IEEE Std 622A-1984
(Supplement to ANSI/IEEE Std 622-1979)

IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems for Power Generating Stations

(Supplement to ANSI/IEEE Std 622-1979, IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Systems for Nuclear Power Generating Stations)

Sponsor
The Power Generating Committee
of the
IEEE Power Engineering Society

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Foreword

(This Foreword is not a part of IEEE Std 622A-1984, IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems for Power Generating Stations.)

In June, 1976, the Working Group on Electric Heat Tracing Systems of the Station Design Subcommittee was formed and charged with producing a recommended practice for electric pipe heating systems. As a result of the working-group formation, ANSI/IEEE Std 622-1979, IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Systems for Nuclear Power Generating Stations was published.

The ANSI/IEEE Std 622-1979 is a much needed coverage of the general design and installation aspects of electric pipe heating systems. It covers such topics as heater design, power systems design, temperature control and alarm considerations along with receiving of materials, installation of materials, recordkeeping, and inspections.

At the time of publication of the ANSI/IEEE Std 622-1979 the Electric Heat Tracing Working Group received numerous inquiries as to the possibility of a standard more specific in the area of design and installation of electric pipe heating control and alarm systems. The Station Design Subcommittee and ultimately the Power Generation Committee endorsed the idea and charged the working group with producing such a standard. This standard, IEEE Std 622A-1984, is a result of the desire to address the electric pipe heating control and alarm questions that exist in the power generation industry today, including nuclear and fossil generating stations.

Anyone wishing to utilize the recommendations of this standard should first review, in detail, the general recommendations of ANSI/IEEE Std 622-1979, for only then will they have a complete understanding of electric pipe heating system criteria.

IEEE Std 622A-1984 covers topics such as types of control components available, freeze protection control, process control and critical process control criteria, design of control systems, type of alarm systems available, design of alarm systems, calibration and testing of controls and alarms, and installation methods.

Since electric pipe heating control and alarm systems can be part of numerous systems in a power generating station, other IEEE standards should be referred to when using this recommended practice. The recommendations here are not intended to supersede any current IEEE standards or practices and sound engineering judgement should always be used when applying this recommended practice.

This recommended practice correlates industry practices; it is not intended to be an exhaustive compilation of rigid procedure manual. This recommended practice was prepared by the Working Group on Electric Heat Tracing Systems, Station Design Subcommittee of the Power Generation Committee.

Suggestions for improvement of this recommended practice will be welcome. They should be sent to the

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1. Scope and Purpose

1.1 Scope

IEEE Std 622A-1984 provides recommended practices for designing and installing electric pipe heating control and alarm systems as applied to mechanical piping systems that require heat. The recommendations include selection of control and alarm systems, accuracy considerations, local control usage, centralized control usage, qualification criteria of controls and alarms, and calibration and testing of controls and alarms.

1.2 Purpose

The purpose of this recommended practice is to provide recommendations that will ensure design consistency and reliable operation of electric pipe heating control and alarm systems which in turn will ensure that piping systems' fluids will be available for use not only during station operation but also during normal shutdown.

2. References

[1] ANSI MC96.1-1975, Temperature Measurement Thermocouple.[1]

[1]ANSI publications are available from the Sales Department, American National Standard Institute, 1430 Broadway, New York, NY 10018.

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[2] ANSI/ASME N45.2.2-1978, Packaging, Shipping, Receiving, Storage, and Handling of Items for Nuclear Power Plant (During the Construction Phase).

[3] ANSI/EIA RS-309-1965 (R1981), General Specifications for Thermistors.

[4] ANSI/IEEE Std 100-1977, IEEE Standard Dictionary of Electrical and Electronic Terms.

[5] ANSI/IEEE Std 622-1979, IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Systems for Nuclear Power Generating Stations.

[6] ANSI/NEMA ICS6-1978, Enclosure for Industrial Control and Systems.

[7] ANSI/NFPA 70-1984, National Electrical Code.[2]

3. Definitions

For definitions of terms and phrases used in this recommended practice, reference should be made to ANSI/IEEE Std 100-1977 [4][3] and specifically ANSI/IEEE Std 522-1979 [5].

Definitions specifically applicable to this recommended practice are defined here (in some cases the terms or phrases are used interchangeably and more than one term or phrase is defined because of industry practice):

alarm, alarm signal: A signal for attracting attention to some abnormal condition. Alarms associated with electric pipe heating systems can signal high temperature, low temperature, loss of heater circuit voltage, etc.

calibration error: In operation, the departure under specified conditions, of actual performance from performance indicated by scales, dials, or other markings on the device.

centralized control/alarm: A common (central) point where multiple control, alarm, or both signals or functions are brought together. With respect to electric pipe heating systems, centralized control/alarm stations usually consist of cabinets or panels where remote control, alarm, or both signals are brought together for a common output signal to the generating unit control room.

components: Items from which a system is assembled; for example, resistors, capacitors, wires, connectors, tubes, switches, etc.

controller: A device that regulates the state of a system by comparing a signal from a sensor located in the system with a predetermined value and adjusting its output to achieve the predetermined value. Controllers, as used in electric pipe heating systems, regulate temperatures on the system and can be referred to as temperature controllers or thermostats. Controller sensors can be mechanical (bulb, bimetallic) or electrical (thermocouple, RTD, thermistor).

critical freeze protection: The use of electric pipe heating systems to prevent the temperature of fluids from dropping below the freezing point of the fluid in important or *critical* outdoor (usually) piping systems at nuclear generating stations. An example of a critical freeze protection system is the heating for the nuclear service water system.

critical process control: The use of electric pipe heating systems to increase or maintain, or both, the temperature of fluids (or processes.) in important or *critical* mechanical piping systems including pipes, pumps, valves, tanks, instrumentation, etc., in nuclear power generating stations.An example of an important or critical mechanical piping system is the safety injection system.

dead band differential: The difference in degrees between the OFF and the ON stage of temperature controllers.

[2]NFPA documents are available from the Sales department of the National Fire Protection Association, Batterymarch Park, Quincy, Mass 02269. In the US, this document is available from the Sales department of American National Standards Institute, 1430 Broadway, New York, NY 10018.
[3]The numbers in brackets correspond to the references listed in Section 2 of this standard.

