



# INSTALLATION, OPERATING & MAINTENANCE INSTRUCTIONS FOR 781 SERIES STORAGE TANK HEATERS

## GENERAL

INDEECO Storage Tank Heaters are designed to provide years of trouble free operation if properly installed and maintained. Please read and follow these instructions for installing and maintaining the heater.

Storage Tank Heaters provide an effective way to heat large storage tanks. The heating element design allows removal and servicing of the heating element without draining the tank.

### HEATING ELEMENT CONSTRUCTION

The heating elements are open coil design and consist of heavy gauge nickel-chromium alloy supported by ceramic insulators. The ceramic insulators are fastened to a strip of heavy sheet metal.

### PIPE ASSEMBLY CONSTRUCTION

The heating elements are installed in 3" NPS pipes of sufficient wall thickness to prevent the pipe from distorting from the heat generated. The pipes are constructed so that the heating elements may be removed without draining the tank. Multiple pipes are provided as required. The heater is mounted to the tank by one of three methods: ANSI flange mount, INDEECO adapter box, or with a custom rectangular flange.

A built-on terminal box is provided with pre-wired controls for proper heater operation. When requested, controls may be remote mounted. Refer to IOM 87-2000-83 for remote Industrial Control Panels.

The heater watt density and design features must be closely matched to the application. Life of the heating element is directly related to its surface temperature.

### CAUTION

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

Temperature regulating devices, temperature limiting controls, and low liquid level controls are recommended for use with Storage Tank Heaters, to control the heating process and safeguard the heater from excessive temperatures that can cause damage. Also, damage to fluid could occur if the heater is allowed to exceed the maximum film temperature recommended by the manufacturer.

INDEECO Storage Tank Heaters can be specially designed for use in hazardous areas as specified in Article 500 through 516 of the National Electrical Code. Refer to the heater nameplate or INDEECO Application Data for classification of the heater provided. See section below labeled Hazardous Areas for specific requirements.

**It is the ultimate responsibility of the user to verify that the construction materials provided by INDEECO are suitable for use with the process fluid. Specifically, corrosion issues must be reviewed. Refer to INDEECO Application Data for heater construction materials and design conditions.**

For additional product offerings, refer to INDEECO catalog literature on Process Heating such as Circulation Heaters, Immersion Heaters, or Tubular Heating Elements.

## INSTALLATION

### CAUTION

INDEECO recommends installation be performed by qualified personnel familiar with the National Electrical Code 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 heaters in an atmosphere containing combustible gases, vapors, dusts, or fibers unless properly marked as suitable for the condition. Refer to section below for special instructions for Hazardous Areas.

### WARNING

Hazardous voltages are present in this equipment. Lock out and tag the branch circuit disconnect switch before working on this heater.

### Handling and Storage

Care must be taken to avoid damage to the heater during storage and handling. The Pipe Insert Heater elements are constructed of ceramics that can be damaged if not handled carefully.

Protect the heater from weather damage during storage.

It is recommended to store the heater in a cool dry area to help prevent the heating element ceramic spacers from drawing moisture.

## Mechanical Instructions

### Site Selection

Review the NEMA Type rating of the heater noted on the INDEECO Application Data. Do not install a heater in an area not consistent with its rating. The standard configuration provided is NEMA Type 4, intended for outdoor use.

Allow sufficient free space around heater installation site. Work space for heater maintenance should be at least three feet in front and on either side of the heater. The minimum pull space for the heating element installation or removal from the pipe/tube should be at least four feet. The heating element is designed to be flexible and can be curved if necessary.

Leave a minimum of 6" clearance to any SCR heat sinks mounted through the side of panels to allow proper cooling.

Electric heaters are capable of developing high temperatures. Therefore, extreme care should be taken to avoid mounting heaters in an atmosphere containing combustible gases, vapors, dusts, or fibers unless properly marked as suitable for the condition.

### Heater Orientation

This style of heater is intended for horizontal use only. The open coil resistance wire must not be mounted in a vertical orientation or failure could occur from the coil sagging. The heater must be mounted plumb horizontally to assure proper operation.

