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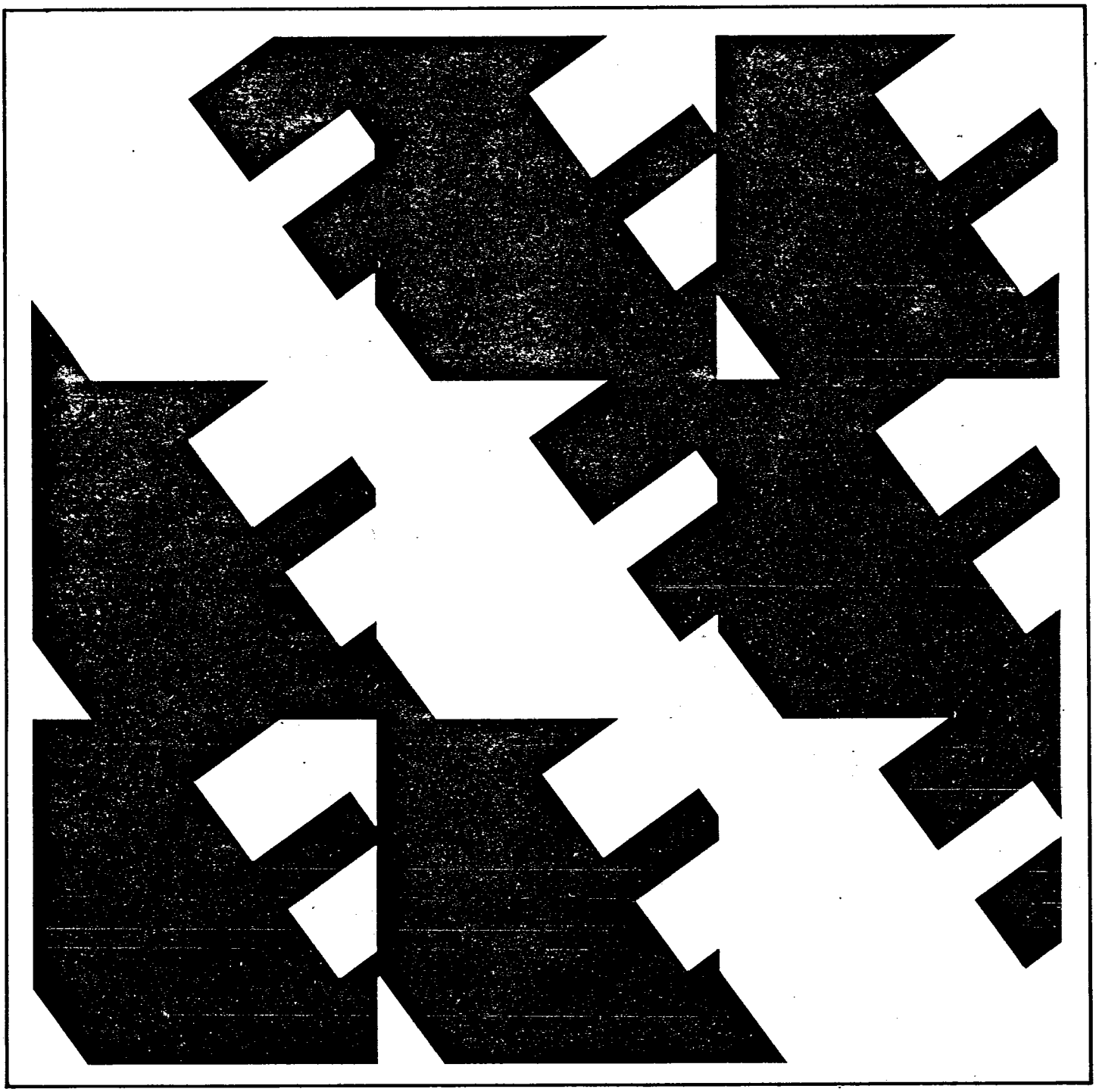
IEEE Recommended Practice for Testing and Startup Procedures for Electric Heat Tracing Systems for Power Generating Stations



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IEEE Std 622B-1988

IEEE
Std 622B-1988

IEEE Recommended Practice for Testing and Startup Procedures for Electric Heat Tracing Systems for Power Generating Stations

Sponsor

Energy Development and Power Generation Committee
of the
IEEE Power Engineering Society

Approved October 20, 1988

IEEE Standards Board

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Foreword

(This Foreword is not a part of IEEE Std 622B-1988. IEEE Recommended Practice for Testing and Startup Procedures for Electric Heat Tracing Systems for Power Generating Stations).

In a continuing effort to provide pertinent recommended practices to the industry on the design and installation of electric heat tracing systems (see ANSI/IEEE Std 622-1987 and ANSI/IEEE Std 622A-1984, ANSI IEEE Std 515-1983 , ANSI/IEEE Std 844-1985), the Electric Heat Tracing Working Group of the Power Generation Committee began an investigation in 1984 into startup and commissioning testing techniques for systems in power generating stations. This investigation covered such areas as testing of materials and components on receipt at the job site, testing and verifying design of systems before and after installation, and periodic testing of systems after commissioning.

This recommended practice is a detailed summary of the said techniques and is offered to the user in the installation, commissioning, and periodic surveillance areas of operation. Electric heat tracing systems play an important part in the operation of power generating stations and other process industries.

While this recommended practice is written for power generating stations, the techniques presented can be used on electric heat tracing systems in any application. Since electric heat tracing systems are interrelated with electric power and alarm systems, other IEEE standards should be referred to when using this recommended practice.