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essential freeze protection: The use of electric pipe heating systems to prevent the temperature of fluids from dropping below the freezing point of the fluid in desirably available or *essential* outdoor (usually) piping systems at fossil fueled generating stations. An example of an essential freeze protection system is the heating for the feedwater system.

essential process control: The use of electric pipe heating systems to increase of maintain, or both, the temperature of fluids (*or processes*) in desirably available or essential mechanical piping Systems including pipes, pumps, valves, tanks, instrumentation, etc, in fossil fueled generation stations. An example of an essential process control system is the heating for the fuel oil system.

freeze protection: The use of electric pipe heating systems to prevent the temperature of fluids from dropping below the freezing point of the fluid. Freeze protection is usually associated with piping, pumps, valves, tanks, instrumentation, etc, such as water lines, that are located outdoors or in unheated buildings.

local control/alarm: The locations where control, alarm, or both signal or function take place. With respect to electric pipe heating systems, these are usually mounted in close proximity to the individual heating circuits that they operate.

modules: Any assembly of interconnected components which constitutes an identifiable device, instrument, or piece of equipment which can be disconnected, removed as a unit and replaced with a spare, and has definable performance characteristics which permit it to be tested as a unit. A module can be card or other subassembly.

monitoring: To check the operation and performance of an equipment or system by sampling the results of the operation. Monitoring with respect to electric pipe heating systems usually consists of checking system temperatures or operation of the heater circuits, voltage, current, etc.

process control: The use of electric pipe heating systems to increase or maintain, or both, the temperature of fluids (or processes) in mechanical piping systems including pipes, pumps, valves, tanks, instrumentation, etc, in power generating stations.

range: The capability span of an instrument, the region between the lower and upper limits of a measured or generated function. With respect to electric pipe heating systems, range is usually defined as the difference between the lowest available set point and the highest available set point.

repeatability: The closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions approaching from the same direction. With respect to electric pipe heating systems, repeatability is usually associated with temperature controllers and is the difference in degrees for repeated operation at a specific temperature setting.

resettability: The restoring of a mechanism, electrical circuit, or device to the prescribed state. Resettability is usually associated with temperature controllers and is the difference in degrees when returning to original temperature setting.

sensitivity: The ratio of the magnitude of a device response to the magnitude of the quantity measured. In electric pipe heating systems sensitivity is usually associated with temperature controls and alarms and addresses their response function.

sensor, sensing element: The first system element that responds quantitatively to the measure and performs the initial measurement operation. Sensors, as used in electric pipe heating systems, respond to the temperature of the system and may be directly connected to controllers, alarms, or both. Sensors can be mechanical (bulb, bimetallic) or electrical (thermocouple, RTD, thermistor).

set point: A fixed or constant (for relatively long time periods) command. With respect to electric pipe heating systems, set points are usually associated with temperature controllers or alarms and are the position of the dials, taps, levels, scales, etc, so as to secure the desired operating characteristics.

4. Selection of Control Systems

There are numerous types of mechanical and electronic controls available that are suitable for electric pipe heating applications. Proper selection of controls should take into account their features and functions, and they should be

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examined with regard for suitability of functional application and physical environment. In a broader sense, controls should be viewed in terms of compatibility to a total system concept. Sample block diagrams representing system concepts are shown in Figs 1 and 2.

4.1 Types of Control Components Available

4.1.1 Mechanical Control Components

4.1.1.1 Fluid Filled Bulb and Capillary

Bulb and capillary type thermostats are the most commonly used mechanical controllers for electric pipe heating applications. Attention to many factors is required to properly select such a thermostat.

Enclosures must be suitable for the environment; otherwise damage to the thermostat will occur. Some areas may require more than one type of equipment rating, such as *NEC Classified* and *weathertight*, and in such instances, the enclosure should be rated to meet all conditions.

Sensor bulb and capillary material should also be suitable for the environment. Copper, chrome-plated copper, and stainless-steel bulbs and capillaries are commonly available. Stainless steel will generally survive better under conditions of mechanical abuse or harsh chemical exposure; however, some manufacturers have units available with chemically resistant coatings. Flexible armored capillaries are recommended.

Switch configuration and load switching capacity are critical. In some thermostats, switches are gravity sensitive and the mounting position can affect set-point accuracy. Sealed, snap-action switches provide greater reliability and are more suitable for generating station applications. Switches capable of a minimum of 100 000 cycles are recommended.

The greatest ease of setting accuracy is obtained from thermostats with smaller divisions on the dial and greater rotation per degree of set-point change, assuming constant differentials. It is desirable to select a range where the expected set point will be near the center of the scale. Most manufacturers offer both Centigrade and Fahrenheit calibrated units, and some dials have both. Units that have accessibility to dials without exposing live electrical connections ensure more operator safety.

Ambient temperature fluctuations can introduce error in thermostat calibration because a relatively large volume of fluid is contained in the bellows assembly which is exposed to ambient air. Volume change in the sensor can be offset by volume change in the bellows which deviates with ambient temperature. Better quality thermostats have built-in ambient temperature compensation mechanisms to minimize the influence of ambient temperature fluctuations. Additionally, some thermostats offer overtravel protection to prevent overexpansion of the bellows from damaging the electrical switch. Thermostats have a maximum temperature exposure that must be observed to prevent damage to the unit. The limit will vary depending on the unit's range.

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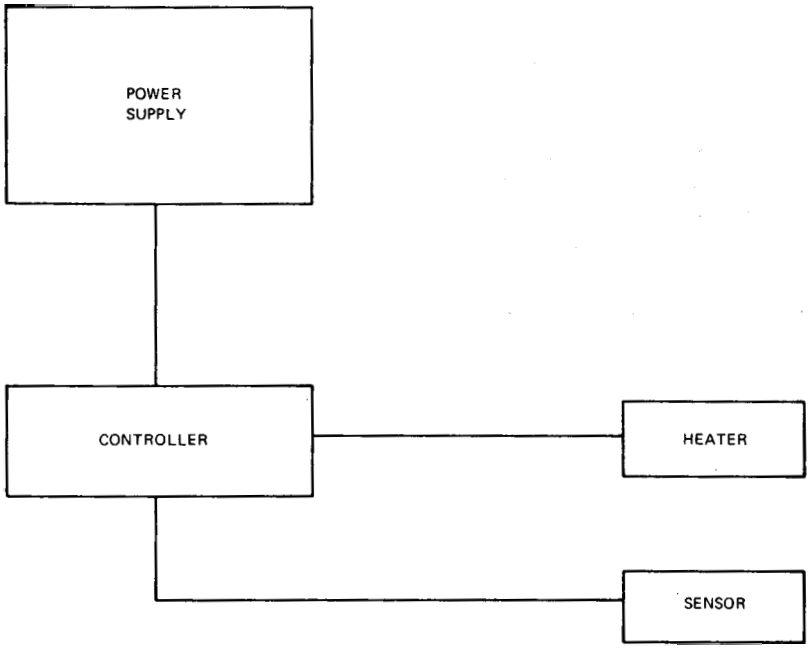