Thermal expansion of the heater pipes must be considered when locating the heater. It can be approximated as:

$$\text{Pipe Length (Inches)} \times .00001 \times \left[ \begin{array}{l} \text{Max Pipe} \\ \text{Operating} \\ \text{Temp (}^\circ\text{F)} \end{array} - 70^\circ\text{F} \right]$$

If the heater is installed in a pressurized tank, a relief valve must be installed. As a minimum, the valve must be sized to relieve at a rate equal to the rate that the heater can thermally expand fluid in the tank.

### Pipe Assembly Installation

On assemblies provided with ANSI flanged connections, take care to prevent scratching the flange faces. INDEECO supplies a non-asbestos nitrile bonded fiber flange gasket unless otherwise requested. The user must confirm that the gasket is suitable for the application. The user must supply high strength studs or bolts and nuts, such as A-193 GR. B7 and A194 GR. 2H, rated for the design conditions. Bolts must be properly installed and tightened to prevent leaks.

When an adapter box is provided, the assembly is welded directly to the user's tank wall. A rectangular cutout is required; not to exceed the adapter box dimensions plus ¼".

Heater pipes must be supported inside the user's tank. Supports must not prevent the pipes from thermally expanding. Supports should be located on a maximum spacing of 10 feet.

Where buildup of solids in the bottom of the tank is expected, the pipes must be located above that level. The pipes must also be located below the minimum operating fluid level of the tank.

Heater pipes must be perfectly clean before installation of heating element. Use only a clean dry cloth to clean. Never use a lubricant. Compressed air with a long wand may be used to remove ceramic chips, etc.

### Insulation

#### **WARNING**

Surfaces of the heater pipes extending beyond the user's vessel may be extremely hot. Avoid contact to prevent personnel injury or fire.

The customer may prefer to insulate the flange or adapter box at the tank for personnel safety and energy conservation.

#### **WARNING**

Do not insulate the terminal enclosure or the first 2" of the pipe. Dangerous over-heating of the terminal box wiring could result.

The heating elements are provided with a "cold section" where stainless steel bussing is used to connect to the heating coils. This area must be packed with insulation to prevent over-temperature of the terminal enclosure. Insulation was factory installed before shipment.

## Electrical Instructions

The potentially high operating and ambient temperatures of Storage Tank Heaters require field wiring to the heater be carefully matched to the application, to avoid serious injury or damage to the equipment. The wiring must be de-rated for the expected terminal box temperature. Terminal box temperatures are typically below 120°F. Lower temperatures can be expected for heaters used in cold climates for freeze protection. If the cold section of the heater is properly insulated, 90°C minimum wire may typically be used. Refer to the National Electrical Code.

The size and type of incoming field wiring will depend upon the heater terminal box temperature, heater current draw per conductor, number of conductors per conduit, and wire insulation rating. Field supplied conductors must be sized for at least 125% of the circuit current.

To calculate the circuit current (in amps):

$$\text{Single phase Line current} = \frac{\text{KW} \times 1000}{\text{Line Voltage}}$$

$$\frac{\text{Three phase}}{\text{Line current}} = \frac{\text{KW} \times 1000}{1.732 \times \text{Line Voltage}}$$

For wiring recommendations refer to the wiring diagram. An additional copy is provided inside the heater terminal box.

Wiring to the heater 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.

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

Where thermocouple extension wire is required between the heater and remote controls, verify it is connected with proper polarity, as shown on the wiring diagram. Failure to do so may result in an uncontrolled heater. Refer to the wiring diagram for the required wire type. Shielded wire is recommended to reduce signal interference.

**WARNING**

Retighten all electrical connections that may have loosened during shipment. Failure to do so may result in damage to the heater or risk of fire.

Confirm all unused conduit holes in the terminal box are sealed with plugs suitable for the heater environment.

Attach a ground conductor to the mounting screw for the heater in the terminal box, or by other appropriate means, per NEC Article 250.

Be sure the terminal box cover is properly installed at all times to ensure personnel protection. Also, contaminants can create leakage, (shock) hazards, permanent heater damage or failure and should be avoided.

