUAL)
SECONDARY JUMPER (BY MFG)
PRIMARY JUMPER (AS REQUIRED)
PRIMARY TAPS (TYP)
ELECTROSTATIC SHIELD
CASE
INSULATOR
EQUIP. GROUND LUG
CONDUIT
GROUND FAULT SENSOR (IF PROVIDED)
TO NEAR END OF PIPE
TO FAR END OF PIPE
SECONDARY WIRE (TYP)
BUSHING (TYP)
CURRENT TRANSFORMER FOR AMMETER (IF PROVIDED)
BANNER TRANSFORMER
H-1
H-2
X-1
X-2
TYPICAL TRANSFORMER WIRING FOR END FEED SYSTEMS
(II-0428-2)

Appendix B


TYPICAL TRANSFORMER WIRING
FOR CENTER FEED SYSTEMS
(e36143-REVA)
BANNER CONTROL PANEL
TO ELEC. PANEL
EQUIP. GROUND
TO CONTACTOR
TO AMMETER (IF OPTION INCLUDED)
TO GFI RELAYS (IF OPTION INCLUDED)
TERMINAL STRIP
GFS1
GFS2
18 GA. SHIELDED WIRES (TYP) 2-COND, 600 V (BELDEN 27325AS OR EQUAL)
TO PANEL GD FAULT
SHIELDED WIRE 2 COND 600V
GROUND FAULT SENSOR (IF OPTION INCLUDED)
WELD PAD GFS ARRANGEMENT TYPICAL AT EACH END OF PIPE
BANNER TRANSFORMER
SECONDARY JUMPER (BY MFG)
PRIMARY JUMPER (AS REQUIRED)
PRIMARY TAPS (TYP)
ELECTROSTATIC SHIELD
CASE
INSULATOR
EQUIP. GROUND LUG
CONDUIT
SECONDARY WIRE (TYP)
TO ONE END OF PIPE
TO OTHER END OF PIPE
TO CENTER OF PIPE
TO CENTER OF PIPE
H-1
H-2
X-1
X-2
BUSHING (TYP)
CURRENT TRANSFORMER FOR AMMETER (IF OPTION INCLUDED)