**Figure 1—Block Diagram Representing System Concept
Simplified Approach**

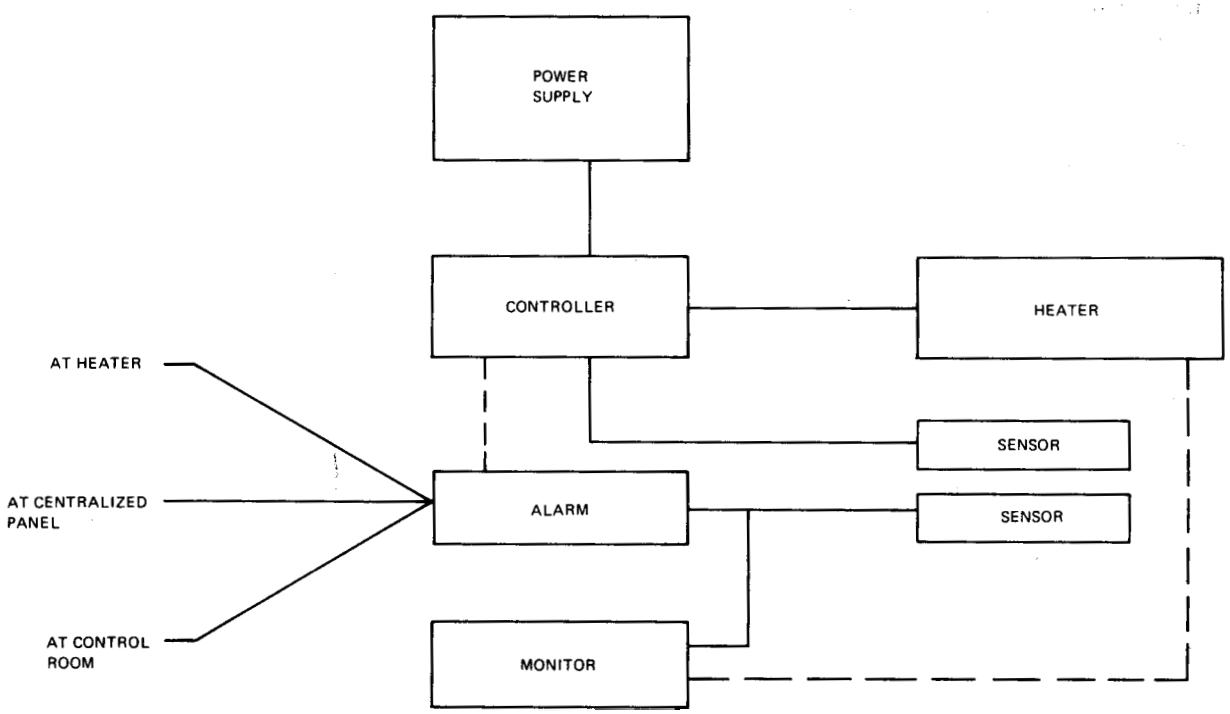

**Figure 2—Block Diagram Representing System Concept
Advanced Approach**

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The length of capillaries should be limited to not more than 3.66 m (12 ft). Beyond this, the volume of fluid in the capillary becomes large enough so that ambient temperature compensation mechanisms cannot overcome error. Liquid filled units have more consistent accuracy than gas filled units. In very cold conditions, it is necessary to check the freeze point of the fluid.

Some ambient sensing thermostats do not have a capillary, while others have relatively short capillaries. The units are similar to bulb and capillary units except that they do not require ambient compensation mechanisms. Two types of construction are available. One type has a liquid filled bellows suspended in a protective probe which extends outside the enclosure. The second type has an air filled bellows suspended in a filled probe which extends outside the enclosure. The first type has dead air space between the temperature being sensed and the sensing medium, which causes slower response. The second type is more susceptible to inaccuracy if slight damage to the probe should occur.

4.1.1.2 Bimetallic Thermal Switch

Bimetallic element thermostats are compact, and they generally come factory pre-set to a specific temperature, and several can be wired together to sense a number of points along a line. Such thermostats are reliable and require no maintenance (except replacement). However, the pre-set characteristic does not lend them well to variable set point applications. Such switches are applicable to freeze protection control and alarm.

4.1.2 Electronic Control Components

4.1.2.1 Sensors

There are three different types of sensors commonly used: thermocouple, RTD, and thermistor. The suitability of a particular type of sensor can be dependent upon the following considerations:

1) Accuracy
2) Environmental conditions
3) Maintainability
4) Distance between sensor and controller
5) Susceptibility of sensor to electrical interference or *noise*
6) Temperature parameters
7) Type of controller

For sensing temperature on electric pipe heating systems, all three sensor types have adequate response time and acceptable physical size, and all three can be fitted with extension leads. Thermocouples and thermistors should comply with ANSI-MC96.1-1975 [1] and ANSI/EIA RS-309-1965 (R1981) [3]. Consideration should be given to proper selection of extension leads including shielding requirements. Table 1 summarizes characteristics of commonly available sensors.

4.1.2.2 Controller Modes

1) *On-Off Mode*. The On-Off Mode type of switching offers an either/or situation. When a pipe temperature drops to a certain point, the controller turns the power *full on*. The actual switch may be solid state or mechanical depending on the heating load. The heater stays on until the pipe temperature reaches the top of the dead band. At that point, it switches off; however, some thermal overshoot will be experienced.
2) *Proportioning Modes*. Proportional control differs from on/off control because it acts as what might be described as a balancing device. It turns power on just enough to keep the temperature at a pre-set level. There is minimal thermal cycling from top to bottom of the proportional band. Zero voltage switching (as opposed to phase angle) can be used to reduce voltage spikes and RFI generation.
3) *Derivative Mode*. The derivative mode is one of sensing a rate of temperature change and anticipating changes so thermal overshoot or undershoot can be reduced. Thus, proportioning starts before the temperature reaches the proportional band. The rate of change to which the controller is sensitive can typically be adjusted. This function is also known as rate adjustment.

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Table 1—Sensor Comparison

	Platinum RTD	Nickel-Iron RTD	Potted Thermo-couple	M.I. Thermo-couple	Thermistor Thermistor
Sensitivity (Swing/°F)	0.22 Ω/°F Low	1.7 Ω/°F Medium	0.03 mV/°F Very Low	0.03 mV/°F Very Low	350 Ω/°F Very High
Extension Cable	Ordinary wire	Ordinary wire	Special wire Matching sensor	Special wire Matching sensor	Ordinary wire
Temp/Output Curve	Linear	Linear	Nonlinear	Nonlinear	Nonlinear
Temp Limits	–320 1200 °F	–320 500 °F	Limit of potting compound or 2500°F whichever is lower	2500°F	–50 650°F
Signal	Resistance change	Resistance change	Microvoltage	Microvoltage	Resistance change

4.1.2.3 Output Control

The output, or heater power control, of an electronic controller may consist of an electromechanical relay with discrete contacts or a suitably isolated solid-state device, such as triac or inverse parallel silicon controller rectifiers. The relay output units are usually associated with a non-proportioning, wide dead band, on-off type of controller. Where proportioning controllers are used to control loads above a few amperes, the solid-state output device is recommended. These output devices have no arcing contacts or moving parts to wear.

4.1.3 Controller Indication

4.1.3.1 Nonindicating

Nonindicating controllers have a means of setting the desired temperature, such as a dial; however, they cannot indicate pipe temperature.

4.1.3.2 Indicating

Indicating type controllers show the actual pipe temperature being sensed as well as the desired set point. Digital readout options are available. Deviation type controllers are also available and give a reading of how far the sensed temperature is deviating above or below the controller set point. Some of the simpler types have lights that indicate whether actual temperature is above or below set point.

4.2 Microprocessors

The advent of reliable microprocessors has expanded the scope of control and alarm functions. The technology in this area enables microprocessors to be used for managing electric pipe heating systems.

Microprocessors should be designed so that they are independent systems and can be interconnected by way of communication lines to a centralized computer system. The microprocessor should provide the intelligence for power distribution and switching, temperature sensing and alarming, and operator display/control assembly. The microprocessor may interface with a centralized computer system which is able to tabulate data received from each input channel.