It is recommended to perform an insulation resistance test prior to energizing the equipment. If the value is less than 1 Meg Ohm using a 500Vdc or similar tester, refer to Maintenance and Troubleshooting sections.

**OPERATION**

Cautions and Setup

**CAUTION**

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

**WARNING**

**DO NOT TURN ON HEATING ELEMENTS UNTIL TANK IS COMPLETELY FULL OF FLUID.**

Permanent damage may result if elements are energized and the heater is not completely submerged.

Pipe Material	Maximum Pipe Temperature
Steel	750° F
Stainless Steel 304	1400° F

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

**DO NOT** operate heaters at voltages in excess of that marked on the heater. Excess voltage can shorten heater life or overload the branch circuit wiring.

**DO NOT** operate heaters unless properly filled with liquid.

**DO NOT** leave heating systems operating unattended unless a closed-loop process controller and over-temperature safety equipment have been completely validated.

**DO NOT** operate heaters at pipe temperatures higher than the recommended maximum. Excess temperatures can cause premature failure. Generally, pipe materials are limited to the following maximum temperatures.

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 to ensure the system is free from short circuits or grounds.

INDEECO recommends that all safety interlocks be tested during initial startup to ensure they properly disable the heater. After 10 days of operation, retighten all electrical connections.

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

PID controlled systems must be auto-tuned after initial installation to optimize control accuracy. Refer to information noted below on Control Methods.

During initial heating, it is recommended to slowly ramp up the process setpoint and inspect the heating system for problems such as excess pressure buildup, or binding of equipment due to thermal expansion.

## Initial Operation

Turn the Control Circuit Switch to the OFF position.

Turn on power ahead of the panel and close main disconnect switch.

If a digital indicating process controller is included with the panel, place the controller in the "Standby" mode and adjust the process setpoint to ambient. Refer to manufacturer's instructions for controller setup. When process control is from a remote DCS system or controller, disable the controller output signal or reduce the setpoint to ambient.

Review the setup of the process controller. INDEECO factory-configures the controller inputs and outputs unless a special controller is specified by the user.

Place the process controller in the "Standby" mode any time that the control circuit switch will be in the OFF position longer than a few seconds. This is important to prevent the process controller from driving to 100% output when the control circuit switch is returned to the ON position.

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.

Remove the controller from the Standby Mode.

Increase the process setpoint 10 or 20 degrees and confirm operation without alarms.

Once all alarm conditions are cleared, follow instructions in process controller manual for auto-tuning (not applicable for

ON-OFF control), and refer to information noted below on Heater Control Methods for tuning.

Note that auto-tuning **must be** initiated while the temperature of the process fluid is below the normal operating temperature.

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

Adjust high limit temperature controllers by setting as close to the operating conditions as possible without nuisance tripping.

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.

On flange mounted heaters, re-tighten flange bolts after the heater has completed one or two heating cycles.

## Shut Down

The heating system may be shut down by reducing the process setpoint to ambient.

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

## 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 can not be accomplished quickly.

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## CONTROL METHODS

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### Heater Control Methods

Many factors affect the setpoint tolerance and control of heating systems. Control method, heat load fluctuations, sensor location, controller tuning, and fluid thermal properties are significant factors that impact process control.

Control methods for electric heaters can either be:

1. ON / OFF
2. Proportional, Integral, and Derivative (PID).

### ON/OFF Systems

On/off systems utilize a process similar to a thermostat that operates a home furnace. A typical heater control circuit is provided with digital indicating process controller which accepts a thermocouple input from the process. The controller is configured to a 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 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. 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.

### 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 or Electronic Multi-Stage Sequencer. Note that reverse acting signals are used with heating systems where the heater is OFF at 4mA and fully on at 20mA.

SCR Power Controllers employ heavy duty SCR switching modules to switch the power. The SCR uses a fixed time base of typically 4 seconds. Within every 4 second time base, the SCR closes to energize the heater for a time frame proportional to the control signal. A 50% signal, or 12mA, would mean the heater is on for 2 and off for 2 seconds every 4 seconds. The result of cycling the heater frequently, but proportional with the load requirement, is more accurate temperature control.