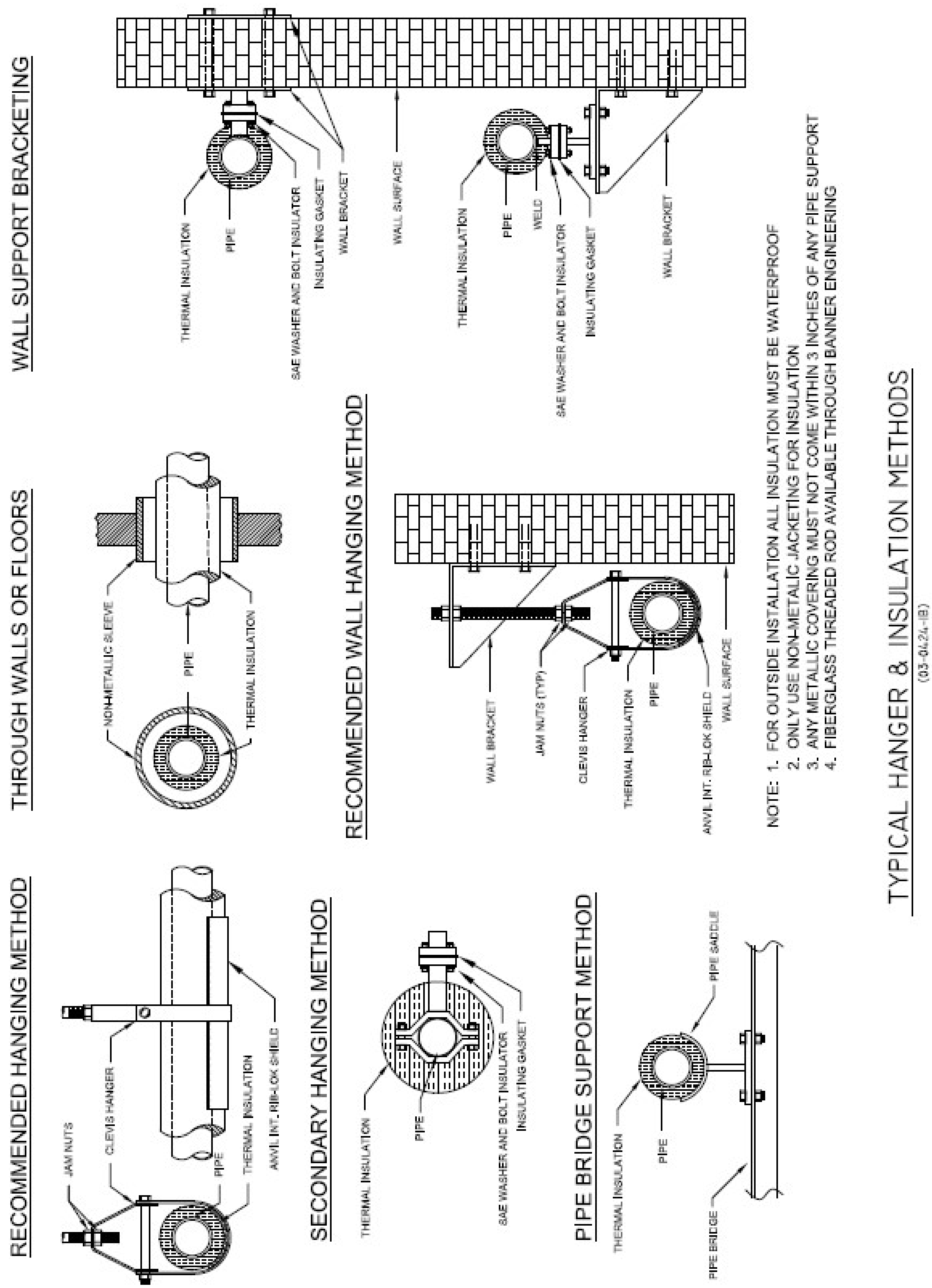
Appendix C



PIPE MOUNTED GROUND FAULT TEST POINT

(94-0811-3A)

Appendix D



WALL SUPPORT BRACKETING
THERMAL INSULATION
PIPE
SAE WASHER AND BOLT INSULATOR
INSULATING GASKET
WALL BRACKET
WALL SURFACE
THERMAL INSULATION
PIPE
WELD
SAE WASHER AND BOLT INSULATOR
INSULATING GASKET
WALL BRACKET
THROUGH WALLS OR FLOORS
NON-METALLIC SLEEVE
PIPE
THERMAL INSULATION
RECOMMENDED WALL HANGING METHOD
WALL BRACKET
JAM NUTS (TYP)
CLEVIS HANGER
THERMAL INSULATION
PIPE
ANVIL INT. RIB-LOK SHIELD
WALL SURFACE
RECOMMENDED HANGING METHOD
JAM NUTS
CLEVIS HANGER
PIPE
THERMAL INSULATION
ANVIL INT. RIB-LOK SHIELD
SECONDARY HANGING METHOD
THERMAL INSULATION
PIPE
SAE WASHER AND BOLT INSULATOR
INSULATING GASKET
PIPE BRIDGE SUPPORT METHOD
THERMAL INSULATION
PIPE
PIPE SADDLE
PIPE BRIDGE
NOTE: 1. FOR OUTSIDE INSTALLATION ALL INSULATION MUST BE WATERPROOF
2. ONLY USE NON-METALIC JACKETING FOR INSULATION
3. ANY METALLIC COVERING MUST NOT COME WITHIN 3 INCHES OF ANY PIPE SUPPORT
4. FIBERGLASS THREADED ROD AVAILABLE THROUGH BANNER ENGINEERING
TYPICAL HANGER & INSULATION METHODS