Microprocessors can be used for the following applications:

1) Energy monitoring/peak demand minimization

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2) Programmed starting of electric pipe heating systems
3) Control, monitoring and alarm
4) System data logging

A station with numerous critical or essential process control systems can have sensors on selected lines and have the information gathered into a computer programmed to scan all sensors on a periodic basis. When an unusual reading is detected, the computer can activate an alarm and provide a readout of the type and location of the trouble.

5. Selection of Monitoring and Alarm Systems

The sophistication of monitoring and alarm systems should depend on how critical a process is for the operation of the generating station. In practice, susceptibility to failure is increased by larger numbers of components. Therefore, simplicity enhances reliability.

5.1 Types of Monitors and Alarms Available

5.1.1 Modes

The modes of monitoring and alarm are shown in Fig 3 and are given in the following subsections.

5.1.1.1 Current Monitoring and Alarm

1) Ammeters are sometimes used as a means of monitoring heater circuit integrity. Ammeters are passive devices and someone must read them to determine the condition of a heater circuit.
2) Loss of current monitors can be used as a means of detecting faulty heater circuits and initiating an alarm.

5.1.1.2 Voltage Monitoring and Alarm

1) Voltage monitoring at the end of a parallel heater is commonly used to detect bus wire integrity or initiate an alarm, or both.
2) Loss of voltage may be monitored at the heater distribution panelboard or branch circuit level and may initiate an alarm.

5.1.1.3 Ground Leakage Detection Devices

Ground leakage detection devices are a means of determining physical damage to heaters. Some devices are available with built-in auxiliary contacts for connection to an alarm system. Ground-fault interruption devices are also available.

5.1.1.4 Temperature Monitoring and Alarm

1) Low-temperature alarms indicate that the piping system temperature is below a set minimum. These alarms can be incorporated with a temperature controller, combined with a high-temperature alarm or can be a separate alarm.
2) High-temperature alarms indicate that the piping system temperature has exceeded a set maximum. These alarms can be incorporated with a temperature controller including high-temperature cut-out combined with a low-temperature alarm, or can be a separate alarm.
3) Data logger systems can also be utilized as alarms by way of output indication.

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*Loss of current or undercurrent alarm is not normally recommended for parallel heaters, however, under special conditions it may be used.

HEATER SYSTEM FAILURE MODES

HEATER TYPE	POWER SUPPLY	HEATER ELEMENT INTEGRITY	HEATER ELECTRICAL INSULATION INTEGRITY	BUS WIRE SEPARATION
SERIES	LOSS OF CURRENT	CURRENT (LOSS OF)	GROUND LEAKAGE DETECTION	N/A
PARALLEL (CONSTANT WATTAGE)	LOSS OF VOLTAGE	SEE*	GROUND LEAKAGE DETECTION	VOLTAGE (END OF CIRCUIT)
PARALLEL (VARIABLE WATTAGE)	LOSS OF VOLTAGE	SEE*	GROUND LEAKAGE DETECTION	VOLTAGE (END OF CIRCUIT)

Figure 3—Monitoring and Alarm Modes

5.1.2 Monitoring and Alarm Indication

5.1.2.1 Local Monitoring and Alarm Indication

Many generating stations utilize monitoring and alarm panels throughout the process areas. There are two modes of monitoring and alarm indication.

1) A passive monitor may require operator action such as pushing a test button or reading a meter.
2) Active alarms do not require operator action. Annunciators, such as bells, horns, or lights provide alarm indication. A secondary response might require pushing a silence/acknowledge reset button.

5.1.2.2 Centralized Monitoring and Indication

Passive monitoring in a centralized location presents the same implications as localized passive monitoring. However, in a centralized situation, the opportunity may exist for an operator to be in attendance.

Active monitors and alarms such as annunciators in a centralized location can be arranged to call attention to either a local panel alarm or a specific individual circuit alarm.

5.1.2.3 Control Room Indication

Due to the large number of station indicators located in the unit control room, it is recommended that a single electric pipe heating system alarm be provided in the control room. This alarm can be tied to a reflash installation in the vicinity of the control room so that on alarm, the operator can quickly walk to the reflash installation to determine what the alarm condition is. Usually the reflash installation will indicate the status of the centralized control systems such as loss of voltage or that some individual heating circuit is in an alarm condition. For individual circuit alarms, the operator can then go to the centralized control cabinet to determine the identity of the circuit in alarm. Also, microprocessors can be used to monitor individual circuits.

5.1.2.4 Reflash (Realarm)

Large installations, particularly those with centralized control and alarm systems, often encounter problems in terms of response to multiple alarms. To handle such situations, the systems are designed such that the operator can push an

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acknowledgement button to reset audible alarms. To handle such situations, the systems are designed so that the operator can push an allows the audible alarm to sound again for other circuits or a second fault on the same circuit.

Alternatives to this system include a periodic reflash which again requires acknowledgement. Reflash can be in the form of a flashing light or audible signal.

6. Design of Control, Monitoring, and Alarm Systems

The function of a control system for an electric pipe heating system is to provide the means to energize and de-energize the heating elements in response to the existing temperature conditions as compared to the preset or required temperature, or both, for the pipe or body being heated.

The function of monitoring and alarm systems is to provide information on the electric pipe heating system's condition. Temperature detection of the pipe indicates the operational condition of the fluid system whereas current and voltage detection are used to monitor the conditions of the heaters.

Pipe temperature sensing, whether by mechanical or electrical means, should be by surface contact with the pipe or body. Insertion type sensors with thermowells are not recommended for controlling electric pipe heating systems.

Parallel heating cables which have buses extending the length of the cables can use loss of voltage detection at the ends of the cables. Such a scheme can use lights at the ends or wires brought back to a centralized panel for connection to lights, relays, or annunicators. Monitoring voltage at the end of a heating cable can verify that heater bus wires are intact, but such monitoring must be used with caution because it does not reflect the heating capability of all parts of the heater.

Attention should be given to detecting loss of voltage to entire distribution/control panels. Such detection may require an independent voltage source and in such cases, special features may be required, such as door interlocks to ensure operator safety. Therefore, it is sometimes more practical to install fused taps off of the incoming buses and run drop-out circuits to relays in another location, or normally closed contacts from continuously picked up alarm relays.

6.1 Freeze Protection

One of the purposes of electric pipe heating systems is to prevent the temperature of a fluid from dropping below the fluid's freezing point. Freeze protection is usually associated with outdoor water piping systems and the set point of the controls is usually between 4 °C and 10 °C (40 °F–50 °F).

6.1.1 Ambient Sensing

With ambient sensing, all of the lines may be controlled from a common ambient sensor regardless of the pipe size, the watts per foot of the heat applied, the thermal insulation, or whether the line fluid is stagnant or flowing.

Control by ambient sensing consists of connecting all freeze protection heaters in an area to a distribution panel and switching the entire panel with a contactor controlled by an ambient sensor. For cases where overheating is a consideration, pipe sensing thermostats may be utilized to act as high-temperature limiting devices or alarms.

In many cases, only a small amount of heat is required to keep a pipe above freezing, even at worst-case conditions.

Low-wattage heaters normally used on such freeze protection systems do not have the capability to heat the pipes above a given level although the ambient temperature may fluctuate. Constant operation on a seasonal basis can be considered as an alternative to controls; however, such a system is not energy efficient.