An Electronic Multi-Stage Sequencer, or Step Controller, accepts the scaled control signal output from a PID Controller and pulls contactors in and out as required. This method is similar to ON/OFF control with multiple stages. The sequencer has an adjustable Cycle Time similar to that used for ON/OFF process controllers. The default used on sequencers is a 40 second delay between stages. This method is effective on high amperage units because the multiple stages help split the load into manageable circuits.

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

### Factors Impacting System Control

Many factors affect the setpoint tolerance and control of heating systems. Control Method (noted above), Heat Load Fluctuations, Sensor Location & Thermal Lag, Controller Tuning, and Fluid Properties are all significant factors.

**Heat Load Fluctuation**, or changes in the process, can cause wide temperature fluctuations. Some typical changes to a heating process loop are:

1. Addition of fluid at a temperature below the process temperature.
2. Opening or closing tank access covers.
3. Starting or stopping fluid agitators.
4. Ambient temperature changes.
5. Fluid flow rate changes.
6. Insulation thickness.

7. Power available can be affected due to user voltage fluctuations.

**Process Sensor Location / Lag** in the tank or piping can impact temperature control. For flowing systems, the sensor must be in the flow stream down-stream from the heater. For stagnant systems, If the sensor is located close to or on the heater, the controls may short-cycle before the tank is up to temperature. Locating the sensor away from the heater will cause a temperature lag and allow fluid temperatures close to the heater to exceed desired temperatures. Thermal Lag is a term relating to process control. Lag is typically a slow reaction by the process sensor to a change in the operating temperature. This is often caused by thermowells. The mass of the thermowell requires heat-up time or "time lag" before the sensor can detect that the operating temperature has reached the setpoint, thus causing overshoot of the setpoint. The PID controller must be tuned down to minimize this impact, which has the result of less accurate temperature control.

**Controller Tuning** is necessary on systems with SCR's or Sequencers and PID control. Tuning allows the proportional, integral, and derivative values to be set based on the actual process conditions. Process controllers are provided with an auto-tuning feature that measures the thermal responsiveness of the heating system. During auto-tuning, the process controller drives the system to heat up, hold, heat up, and finally, hold. If an alarm condition is encountered during auto-tuning such as a high limit alarm, the cause of the alarm must be remedied and the auto-tune must be repeated. Tuning may need to be repeated after any change in the process which affects the thermal responsiveness of the system such as the heat load, flow rate, or fluid properties. Systems which are unsteady may require manual tuning. Refer to the process controller manual for instructions.

**Fluid Thermal Properties** 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 heaters must be designed with a much lower sheath watt density than with most fluids. Temperature gradients can be significantly reduced in tanks by using an agitator. Solids buildup on the heaters can also reduce the heat transfer.

To obtain optimum control, the use of PID control, properly tuned for the application, is recommended.

## MAINTENANCE

### CAUTION

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

### WARNING

Hazardous voltages are present in this equipment. Lock out and tag the branch circuit disconnect switch before working on this heater.

Periodically check all electrical connections, including field and factory-made connections for tightness, and all wiring for deterioration at least once a year.

Periodically inspect for leakage and retighten flange bolts when required.

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

### Heating Element Installation & Removal

Remove electrical terminal connections after noting how they are connected. Remove insulation blanket in the bottom section of the terminal box to provide access to the heating elements.

To remove the heating element from a heater pipe, first remove the fastening nut at the terminal end. Hold the ceramic insulator firmly in order to avoid undue pressure on the ceramic and possible breakage. If obstructions are encountered, rotate the heater slightly back and forth while pulling out.

Since heating elements can be of considerable length, it may not always be possible to remove the element in a straight line, due to space limitations. Since the element bar is flexible, the element may be curved on a radius of 4 feet minimum. It is recommended that at least 2 people be used for this procedure, in order to avoid breaking the ceramics.

After the element bar has been removed, it should be carefully stretched out on a clean table for inspection. Broken ceramics must be replaced and burn spots should be cleaned with a dry clean paper or cloth towel. Oil or other contamination on the heater will cause a failure.