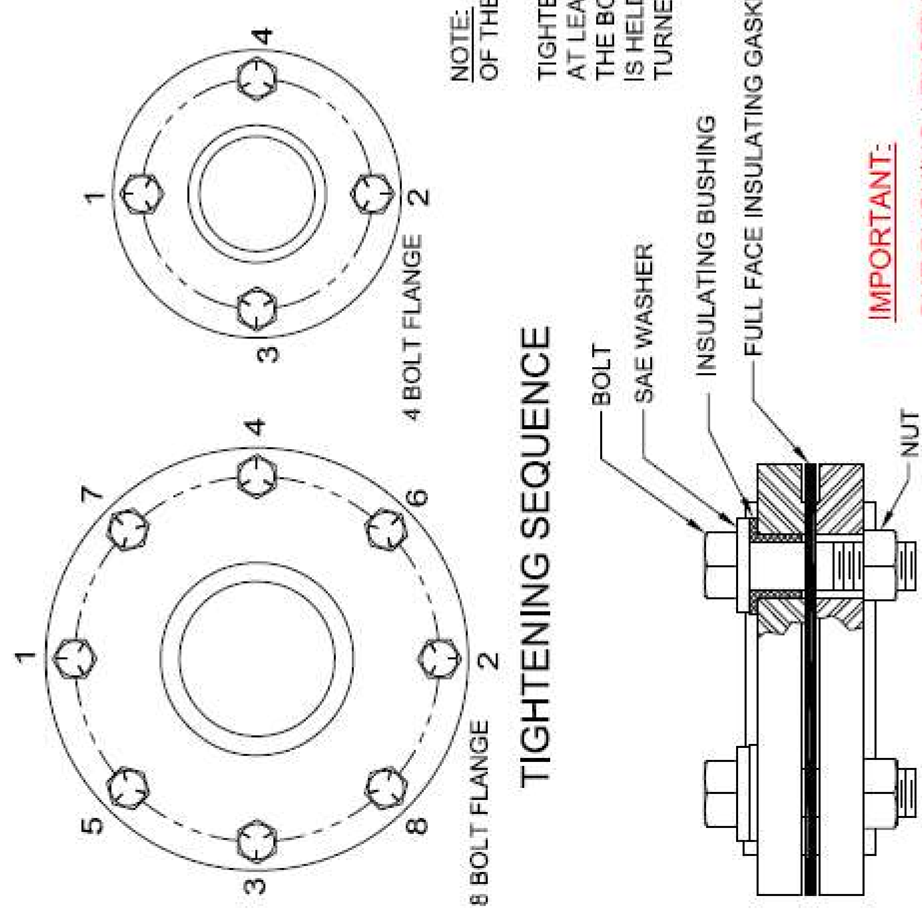
Appendix E

RECOMMENDED BOLT TORQUE VALUES		
Nominal Diameter	Torque Values	Torque Values
(Inches)	Ft. Lbs	Nm
1/2"	30	41
5/8"	45	61
3/4"	60	82

GRADE 5 BOLT IDENTIFICATION

NOTE: DO NOT OMIT ANY PART OF THE INSULATED PIPE JOUNT (IPJ)

TIGHTEN BOLTS EVENLY BY MAKING AT LEAST THREE (3) PASSES AROUND THE BOLT CIRCLE. ENSURE THAT BOLT IS HELD IN PLACE, AND ONLY NUT IS TURNED



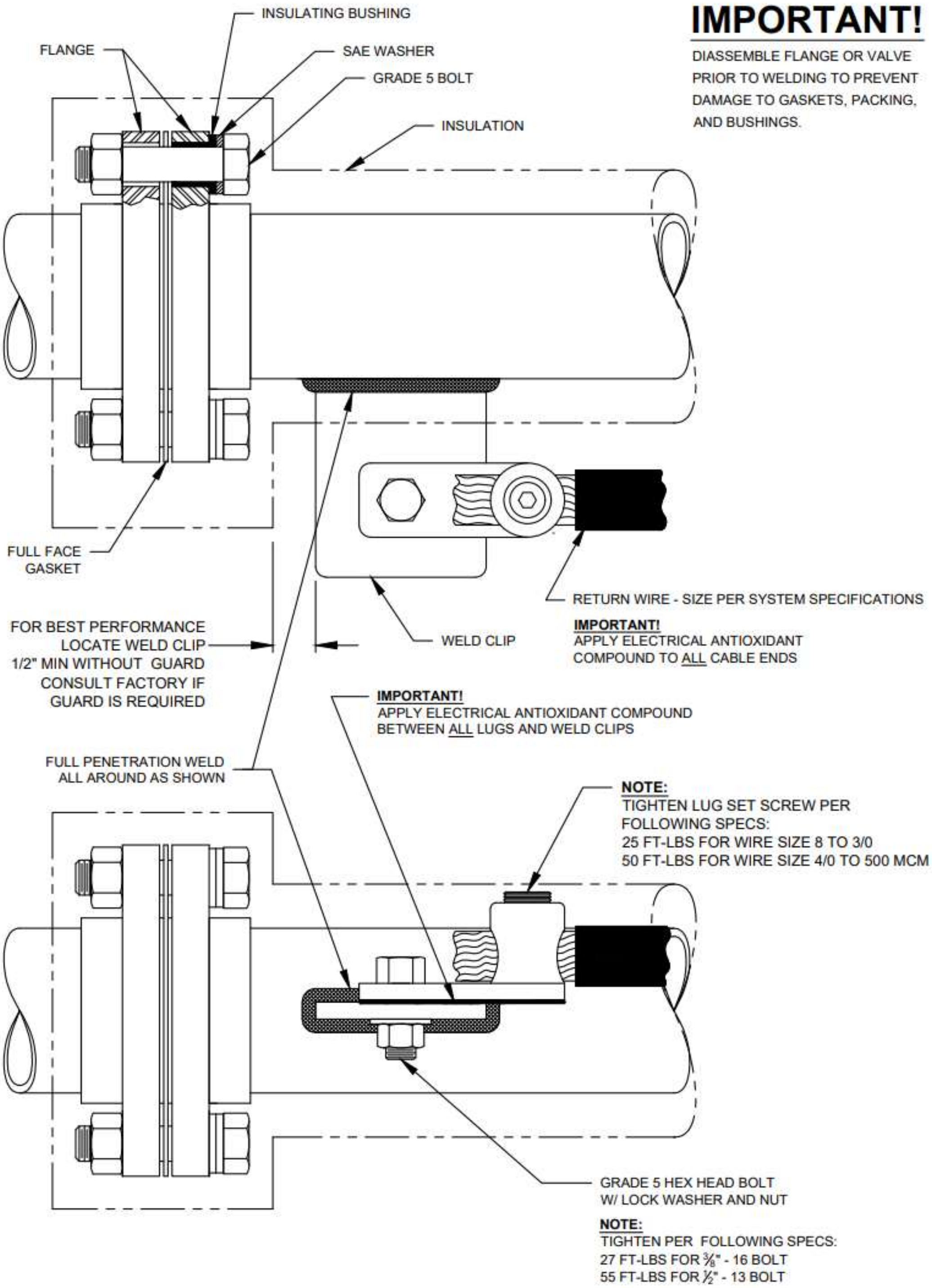
IMPORTANT:

CUT BUSHING LENGTH TO FLANGE THICKNESS.