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Variable wattage heaters that reduce their output as the temperature rises may be used without controls for freeze protection; however, in most applications, control is recommended for energy conservation.

Systems falling under the ambient sensing category are normal plant water lines such as sanitary, fire, cooling, and service water lines.

CAUTION — *Freeze protection for drinking water, eye wash stations and safety showers must be treated as process control systems to avoid excess heating of the water which could result in an unsafe situation.*

6.1.2 Dead Leg Sensing

Dead-leg sensing is an alternative to ambient sensing when energy conservation is a consideration. By inserting a tee into the piping system and attaching a dead-end piece of the same size piping, a section can be created that is always in a nonflowing condition. The dead leg should be electrically heated and thermally insulated in the same manner as the rest of the piping. The dead leg must have a duty cycle equal to or greater than the rest of the system assuming worst-case conditions. By placing a control sensor on the dead leg, the entire system can be controlled.

Systems falling under the dead-leg category are the same as for ambient sensing.

6.1.3 Criteria

The recommended criteria for a common or central freeze protection control system is as follows:

1) A 600 V ac or 480 V ac breaker in a station-service motor control center (MCC) should supply power to a dedicated stepdown transformer primary, if required, through a contactor or combination starter.
2) The contactor or starter closing coil should be energized by the contacts of either an ambient sensing thermostat or electronic controller with RTD or thermocouple input.
3) Power to the heating circuits should be distributed through a circuit breaker or a fused distribution panel.

6.1.4 Critical Freeze Protection

Critical freeze protection systems require that the design and control be similar to that used in critical process control systems. Critical freeze protected lines should be redundantly heated (where there is no redundancy in piping) and each heating circuit separately controlled by independent pipe sensing systems. It is also necessary to alarm each circuit for low temperature. Examples of piping systems requiring critical freeze protection are reactor makeup water, containment spray, and any water lines required for the safe and orderly shutdown of the station.

6.2 Process Control

The purpose of process control heating is to maintain the temperature of fluids in mechanical piping systems within a specified range. To maintain the predetermined temperature of a fluid, the pipe surface temperature is sensed by either a bulb, thermocouple, or RTD. This signal is sent to a heater controller.

6.2.1 Design

The recommended type of process control heating consists of individual pipe sensing controllers with a separate circuit for each heated section of pipe. In process applications sensor placement becomes critical, and sensors should be placed near the spots most likely to be the coldest, for example, at the bottom of vertical runs of pipe.

The design for process control systems should have flowing and nonflowing sections of pipe controlled separately.

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For process control systems it is likely that the heating circuits will have to placed in National Electrical Code (NEC) [7] classified areas. Electronic controls located outside the area offer a good solution. Controls should always be located for easy access for calibration and maintenance, and all enclosures should be suitable for their environment.

A second control device can be used as a high-limit cut-out device in case of primary control failure. Wiring can be arranged so activation of the backup device also triggers an alarm. Various options such as manual reset are available.

Ambient sensing for process control is not generally recommended. An alternate approach to controlling a number of Short heating circuits on equally sized Complex piping systems such as manifold systems is to use a dead leg as described in 6.1.2.

Proportioned mode control is not generally used on low-wattage heating where close temperature control is not required.

6.3 Critical and Essential Process Control

All of the criteria outlined in 6.2 also apply to critical and essential process control systems. When a system is designated critical or essential, it is then necessary to apply the following additional criteria for control.

6.3.1 Redundancy (where there is no redundancy in piping)

Redundant electric pipe heating, which is usually applied on such systems, should also be redundantly controlled where each heater has its own controller, alarm, sensor, and power source.

6.3.2 Qualification

All controllers should be qualified for the environment in which they operate. This may include seismic, radiation and environmental including protection from steam line breaks. Generally, the controller should be required to operate before and after any specified design basis event.

6.3.3 Vertical Piping

Caution should be used when vertical piping runs are heated. Because thermal gradients are possible in vertical piping runs, it may be desirable to divide the piping runs into zones and control each zone separately to obtain temperature uniformity.

6.3.4 Sensor Location

Reliability of control and alarm information depends on the location of the sensors with respect to their physical relationship with heaters, heat sinks, and areas subjected to unassociated heat or cold. Operational flow patterns can also change sensed areas to misrepresent the actual condition of the heated section.

With electronic controllers, it is possible to activate alarms if temperatures fluctuate at an abnormal rate, indicating trouble in the system. Care must be taken to ensure that sensors are located to prevent false alarms during normal operation. As an example, during cold weather a fluid may enter a line at a lower-than-normal temperature and cause a rapid cooling near the point of entry.

A combination of sensors may be used to monitor critical or essential systems. As an example, boron fluid systems that are difficult to melt once solidified, may incorporate monitoring of the electrical condition of the heaters and the temperature of the fluid line so as to provide a longer response time for corrective action to be taken.

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6.4 Control and Alarm of instrumentation Lines

The heating of instrumentation lines and their associated instruments are given here. The lines are typically small in diameter, 1.27 cm (0.5 in) or less, and are usually short in length, 6 m (20 ft) or less.

The criteria outlined throughout this recommended practice for sensing, controlling, and alarming is also applicable to instrumentation with the additional criteria as listed below.

1) Redundant instrumentation systems are recommended rather than redundant heating of single systems. A single process tap to connect process signals to redundant instruments is not recommended.
2) Instrument enclosures and instrument lines should be controlled independently of one another.
3) Prefabricated, pre-insulated electrically heated lines are a viable alternative to field-fabricated lines from a total installed cost standpoint and from performance predictability.

6.5 Local Control and Alarm

Local control is a term applied to devices that are physically located adjacent to the equipment being controlled. Typical applications are freeze protection, pump enclosures, and isolated circuits. The same device may be used to sense temperature and trigger an alarm, either locally or remotely. Local controllers or alarms should not be used in radiation areas where maintenance programs would require exposure to personnel.

6.6 Centralized Control and Alarm

The use of centralized control and alarm systems was born out of nuclear station requirements of accessibility to the controls outside of radiated and inaccessible areas, maximum serviceability, and testability. Installation time is reduced because controllers are completely assembled, wired, and tested at the factory. Centralized controls simplify the monitoring and automation of system alarms.

6.6.1 Design

Centralized control systems take many forms and incorporate a variety of functions particular to the system to which they are applied. A centralized control and alarm system may include, but is not limited to, the following components assembled together in a common enclosure:

1) Panelboard with circuit breakers for branch heater circuits.
2) Solid-state control devices. These can be: on/off, proportional, with or without power on, high or low alarm indication.
3) Electromechanical or solid-state power relays. These devices are used when the circuit load is in excess of the current capacity of the controller.
4) DC supply for control
5) Indicating lights
6) Terminal blocks for sensor input and power output

Enclosures for centralized control and alarm systems may be designed for rack mounted components and may be wall or floor mounted. Larger enclosures are typically floor mounted and may also be forced-air cooled.

6.6.2 Application

6.6.2.1 Freeze Protection

A centralized control and alarm panel for freeze protection may include a contactor and distribution panel. It may also include relays, lights, meters, and alarms for system and circuit monitoring.