When installing the heating element into the heater pipe, reverse the steps noted above.

Heater pipes must be perfectly clean before installation of element. Use only a clean dry cloth to clean. Never use a

lubricant. Compressed air with a long wand may be used to remove ceramic chips, etc.

### CAUTION -Hazard of Electric Shock

Heaters must be bolted into position at the terminal end to prevent movement, which could allow the heater to short out against the pipe.  
See figures attached for mounting configurations.

The heating element is only intended to be installed with the sheet metal strip on the bottom. Do not rotate the heater in the pipe.

Thermal insulation must be installed between the first few ceramics in the "cold" section of the heater where the resistance wire is not coiled. A loose fill cerafiber (INDEECO P/N 1008466) or equal, rated for 2000°F, is preferred. The insulation must be free of moisture or contamination in order to provide electrical isolation. The insulation is necessary to allow 90°C rated field wiring.

Caution, INDEECO recommends replacing the entire pipe insert assembly under most conditions. The condition of the ceramics must be considered before attempting to replace coils. Field replaced heating coils must be installed properly or failure may occur.

If field-replacing one or more heating coils, mechanical connections at the end ceramics need to be removed. Remove the burned out coil from both ends by pulling lightly, and at the same time turning the coil back and forth. Check the ceramics near the area where the burnout occurred. Broken ceramics must be replaced, and burn spots should be cleaned with a dry clean paper or cloth towel. Oil or other contamination on the heater will cause a failure.

The new coil should be stretched to the correct length (do not over stretch), and then inserted from the far end by lightly pushing with a constant back and forth turning motion. After the coil is in place, the loop at the end of the coil should be guided over the bolt on the end ceramic and then tightened in place with the previously removed unit.

Re-install the heating element in the pipe by reversing the instructions above.

Use care when making connections to the heating element to avoid breaking the end ceramic.

Where the heater is installed in cold climates, consider safety precautions to prevent damage due to freezing fluid when the heater is not in service.

## TROUBLESHOOTING

### CAUTION

Troubleshooting and repair should only be attempted by qualified maintenance personnel.

The nature of the ceramic insulators used to electrically isolate and support the nickel chromium resistance wire in the heating elements is such that over a long period of storage, they will absorb considerable moisture from the atmosphere unless the pipe and conduits are sealed. It is recommended to perform an insulation resistance test prior to energizing the equipment. If the value is less than 1 Meg Ohm using a 500Vdc or similar tester, care must be taken to dry out the heater to prevent failure. It is recommended that the elements be turned on at a reduced voltage at first, to boil off the moisture. Meg Ohm readings may drop initially

after a few minutes of operation, indicating moisture being forced out of the elements. The terminal enclosure lid should be left open during this period to allow the moisture to escape.

If the heater has a manual-reset high limit thermostat, be sure that the reset button is pressed in.

If reduced heat output is suspected, verify the condition of the heating elements by using an ammeter to check the current draw of each input line. All input lines should draw approximately equal current, which should agree with nameplate rating. If they do not, one or more of the heating elements could be damaged.

## HAZARDOUS AREAS

(where applicable)

### WARNING – Explosion Hazard

INDEECO strongly recommends installation be performed by qualified personnel familiar with the National Electrical Code and all local codes and standards regarding explosion-proof equipment. It is the responsibility of the installer to verify the safety and suitability of the installation.

Per article 500-516 of the National Electrical Code, a hazardous area is defined by a "Class", "Division", "Group", and "Temperature Code". The Class can be I or II, where Class I indicates that the hazard classification is due to the presence of an explosive vapor. Class II indicates an explosive dust. The division can be either 1 or 2. Division 1 indicates a hazard is ALWAYS considered to be present. Division 2 means the hazard is only present under abnormal conditions. The Group defines the explosiveness of the hazard. The Temperature Code specifies the temperature at which a hazard will ignite.

INDEECO can provide designs suitable for all of the above conditions, but a heater should never be placed in an environment not noted on the heater nameplate.

NEVER operate the heater in an atmosphere with an ignition code temperature LOWER THAN the nameplate rating. The user must determine the actual area classification.