IPJ ASSEMBLY & TIGHTENING SEQUENCE

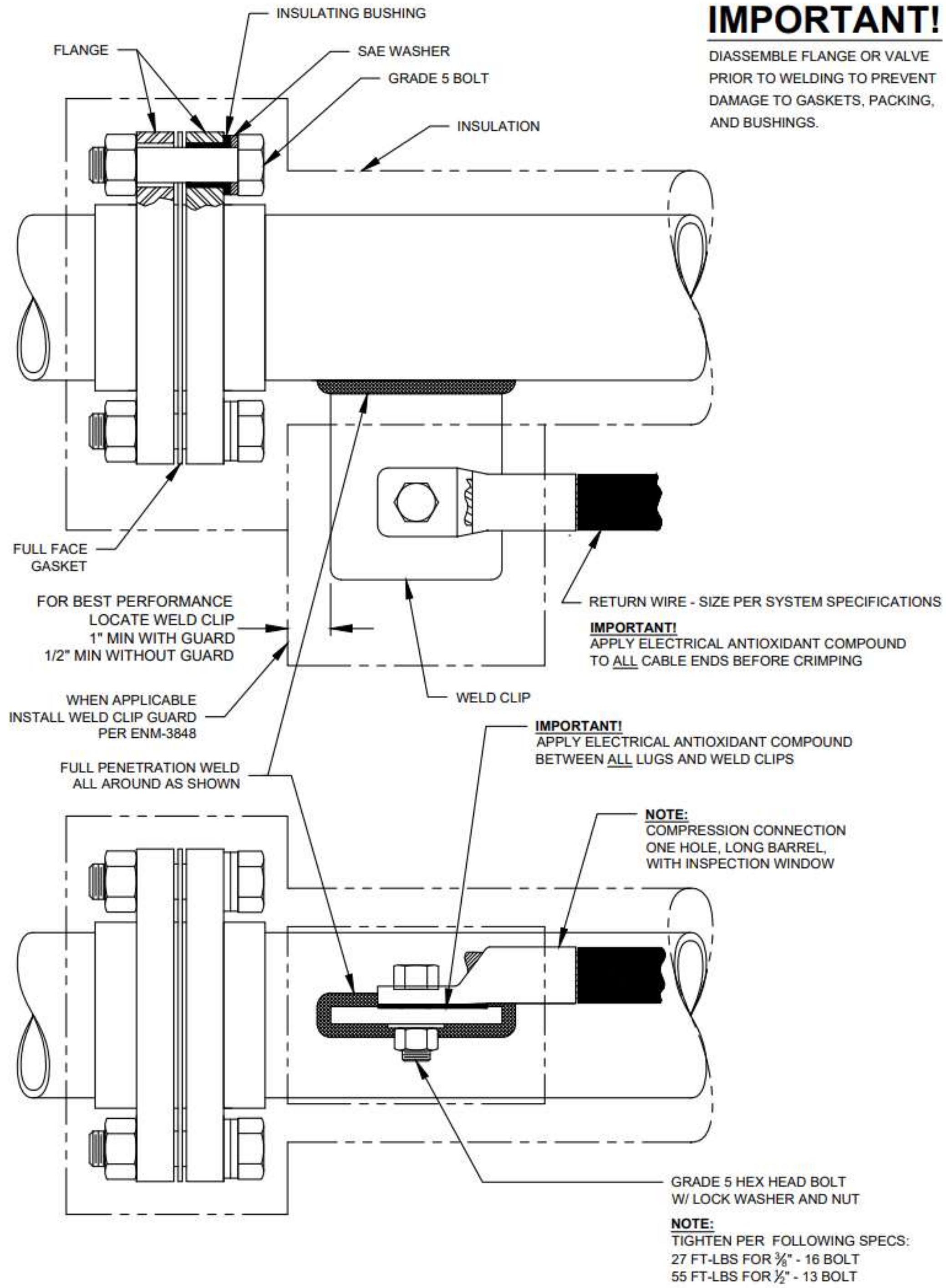
(09-1119-28)