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6.6.2.2 Process Control

Centralized control and alarm systems for process control can incorporate the power, control, and alarm indicators. One control may be used to control alarm circuits of different temperatures, as each circuit control may be individually set.

Freeze protection alarm and circuit protection may be incorporated in a process control and alarm cabinet.

6.6.2.3 Critical and Essential Process Control

Centralized control and alarm systems in this application provide the same function and application as the previously listed process control system with one major exception. Critical and essential process control systems are generally redundantly heated. Therefore, two independent centralized control and alan cabinets are required. These cabinets should be physically as well as electrically isolated from each other. The changeover from primary system control to backup system control should be accomplished by the positioning of the set points of the controls; therefore, electrical interconnections are not involved.

6.6.3 Spare Capacity

It is recommended to provide for a minimum of 10% growth of the centralized control and alarm system. Fully wired spare controllers, alarm contacts, circuit breakers, relays, and terminal blocks should be supplied in the initial installation. It is suggested that an additional 20% fully wired space be provided in the control cabinet for future growth when possible. Power requirements for main breakers, contactors, and transformers should be based on possible connected load including spares.

6.7 Qualification

The control and alarm system cabinets and components should be qualified to function in the environment in which they are located. The following subsections describe the requirements of the four areas of qualification for critical systems and essential systems, if applicable.

6.7.1 Environmental Conditions

Materials used in the electric pipe heating control and alarm systems should be suitable for the environment in which they operate. Typical environments to be considered are:

1) Indoor or outdoor
2) Minimum and maximum ambient and operating temperatures
3) Enclosure temperature
4) Maximum wind velocity
5) Humidity and water spray
6) Dust, salt, or other particulate-laden air
7) Chemical spray
8) Compatability of materials
9) Vibration
10) Radiation

All control devices installed in a NEC classified location should be certified by a nationally recognized testing authority.

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6.7.2 Design Life

Design life of components should be equal to the life of the generating station. However, if it is determined that a component will not last the life of the station, then an anticipated service life should be identified and a record should be made in the equipment log.

6.7.3 Seismic Requirements

Seismic analysis or seismic qualification, or both, should be made for operation before and after an operating basis earthquake (OBE) for controls, cabinets, transformers, and other equipment associated with the electric pipe heating system.

6.7.4 Radiation Requirement

Materials used in a nuclear radiation environment, such as sensors, should be able to withstand the maximum total integrated dose of gamma radiation, as determined for each area, without loss of function, through the life of the system. Typical accumulated gamma radiation doses are $1 \cdot 10^6$ to $1 \cdot l0^8$ rads accumulated over 40 years.

6.8 Redundancy Consideration

Redundant electric pipe heating systems should be applied on critical and essential process control systems and critical freeze protection systems and may be considered for process control systems, or from a station reliability, availability, and maintenance accessibility standpoint. Redundancy is not normally applied on freeze protection systems but may be applied if conditions warrant.

Redundant heating is not normally used when the piping systems are redundant.

6.9 Mounting of Components

Control, monitoring, and alarm components should be mounted in enclosures in a manner which will provide accessibility for wiring, operation, inspection, and maintenance. The components should be mounted in such a manner that damage or failure due to physical impact, shock, vibration, dust, dirt, oil, water, heat or other adverse conditions can be prevented. The enclosures or panels should be designed to provide for component protection and the safety and convenience of the personnel of the station.

Component mounting in enclosures is usually accomplished by three methods: panel mounting, rack mounting, or pan mounting on subpanels. The following sections provide recommendations for application and design for these three methods.

6.9.1 Panel Mounting

When mounting components which protrude through a panel, such as meters, gauges, and control switches, care should be taken so that they are easily visible and accessible to the operating personnel of the station. On the rear of the panel, heavy components should be located in the lower part of the panel and lighter components should be located in the upper part of the panel. Components which penetrate through the panel and are equipped with escutcheon plates should be arranged to provide adequate clearance between the plates and so that the components are accessible from the rear without removal of other components. If excessively heavy components must be mounted on a panel, it is usually recommended that panel stiffeners be installed to prevent warping or bending of the panel.

Rear mounted components and devices including, but not limited to, terminal blocks, fuse blocks, contactors, and circuit breakers should be arranged so that they do not block accessibility to other components and so that they can be easily maintained or replaced if necessary.

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It is recommended that a minimum 0.1 m (4 in) of space be allowed between rows of terminal blocks for training of wiring. Additional space may be required if wiring troughs are to be utilized.

6.9.2 Rack Mounting

Where larger, solid-state components are required and where building space permits, it is usually recommended that electronic controllers and printed circuit board subassemblies be specified as suitable for rack mounting in their associated enclosures. It is a standard industry practice for such equipment to be 0.5 m (19 in) or 0.59 m (24 in) wide; however, the assemblies vary with respect to depth and consideration should be given to wiring harness and connector space in the rear of the equipment. As a precaution against overheating, the manufacturer's recommendations should be followed as a minimum for spacing the rack mounted assemblies in a manner which will allow for free air circulation.

The rack mounted arrangement should be such that rack space is available for the addition of future components without blocking access to existing devices such as fuse blocks or terminal blocks. Associated components such as fuse blocks, terminal blocks, circuit breakers, or contactors may be mounted on subpanels secured to the racks or to the interior of the equipment enclosure if required. Terminal blocks should be arranged in such a manner that wiring, wiring troughs, and wiring harnesses from rack mounted components can be easily installed and maintained. Rack mounted equipment should be mounted in enclosures rather than open frame racks.

6.9.3 Pan Mounting

When it is not practical to specify rack mounted equipment and in the case of small, individual components, it is recommended that components be surface mounted on subpanels secured to the inside surface of the appropriate enclosure. This is usually referred to as pan mounting of components.

The subpanels should be arranged on the sides or back of the enclosure in such a manner that interconnecting wiring may be neatly trained in wiring troughs or bundles and so that entry of external cables is possible through the top or bottom of the enclosure as required.

The pan layout and mounting of components and devices should be arranged so that adequate clearance is available for wiring terminations and routing of wiring troughs if desired. Components should be arranged so that they do not block access to other components. Fuse blocks, circuit breakers, or other devices which require periodic maintenance or replacement should be located in a clear area where they are available for servicing by station personnel. Terminal blocks should be arranged in a manner that will not block access to other devices and in a manner that will allow a neat and orderly installation of electrical cables, wiring harnesses, or wiring troughs. The terminal blocks should be accessible and visible so that cables and conductors may be easily identified or maintained if required.

6.9.4 Enclosures

If equipment heat load is not severe and with plant environmental conditions taken into consideration, it may be desirable to specify a nonventilated, oil, dust- and moisture-resistant enclosure, NEMA Type 12 or equivalent. In NEC classified areas [7] such as Class I or Class II, NEMA Type 7 or NEMA Type 9 are recommended. Enclosures which are to be located outdoors and exposed to elements of weather and corrosive atmosphere should be NEMA Type 4X construction. Outdoor enclosures should be provided with a thermostatically controlled space heater to prevent damage or failure of components from moisture or humidity in accordance with ANSI/NEMA-ICS6-1978 [6].