Special design considerations for electric heaters used in hazardous locations:

1. Locate all electrical connections in an appropriate enclosure.
2. Prevent surface temperatures of the heater from exceeding the design ignition temperature.

INDEECO Storage Tank Heaters designed for hazardous locations are typically provided with a purged terminal enclosure.

When the design temperature of the process exceeds the rated ignition temperature, it is critical that the heater and all customer piping is properly insulated.

A hazardous area heater must be powered and controlled by a heater control panel designed to provide necessary over-temperature safety interlocks. Contact INDEECO if assistance is required to properly control and protect the heater.

Never apply power to a heater in a hazardous atmosphere unless all terminal box covers are properly installed with all cover bolts.

All conduits entering the heater terminal box must be sealed within 18" of the heater using an explosion-proof conduit seal. Any unused openings must be properly sealed with a steel pipe plug. Follow the NEC for specific conduit requirements such as the requirement for Rigid Conduit.

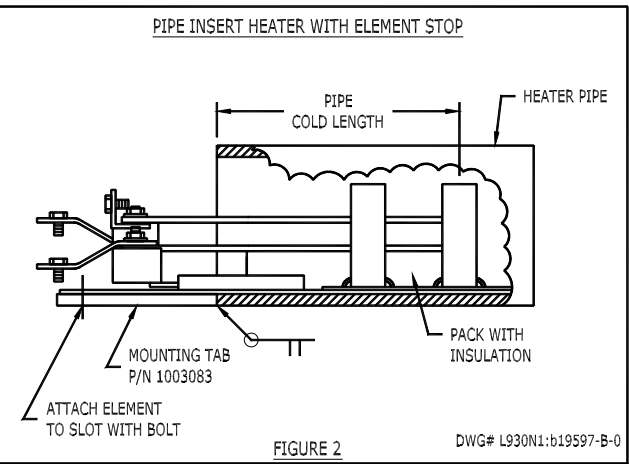
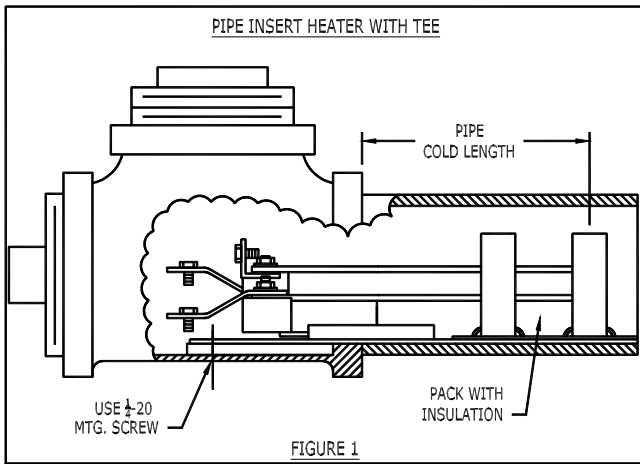
To ensure proper flamepath, all threaded conduits must use rated fittings and be tight, with a minimum of 5 good threads engaged. Any machined metal-to-metal surfaces on terminal boxes must be handled carefully to prevent scratches which may void the explosion-proof rating.