Appendix F1



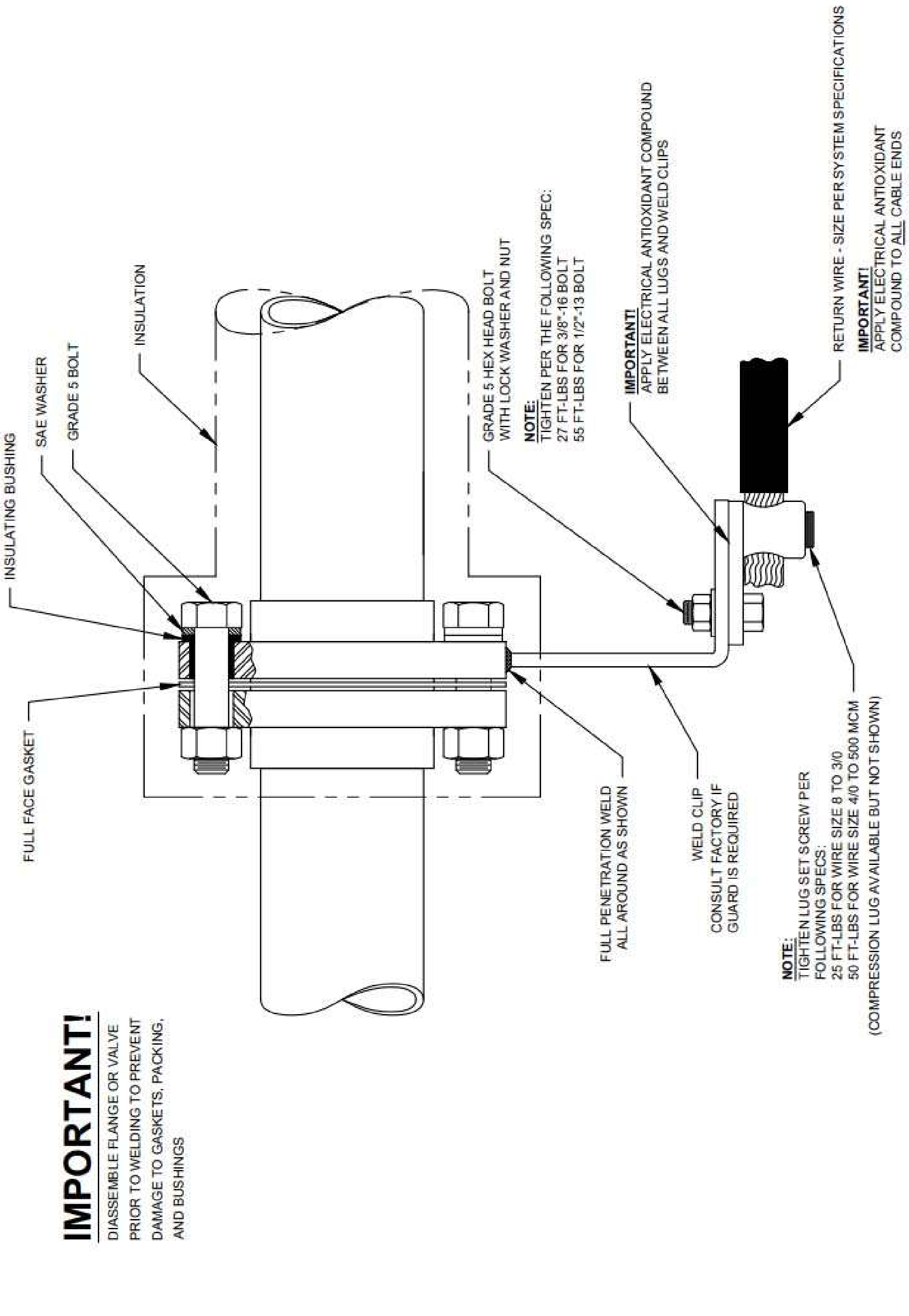
PIPE MOUNTED
TERMINAL LUG INSTALLATION
(REF: 92-0710-IC)