In other clean, dry, nonclassified areas, and when ventilation of the cabinet is desirable to dissipate internal component heat, NEMA Type 2 enclosures modified for natural or forced air circulation are recommended. In this case, adequate quantities of cool air should be available and the air intake and discharge louvers should not be blocked by other equipment. Removable filters should be provided for the cooling air intake louvers where blowers are used and should be accessible for cleaning and maintenance. Ventilation openings should be designed with screens or such so that foreign objects will be prevented from entering the enclosure and to prevent accidental electrical shock to station personnel.

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6.10 Use of Monitoring and Alarm Systems

The complexity of monitoring and alarm systems will depend on the type of electric pipe heating system to which they are applied. For example, a freeze protection system may incorporate only a loss of voltage alarm on the power distribution panel while a critical process control system may incorporate a loss of voltage alarm on the centralized control cabinet along with heater circuit monitoring and pipe temperature low and high alarms. In all cases, the monitoring and alarm systems are for the use of station operating personnel to ensure adequate system performance and to initiate corrective action in a timely manner. This is important from a station reliability standpoint in that corrective action must be taken on individual circuits (by way of circuit monitoring) to ensure that backup circuits are energized and to prevent individual circuit faults from taking out an entire system. Temperature alarming is a desirable complement to the circuit monitoring to allow operating personnel to know the state of the piping system with respect to the operating technical specifications of the station.

6.11 Design Checklist for Control, Monitoring, and Alarm Systems

The following points should he considered and determined where appropriate when designing electric pipe beating control, monitoring, and alarm systems.

1) Type of heating system under design, for example, freeze protection, process control, critical process control, etc
2) Type of heating cables used
3) Type of sensor to be used
4) Type of controller function required
5) Type(s) of controllers to be used:
    - Repeatability and Accuracy
    - Response time
    - Reliability
    - Dead band
6) Location and mounting of controllers
7) Type of power control device
8) Sensor location
9) System requirements including:
    - Temperature tolerance
    - Environmental
        - seismic
        - radiation
        - spray, etc
10) Monitoring aspects considering:
    - Local or remote
    - Temperature range
    - System operability
    - Power source
    - Lights, meters, recorders (including chart), computer, microprocessor, digital readout
    - Relay requirements
11) Alarm requirements considering: Local or remote Type — annunicator, lights, data logger, etc Conditions — high, low, loss of voltage, etc
12) Adequate spare parts provided for

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7. Factory Calibration and Testing of Controllers and Alarms

Any temperature controller or alarm supplied for electric pipe heating systems should be calibrated prior to its use in the system. The device will generally first be calibrated at the factory where it was assembled. Devices should he calibrated as close as possible to their operating set point temperature and in accordance with manufacturer's procedures. Mechanical devices should be allowed to stabilize at room temperature while electronic devices should be powered-up and allowed to stabilize under power prior to calibration.

The specifications of each device should be considered when the device is being calibrated. The rate of signal change (device response time), dead band, repeatability, drift, etc all determine the exact values and accuracies to which the device may be calibrated.

The device will generally be calibrated close to midrange of the device's operating range. If it is calibrated specifically for a given job, the calibration temperature should be as close as possible to the required control or alarm set point, and documentation should be provided.

When a calibrated device is installed and wired into a cabinet or instrument housing, it should be operationally tested after the installation. A signal should be put into each controller input and a power load should be switched on and off by adjusting the input signal over a specified range of values. This operational test verifies that the interconnecting wiring has been properly installed.

Monitoring and alarm devices should be calibrated and tested in the same manner as controllers.

8. Acceptance Testing of Controls and Alarms at Generating Station

While it is recognized that factory testing and inspection has been specified and verified by test and inspection reports received with the shipment of controls and alarms, it is still necessary to verify that the quality of the equipment was not damaged during shipping.

8.1 Physical Acceptance Tests

Verification should be made that the equipment received is in accordance with the specification and procurement documents and for nuclear applications, ANSI/ASME N45.2.2-1978 [2]. Verification should also be made that instruction manuals have been received and are applicable to the specified equipment. The manuals should be reviewed at this time to determine if any special handling or storage will be required. The equipment should be visually inspected to ensure physical integrity such as the absence of physical damage, rust, or corrosion.

The inspection should be documented in a suitable test report or data sheet.

8.2 Electrical Acceptance Tests

When control and alarm panels are shipped completely wired and manufacturer's electrical test reports have been received with the equipment, further electrical tests should not be performed unless recommended in the manufacturer's instruction manual.

Temperature controllers and alarm devices should be tested and calibration verified if required. Each controller should be tagged or labeled after calibration is verified. Manufacturer's instructions should be followed when performing this verification.

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9. Installation of Controls and Alarms

It is understood the equipment should be located, mounted, and connected in strict accordance with the latest approved-forconstruction drawings. These drawings should include, but are not limited to:

Wiring diagrams
Location general arrangements
Mounting details
Conduit plans and panel or drilling plans
Component layout diagrams and dimensional or outline drawings
External connection diagrams
Schematic diagrams

9.1 Mounting of Controls and Alarms

9.1.1 Seismic Considerations

It is recognized that if seismic qualification for the equipment is required, it will be specified and drawings will locate the equipment in a Category I structure. However, the equipment location relative to nonseismic equipment is equally important. The control and alarm equipment should be located in an area where the seismic failure of surrounding nonseismic equipment will not damage the control and alarm equipment.

9.1.2 Accessibility/Environmental Considerations

Ideally, all electric pipe heating control and alarm equipment should be located near the control room so as to provide easy access for maintenance personnel. If this is not possible, consideration should be given to the periodic and emergency maintenance of the equipment. Therefore, the equipment must be located in areas that are environmentally habitable and readily accessible to the maintenance personnel.

Control and alarm cabinets should be located in an area where a sufficient supply of clean cooling air is available. When required, internal cooling fans or heaters, or both, should be specified. When control and alarm cabinets must be located in close proximity to piping systems, precautions should be taken to prevent damage from flooding and water spray. Control and alarm cabinets should be elevated and the area should be provided with proper drainage. If water spray is a possibility, some form of a barrier should be provided.

9.1.3 Physical Protection

If the control and alarm equipment is located in the vicinity of rotating machinery, cranes, or other moving objects, some form of missile barrier should be provided.

9.2 Sensors

Sensor location is very critical to the performance of the electric pipe heating system. Reliability of information depends on the location of the sensors in regard to physical relationships with heaters, heat sinks, and areas subjected to unassociated heat or cold.

Control and alarm sensors should be positioned at a point that is representative of the design temperature and circuit heat loss and in strict accordance with installation drawings or instructions. If any deviation from the drawings or instructions is required, approval should be obtained from the responsible engineering discipline.

