INSTALLATION, OPERATING & MAINTENANCE INSTRUCTIONS FOR 870 SERIES INDUSTRIAL CONTROL PANELS

GENERAL

INDEECO Industrial Control Panels 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 Control Panel.

Industrial Control Panels can be provided for use with various electric heating equipment to interlock safety devices and to control a process at a desired setpoint temperature.

Refer to the appropriate Installation, Operation, and Maintenance Instructions for any heater provided with this Control Panel.

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 electric 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 Industrial Control Panels can be specially designed for use in hazardous areas as specified in Article 500 through 516 of the National Electrical Code. Refer to the Control Panel nameplate for classification of the heater provided. See section below labeled Hazardous Areas for specific requirements.

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

TYPICAL CONTROLS

Refer to the wiring diagram included with this instruction sheet for equipment included with the control panel.

See individual manufacturer data sheets or IOM's for additional information on components listed below.

Typical Power Circuit Equipment:

Disconnect Switch – removes line voltage from the control panel for servicing and maintenance.

Fusing or Circuit Breaker – protects wiring and controls from excessive current due to short circuit or overload.

Power Contactor – magnetic definite purpose device 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 Process Temperature Controller and proportions heater output (also see Electronic Multi-Stage Sequencer).

Electronic Multi-Stage Sequencer (as alternate to SCR) - provides power proportional to a 4-20mA signal from a process temperature controller by pulling in multiple heater stages as required.

Typical Control Circuit Equipment:

Control Transformer – provides 120VAC power for control circuit.

Process Temperature Controller – receives a temperature signal from a process sensor or remote input and adjusts heater 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 – over-temperature protection that breaks the control circuit when measured process or element sheath temperature exceeds setpoint. Typically provided with manual reset.

Control Relay – defines control logic by interlocking safety devices to the heater power or can provide remote alarm indication to the customer.

Panel Heater – provided when required for panels installed outdoors in cold climates, to keep temperature of control components above 32^{o}F.

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 Control Panels 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 Control Panel.

Handling and Storage

Care must be taken to avoid damage to the Control Panel 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.

Mechanical Instructions

Site Selection

Review the NEMA Type 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 6' 6", 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).

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

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.

Electrical Instructions

The potentially high operating and ambient temperatures of electric heaters used with industrial control panels 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 heater terminal box temperature. Refer to the National Electrical Code.

The size and type of incoming and interconnecting field wiring will depend upon terminal box or panel temperature, heater current draw per conductor, number of conductors per conduit, and wire insulation rating. The control panel temperature can be assumed to be 130^{o}F max. Refer to the appropriate IOM for the estimated heater terminal box temperature. Field supplied conductors must be sized for at least 125% of the circuit current.

To calculate the circuit current (in amps):

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

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

Refer to the wiring diagram included with this instruction sheet for wiring recommendations. An additional copy is provided inside the panel. Review the field wiring requirements carefully. Select instrument wiring to properly match the required signal. Shielded cable is recommended for low voltage and thermocouple signals to minimize 60Hz noise. Shields must be grounded at one end only to prevent a ground loop.

Where thermocouple extension wire is required between the heater and panel, verify it is connected with proper polarity, as shown on the wiring diagram. Failure to do so may result in an uncontrolled heater. Keep in mind that the "Red" wire is negative for type J and K thermocouples. Refer to the wiring diagram for the required wire type. The maximum loop resistance allowed is 100 ohms to avoid measurement error.

Any remote interlock, such as a flow switch or remote shut-down, may be interlocked with the heater by removing and replacing the jumper typically provided at terminal block labeled C1-C2 with the interlock dry contact.

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.

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

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.

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 Article 250.

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.

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.

It is recommended to perform an insulation resistance test to the power circuit prior to energizing the equipment, to confirm the electric heater is not wet. Test in-between all de-energized power components. If the value is less than 1 Meg Ohm using a 500Vdc or similar tester, refer to Maintenance and Troubleshooting sections.

If the user prefers 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 transformer. If the control circuit is tested, remove control boards from any SCR's, pull out process controller, remove secondary ground(s), and disconnect any High Limit Controllers. Test control circuit at 1200V max.

OPERATION

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 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 at temperatures higher than the recommended maximum. Excess temperatures can cause premature failure.

DO NOT operate heaters unless properly filled with liquid, and flow is established (if applicable).

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

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.

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 setpoint down below the 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 panel 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.

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.

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.

CONTROL METHODS

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 Control Panel is provided with a digital indicating process controller which accepts a thermocouple 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 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^{o}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 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. Inspect for signs of overheating, corrosion, or pitting of electrical joints. Dress up and clean all contact surfaces.

Exercise all switches, circuit breakers and operating mechanisms to confirm they operate freely. Clean and lubricate 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.

Replacement parts must be of equal or higher ratings. Fuses should only be replaced by those of equivalent amp rating and class. Contact the factory for recommended spare parts.

TROUBLESHOOTING

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

The design of most electric heaters includes ceramic materials to isolate and support the nickel chromium resistance wire in the heating elements. Over a long period of storage, the ceramics will absorb considerable moisture from the atmosphere unless hermetically 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 heater terminal enclosure lid should be left open during this period to allow the moisture to escape.

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.

Check insulation resistance:
° If a severe electrical fault has occurred.
° If it has been necessary to replace parts or clean insulating surfaces.

GENERAL TROUBLESHOOTING GUIDE

PROBLEM	CAUSE	SOLUTION
o System will not energize.	o No power to panel.	o Supply power.
	o Disconnect switch is not turned on.	o Turn disconnect switch to the ON position.
	o Control circuit fusing is blown.	o Check and replace fusing if necessary.
	o Remote interlock is open.	o Close remote interlock.
	o Component failure.	o Check and replace component if required.
o Heater does not energize.	o High limit controller has tripped.	o Allow heater to cool and reset high limit.
.	o Interconnecting wire between panel and heater is broken or connection is loose.	o Check wire continuity and repair if necessary.
	o Heater fusing is blown.	o Check and replace fusing if necessary.
		o Confirm supply power no more than 7% high.
	o Component failure.	o Check and replace component if necessary.
	o Process temperature is above setpoint.	o Raise setpoint.
o Pilot light not operating when system is operating correctly.	o Bulb burnt out.	o Replace bulb.
o Nuisance over-temperature tripping.	o High limit setpoint temperature too low.	o Consult this manual for the proper setpoint.
	o Insufficient fluid flow.	o Increase fluid flow.
o System does not get up to to temperature.	o High limit controller has tripped.	o Review above.
	o Heater element failure.	o Measure amperage on all 3 legs for 3phase htrs and compare to nameplate.
	o Low line voltage.	o Confirm supply power no more than 3% low.
	o Insufficient insulation.	o Insulate exposed piping to reduce losses.

IF PROBLEM PERSISTS, PLEASE CONSULT FACTORY.

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 Panel should never be placed in an environment not noted on the nameplate.

NEVER operate the panel 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 and panels 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 Control Panels designed for hazardous locations are typically provided with a purged enclosure. The protected enclosure shall be constantly maintained at a positive pressure. Air of normal instrument quality, nitrogen or other nonflammable gas shall be used as the source of the protective gas. Electric power for the protective gas supply shall be supplied from a separate power source or before any service disconnects of the protected enclosure power supply. Cast aluminum enclosures can also be provided.

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 and panel 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 or rated cover. 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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