Appendix F2

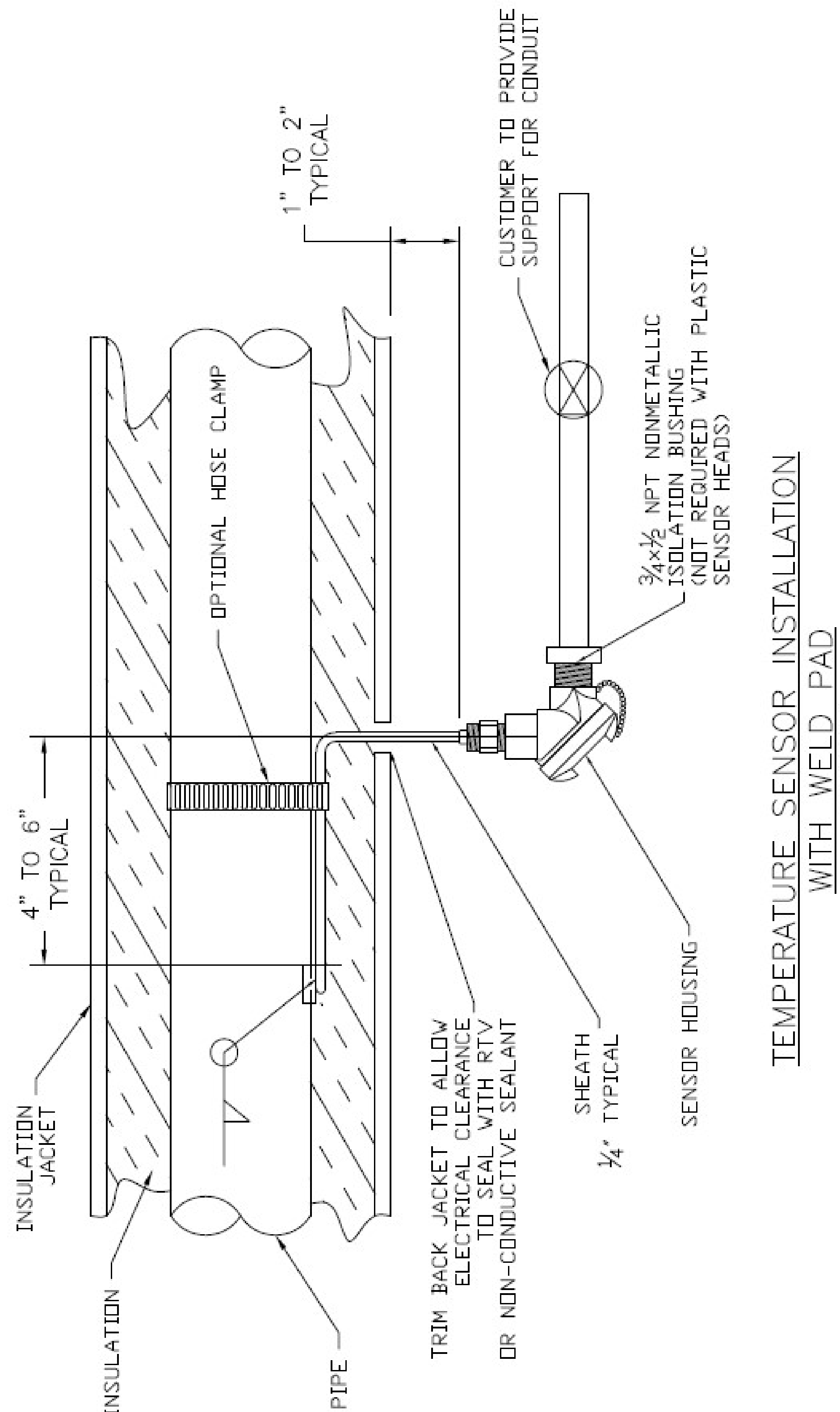


PIPE MOUNTED
COMPRESSION STYLE LUG
(REF: 12-1009-1)