When installing sensors consideration should be given to the following list of recommendations:

1) Manufacturer's recommendations

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2) Sensor location should be representative of the heat transfer environment in which the piping system is located.
3) Sensors should be located with consideration to flow patterns, including downstream flow, nonflow (static) piping and by-pass lines.
4) Sensors should be located in the lower portion of zones on vertical piping.
5) Sensor location for redundant heating circuits should be representative of the same pipe temperature but spaced in accordance with minimum separation criteria.
6) Sensors on vessels should be located below the minimum liquid level.
7) Where two or more heating cables meet or join, the sensors for each should be mounted 1 m to 1.5 m (3.3 ft to 5 ft) from such areas if physically possible.
8) If an electric heater circuit includes both piping and any inline heat sinks or heat sources, the sensor should be located on a section of pipe in the system approximately 1 m to 1.5 m (3.3 ft to 5 ft) from any of the inline equipment if physically possible and considering the possible effect of the inline heat sink as a worst-case condition.
9) Sensors should be located so as to avoid direct temperature effects of the heater it is controlling or alarming or any adjacent heater.
10) Sensors should be located so as to avoid physical abuse or damage. This can be complished by locating sensors on the lower acquadrants of the pipe.
11) Sensors should be secured to equipment in a manner that ensures good thermal contact.
12) Penetrations of thermal insulation by sensor leads should be weatherproofed to prevent entry of moisture.
13) Any required electrical connections should be in accordance with specified instructions and should be compatible with the type of sensor used.
14) If possible, sensor leads should be run along the pipe a minimum of 0.61 m (2 ft) before exiting the thermal insulation.
15) Attaching sensors to piping by means of straps, tapes, etc should have no damaging effect on the pipe or sensor.
16) Additional sensors can be installed for monitoring or startup considerations.
17) Ambient sensors should be located in areas sheltered from the sun, yet exposed to the weather. Temperature may be sensed in different locations to account for varying weather conditions.

10. Testing, Commissioning, and Maintenance

For electric pipe heating control and alarm systems to perform their design functions, attention must be given to proper testing, commissioning, and maintenance programs.

10.1 Testing

After installation, control and alarm equipment should be tested so as to demonstrate that the installation is in accordance with design requirements and that the quality of the equipment has not deteriorated during construction. Each control and alarm circuit should be functionally tested by manually operating the controller and observing output voltage in the case of a control circuit, or in the case of an alarm circuit, by observing annunciation. Electronic controllers and alarms may be checked by imposing the proper signal on the input, such as voltage for a thermocouple controller or a resistance for an RTD controller. When changing the input signal, the controller's output will change in response to the input, verifying controller operation. The same procedure may be used to verify the proper operation of alarms and monitors. The rate of change specification (response time) must be considered for the control and alarm circuitry. Current and bus continuity alarms may be checked by manually introducing a failure condition by turning the associated heater circuit breaker to off or by disconnecting the heater. The sensors (RTDs, thermocouples)may be checked by measuring their (1) resistance for RTDs or (2) millivolt output for thermocouples. The sensor output, converted to temperature by way of published data for the sensor, compared to the pipe temperature, measured by way of an independent means, should be within stated tolerances.

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10.2 Commissioning

A complete system test should be performed to verify operation of all control and alarm components of the system. This system test should be conducted with static fluid in the piping system. The complete heating system should be energized and the pipe temperature allowed to stabilize at the operating set points. During startup conditions, consideration should be given for acknowledgement of alarms until the system is brought up to temperature. All system tests should be documented and included in the data package for the system.

10.3 Maintenance

10.3.1 General Maintenance Requirements

There are three requirements for a satisfactory maintenance program of electric pipe heating control and alarm systems. The first requirement is to have the control and alarm systems properly designed and controlled. The second requirement is to have qualified maintenance personnel and good operational manuals and instructions to administer the program. These persons should have a thorough knowledge of the equipment and have the ability to expediently locate defects and maintain any component. Training programs should be repeated periodically.

The third requirement of a satisfactory maintenance program is the establishment of a preventive maintenance program that is all inclusive for continuing inspection, reporting and recording of the condition, and repair of all control and alarm equipment.

10.3.2 Visual Inspection

Periodic visual inspection should consist of careful observation for damage or defects in thermal insulation with respect to the location of sensors. In these cases, the thermal insulation would have to be removed, repaired or replaced, and the sensor inspected for any damage. Inspections should also consist of observing all parts and connections for overheating, corrosion or foreign matter, tightness of electrical connections, and sealing of thermostat and control cabinets.

10.3.3 Periodic Operational Check

Periodic operational checks on control and alarm systems should be performed in accordance with the criteria in 10.1 and on a regularly scheduled basis. In additon to the above, when electric pipe heating is used for freeze protection, a major operational check should be carried out during the fall season. All circuits and controls should be checked and determined that each are fully operational. All controls, including thermostats, indicating lights, meters, etc, should be checked for proper operation and indication.

A checklist of operational checks and visual inspections should be utilized and maintained in the equipment log.

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This inspection is to ensure that the installation has been in accordance with manufacturer's instructions and installation drawings. This will become part of the base-line documentation. Record on this form any acceptable changes from installation drawings and unusual configuration of heater cable or sensors that would not be visible when the pipe is covered with insulation. Attach sketch to form if required.

PIPELINE NUMBER _____

HEATING CABLE CIRCUIT NUMBER _____

	ACCEPTABLE	UNACCEPTABLE
I. HEATER INSTALLATION		
(1) PHYSICAL DAMAGE	_____	_____
(2) CONTACT WITH PIPE	_____	_____
(3) LOCATION ON PIPE	_____	_____
II. SENSOR INSTALLATION		
(1) PHYSICAL DAMAGE	_____	_____
(a) SENSOR	_____	_____
(b) SENSOR LEADS	_____	_____
(2) SENSOR LOCATION	_____	_____
(3) CONTACT WITH PIPE	_____	_____
(4) SEPARATION FROM HEATER CABLE	_____	_____
III. REMARKS/RECOMMENDATIONS		

_____ _____
INSPECTED DATE

Figure 4—Electric Pipe Heating Checklist
Heater and Sensor Inspection — Visual
(Prior to Insulation of Pipes)

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PIPLINE NUMBER _____

HEATING CABLE CIRCUIT NUMBER _____

I. THERMAL INSULATION	ACCEPTABLE	UNACCEPTABLE
(1) PIPE COMPLETELY COVERED	_____	_____
(2) INSULATION FIRMLY ATTACHED	_____	_____
(3) EVIDENCE OF WET INSULATION	_____	_____

II. MANUALLY OPERATE THE CONTROLLERS

(1) CONTROL CIRCUIT (REFER TO BASE LINE DATA)

(a) VOLTAGE _____ V

(b) AMPERES _____ A

(c) PIPE TEMPERATURE _____ °F

(2) ALARM CIRCUIT

(a) ANNUNCIATION	_____	_____

III. REMARKS/RECOMMENDATIONS _____

_____

_____

_____ _____

INSPECTED DATE

Figure 5—Electric Pipe Heating Checklist
Freeze Protection Checklist
Seasonal Inspection (Fall/Early Winter)

10.3.4 Record Keeping

Keeping adequate up-to-date records of the electric pipe heating system is an important aspect of the preventive maintenance program for control and alarm systems.

It is recommended that three basic sets of records be maintained. These records are as follows:

1) *Equipment Documentation*. This usually consists of drawings and manuals which contain the basic information on all system components.
2) *Equipment Log*. This is a record of the measured electrical characteristics of each heating circuit along with maintenance and change records. This log should begin with pre-operational test and inspection data and contain such information as to the history of all components and any checklists used. Example inspection checklists are shown on Figs 4 and 5.
3) *Inventory Control*. This is to keep track of the parts and components on hand to be used to make repairs on the control and alarm systems and should include current availability.

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