### WARNING - Risk of Explosion

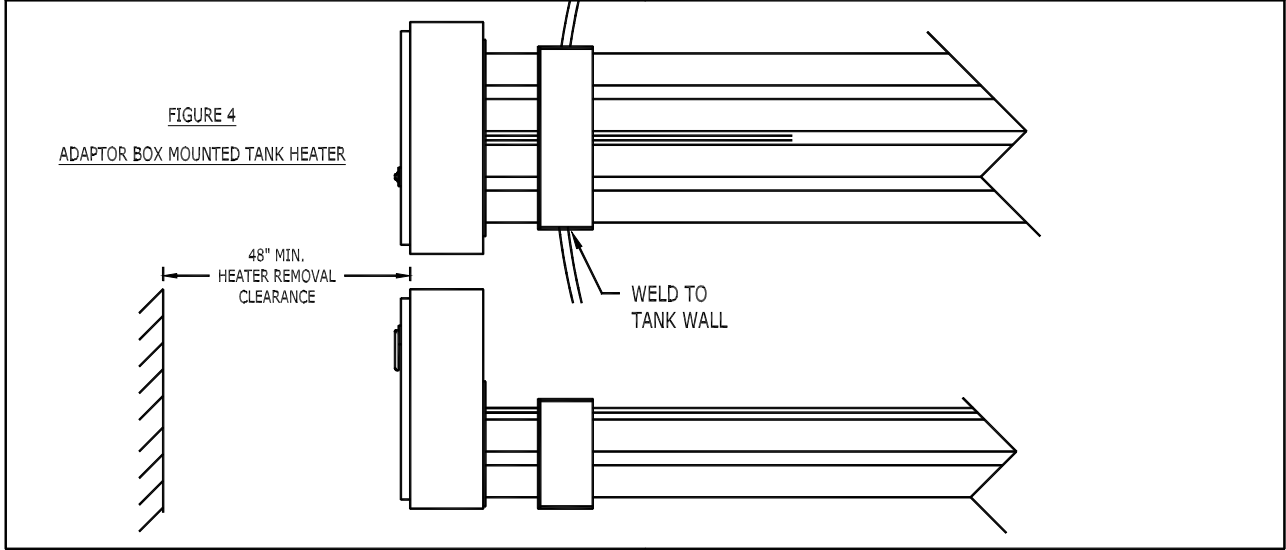
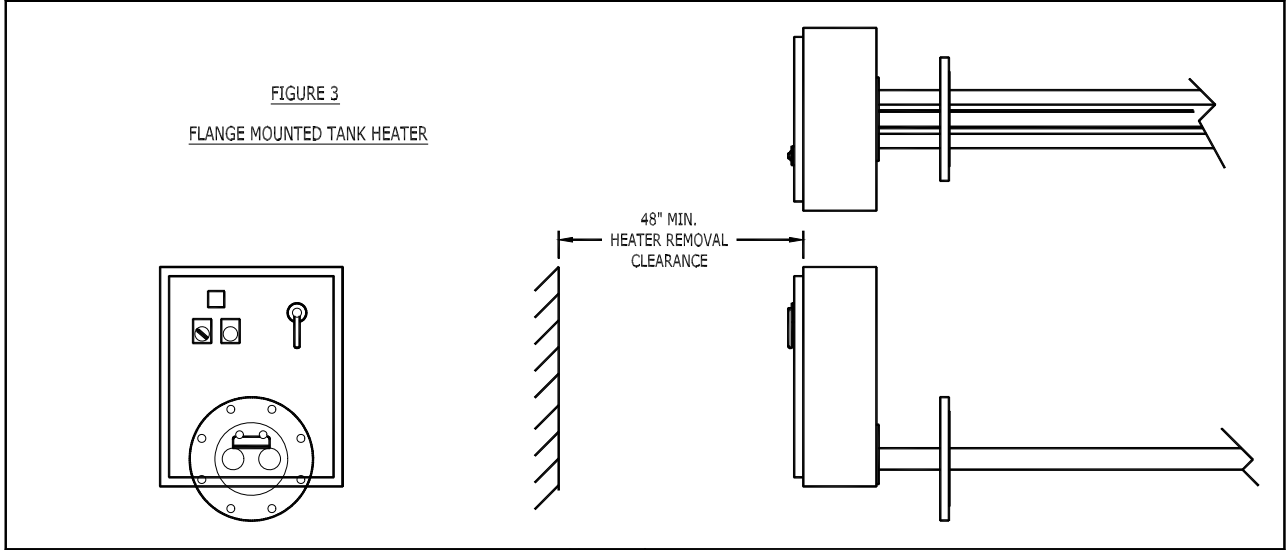
Operating the heater at a voltage higher than the nameplate value may result in elevated temperatures and amperage above the design ratings.

Proper grounding of equipment in hazardous areas is critical to eliminate potential sources of sparking.

Replacement of electrical components should only be done by authorized personnel familiar with the requirements of maintaining electrical equipment in an explosion-hazard area.



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