Appendix F3

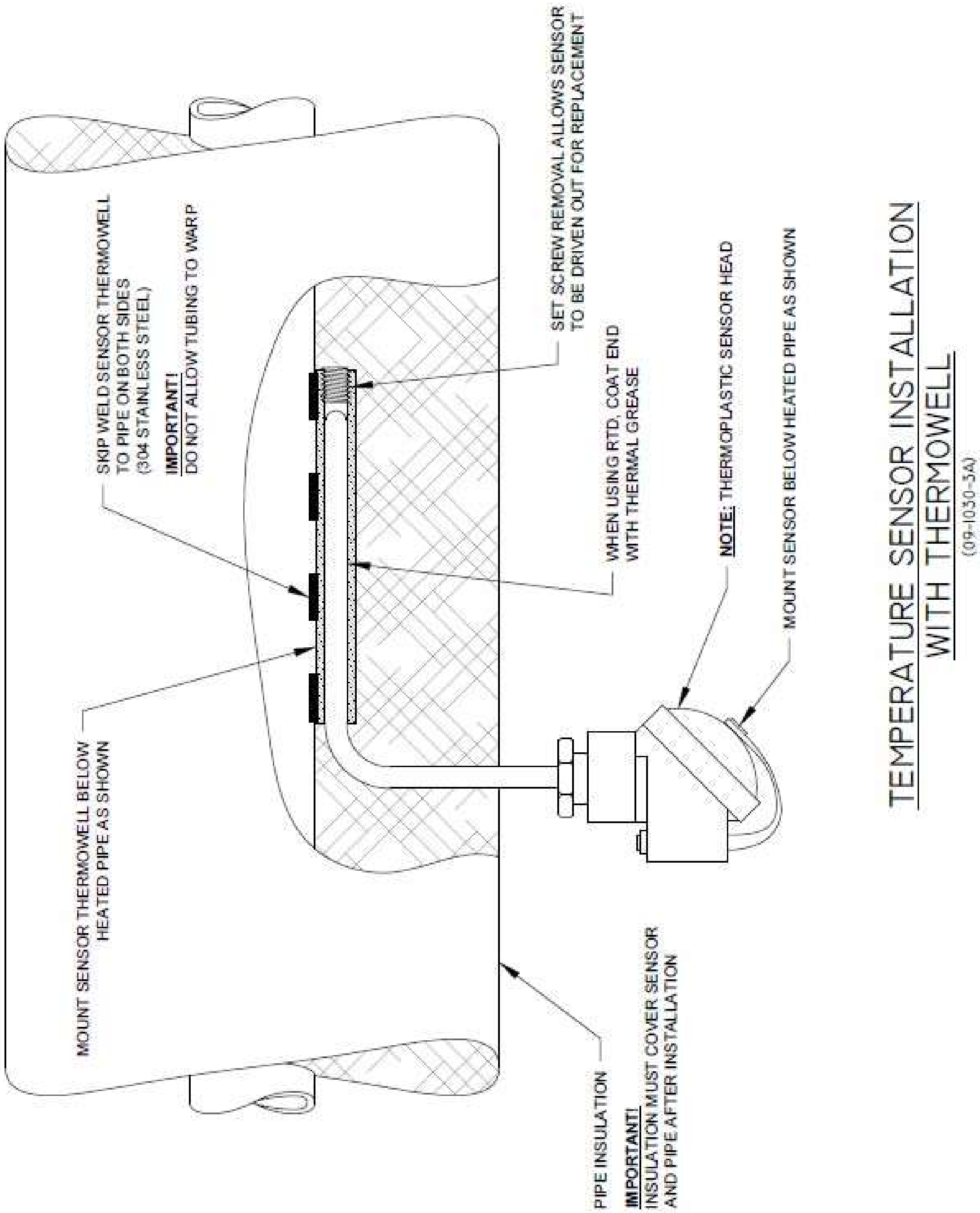

INSULATING BUSHING
SAE WASHER
GRADE 5 BOLT
INSULATION
GRADE 5 HEX HEAD BOLT WITH LOCK WASHER AND NUT
NOTE: TIGHTEN PER THE FOLLOWING SPEC: 27 FT-LBS FOR 3/8"-16 BOLT 55 FT-LBS FOR 1/2"-13 BOLT
IMPORTANT! APPLY ELECTRICAL ANTIOXIDANT COMPOUND BETWEEN ALL LUGS AND WELD CLIPS
RETURN WIRE - SIZE PER SYSTEM SPECIFICATIONS
IMPORTANT! APPLY ELECTRICAL ANTIOXIDANT COMPOUND TO ALL CABLE ENDS
FULL FACE GASKET
FULL PENETRATION WELD ALL AROUND AS SHOWN
WELD CLIP CONSULT FACTORY IF GUARD IS REQUIRED
NOTE: TIGHTEN LUG SET SCREW PER FOLLOWING SPECS: 25 FT-LBS FOR WIRE SIZE 8 TO 3/0 50 FT-LBS FOR WIRE SIZE 4/0 TO 500 MCM (COMPRESSION LUG AVAILABLE BUT NOT SHOWN)
FLANGE MOUNTED TERMINAL LUG
(REF: 09-II20-IA)
IMPORTANT!
DIASSEMBLE FLANGE OR VALVE PRIOR TO WELDING TO PREVENT DAMAGE TO GASKETS, PACKING, AND BUSHINGS

Appendix G1



1" TO 2"
TYPICAL
CUSTOMER TO PROVIDE
SUPPORT FOR CONDUIT
OPTIONAL HOSE CLAMP
¾×½ NPT NONMETALLIC
ISOLATION BUSHING
(NOT REQUIRED WITH PLASTIC
SENSOR HEADS)
4" TO 6"
TYPICAL
INSULATION
JACKET
INSULATION
PIPE
TRIM BACK JACKET TO ALLOW
ELECTRICAL CLEARANCE
TO SEAL WITH RTV
OR NON-CONDUCTIVE SEALANT
SHEATH
¼" TYPICAL
SENSOR HOUSING
TEMPERATURE SENSOR INSTALLATION
WITH WELD PAD
(e35902-REV0)

Appendix G2


SET SCREW REMOVAL ALLOWS SENSOR TO BE DRIVEN OUT FOR REPLACEMENT
SKIP WELD SENSOR THERMOWELL TO PIPE ON BOTH SIDES (304 STAINLESS STEEL)
IMPORTANT! DO NOT ALLOW TUBING TO WARP
WHEN USING RTD, COAT END WITH THERMAL GREASE
NOTE: THERMOPLASTIC SENSOR HEAD
MOUNT SENSOR BELOW HEATED PIPE AS SHOWN
MOUNT SENSOR THERMOWELL BELOW HEATED PIPE AS SHOWN
PIPE INSULATION
IMPORTANT! INSULATION MUST COVER SENSOR AND PIPE AFTER INSTALLATION
TEMPERATURE SENSOR INSTALLATION WITH THERMOWELL
(09-1030-3A)

PRE-START / INITIAL OPERATION CHECKLIST

Before energizing the system for the first time, the following items must be verified:

Control Panel

- ☐ Correct voltage source at main control panel disconnect.
- ☐ Incoming wire size and rating in compliance with the system wiring diagram.
- ☐ Disconnect fusing as specified or adequate for expected system amperage.
- ☐ Primary power lines to transformer(s) connected to terminal strip.
- ☐ Thermocouple(s) / RTD(s) properly wired.
- ☐ Ground from transformer(s) connected to terminal strip
- ☐ If option included, current transformer (CT) from system transformer(s) connected to terminal strip.
- ☐ Ground fault test point connected to terminal strip (for systems with Ground Fault only).
- ☐ Ground fault current transformers connected to terminal strip. (for Center Feed systems with Ground Fault only)

Pipeline

- ☐ IPJ's are placed at all locations specified on Piping Layout drawing.
- ☐ All IPJ's inspected for proper components and assembly.
- ☐ Pipeline is fully and uniformly insulated.
- ☐ Check that insulation underneath outer jacket is not wet.
- ☐ Ground fault test point properly located and grounded. (for systems with Ground Fault only)
- ☐ Ground fault current transformers properly mounted at each end of pipeline. (for Center Feed systems with Ground Fault only)
- ☐ Inspect the entire pipeline and verify the following:
    - **ALL** pipeline supports are electrically isolated
    - **ALL** protrusions (drain ports, gages, mounting brackets, etc.) are electrically isolated.
    - Electrical connections for all automatic valves, sensors, etc. are electrically isolated.
    - Air lines for pneumatic valves are electrically nonconductive or isolated

Wires, Terminal Lugs, and Weld Clips

- ☐ Weld clips, terminal lugs, jumper and return wires are placed at all locations specified on Piping Layout drawing.
- ☐ All weld clips are attached with a full penetration weld on both sides with cross section at least equal to the cross section of the weld clip.
- ☐ All wires are copper conductor sized according to Piping Layout drawing.
- ☐ Electrical antioxidant compound is applied to the ends of each secondary wire prior to application of connection lug.
- ☐ All wire lugs are tightened to the weld clip with the proper torque specification and electrical antioxidant compound is applied between each weld clip and wire lug interface.
- ☐ Wires are routed in free air along the top of pipeline, outside the insulation with nonmagnetic straps. If multiple wires are used, make sure they are evenly spaced apart.
- ☐ Wire lugs and weld clips are not insulated.
- ☐ Earth ground wires have been properly placed at both ends of the pipeline. (for Center Feed systems only)
- ☐ Earth ground wires have been run through ground fault current transformers. (for Center Feed systems with Ground Fault only).

PRE-START / INITIAL OPERATION CHECKLIST

Temperature Sensors

- ☐ Sensors are located in the same ambient conditions as the pipeline being heated.
- ☐ Sensors are not located within 10' of weld clips, wire lugs, flanges, valves, or other heat sinks.
- ☐ Sensor thermowells or welding pads are welded to the pipeline.
- ☐ Sensor probe tips are coated with conductive compound and mounted in the wells.
- ☐ Sensors and wells are covered with the same type and thickness of insulation as main pipeline except as indicated on the layout drawing where sensor heads penetrate the insulation.
- ☐ Sensor extension wires are consistent with wiring diagram (Red wire is negative for thermocouples)

Transformer

- ☐ Primary voltage matches transformer label
- ☐ Transformer matches system drawing (if installing multiple systems).
- ☐ Transformer primary tap has initial setting to achieve lowest secondary output voltage. (multiple tap transformers using ON/OFF control only).
- ☐ The following items are verified with X1 & X2 wires disconnected from transformer:
  - o Continuity between X1 and X2 terminals
  - o Insulation Resistance between X1 or X2 terminal and ground. Ideal reading is open circuit. System start up may be attempted with readings of 200 MΩ or higher.
- ☐ X1 & X2 wires are reconnected properly at transformer terminals
- ☐ X2 wire from transformer run through ground fault current transformer and connected to earth ground. (for End Feed systems with Ground Fault only)

During and after energizing the system for the first time, check the following items and adjust as needed:

Initial Operation

- ☐ If a SCR is used, check. If necessary, adjust the "Bias – Gain" and "Current Limit".
- ☐ Check the operation of all controlling instruments.
- ☐ Check that secondary amperage is as specified, adjust primary voltage taps as necessary.
- ☐ After the design temperature of the pipe has been reached, check again the secondary current and compare with the design current at that temperature.
- ☐ Check again for grounds which are possibly caused because of expansion of the piping.
- ☐ Retighten all electrical connections and again after a 24-hour period. After a satisfactory second check, the connections should be properly taped with glass or equal high temperature material.

Note: It's recommended that the installation supervisor or customer review and complete the above start-up checklist prior to engaging the factory for support.

Signature:_______________________________________ Date:_____________

BannerDay Pipe Heating	TraceFREE® Electric Pipe Heating

PREVENTIVE MAINTENANCE RECORD

System Name:		
Panel Number:		
Material Heated:		
Transformer Primary Voltage:		Volts
Transformer Primary Current:		Amps
Transformer Secondary Voltage:		Volts
Transformer Secondary Current:		Amps
Ground Circuit Current:		Amps
Temperature Controller Set Point:		°F
Heated Pipe Temperature:		°F
Heated Pipe Ambient Temperature:		°F
Remarks:		
Signature:		
Date:		