The recommendations herein are not intended to supersede any current IEEE standard or practice and sound engineering judgment should always be used when applying this or any other IEEE standard.

This recommended practice correlates industry practices; it is not intended to be an exhaustive compilation or a rigid procedure manual. The document was prepared by the Working Group on Electric Heat Tracing Systems, Station Design Subcommittee of the Energy Development and Power Generation Committee. At the time this recommended practice was approved, the members of the working group were:

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IEEE Recommended Practice for Testing and Startup Procedures for Electric Heat Tracing Systems for Power Generating Stations

1. Scope and Purpose

1.1 Scope. IEEE Std 622B-1988 provides recommended practices for the testing and startup of electric heat tracing systems in power generating stations. The recommendations include the testing sequence of materials and components of the electric heat tracing system, installation, and pre-operational testing of the system, verification of system performance, and the necessary records to be filed.

1.2 Purpose. The purpose of this recommended practice is to provide recommendations that may be used to ensure that an electric heat tracing system is installed correctly and that it is properly tested and commissioned. The recommendations are also intended to ensure that the electric heat tracing system will function correctly.

2. Reference

When the standard referred to in this document is superseded by a revision, the revision shall apply.

[1] ANSI/IEEE Std 100-1988. IEEE Standard Dictionary of Electrical and Electronics Terms.[1]

[1]ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Service Center, The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

3. Definitions

The following definitions apply specifically to the subject matter in this recommended practice. In some cases, more than one term or phrase is defined because in industry practice the terms or phrases are used interchangeably. Additional terms or phrases used in this recommended practice may be found by referencing ANSI/IEEE Std 100-1988 [1].[2]

alarm, alarm signal. A signal for attracting attention to some abnormal condition. Alarms associated with electric heat tracing 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 heat tracing 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, transistors, switches, etc.

[2]The numbers in brackets correspond to the references listed in Section 2 of this standard.

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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 heat tracing systems, regulate temperatures on the system and can be referred to as temperature controllers or thermostats. Controller sensors can be mechanical (bulb, bimetallic) or electric (thermocouple, RTD, thermistor).

critical freeze protection. The use of electric heat tracing 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 heat tracing 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.

essential freeze protection. The use of electric heat tracing 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 heat tracing for the feedwater system.

essential process control. The use of electric heat tracing systems to increase, 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 heat tracing 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 heat tracing 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 a 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 heat tracing systems usually consists of checking system temperatures or operation of the heater circuits; voltage, current, etc.

process control. The use of electric heat tracing 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, or the region between the lower and upper limits of a measured or generated function. With respect to electric heat tracing 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 heat tracing systems, repeatability is usually associated with temperature controllers and is the difference in de-

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grees 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 heat tracing the 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 and performs the initial measurement operation. Sensors, as used in electric heat tracing 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 heat tracing 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. Testing Philosophy, Sequence, and Timing

The philosophy and reasons for using different testing procedures for different components and materials that make up electric heat tracing systems are important for the comprehension of the rest of this recommeded practice.

While there can be a number of different tests at virtually all the steps that occur in the design, procurement, installation and startup of an electric heat tracing system, this document recommends four major test categories, namely:

(1) Receipt of Material Testing
(2) Preinsulation Testing
(3) Performance Testing
(4) Periodic Testing and Surveillance

As noted elsewhere in this recommeded practice, the exact testing procedures and timing for electric heat tracing systems should be left up to engineering management of the project.

4.1 Receipt of Materials Testing. Incoming inspection should be done as materials are received at the job site. This should include a general inspection to check for correct quantities and types of material as well as inspection for any damage during shipping and handling. Material and component testing should be carried out as prescribed in 5.1, 6.1, 7.1, 8.1, and 9.1.

4.2 Preinsulation Testing. This testing should be done after the electric heat tracing materials and components are installed but before thermal insulation is installed. The materials and components should be tested before power is turned on. Tests to be performed are discussed in 5.2, 6.2, 7.2, 8.2, and 9.2.

NOTE: Electric heat tracing materials and components should not be installed on piping systems until after all hydrostatic testing has been successfully completed.

4.3 Performance Testing. This testing should be done after the thermal insulation has been installed and the electric heat tracing system has been energized. This testing should include both component and system operational testing. It is at this time that the design maintenance temperature should be verified. This testing should be done on a circuit by circuit basis as discussed in 5.3, 6.3, 7.3, 8.3, and 9.3.

4.4 Periodic Testing and Surveillance. This activity should be performed at regular intervals after the electric heat tracing system has been commissioned. Operational checks, including review of the performance data to verify properly insulated heat sinks and no overheating, are essential for reliable operation of the system. Also, a visual inspection should be made to check for damaged insulation. This activity is discussed in 5.4, 6.4, 7.4, 8.4, and 9.4. A sample periodic testing and surveillance form is provided in Appendix B.

Each of these testing categories for the fol-

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lowing five component classes are discussed in the remaining portions of this document. These classes are:

(1) Series resistance heater cables
(2) Parallel resistance heater cables
(3) Mechanical temperature controllers
(4) Electronic temperature controllers
(5) Control and alarm panels

5. Series Resistance Heater Cable Tests

This section defines the recommended procedures that should be used for testing and commissioning series resistance heating systems.

5.1 Receipt of Materials Testing. A procedure for logging in material and a process for testing the materials should be developed. All paperwork associated with these processes should be properly filed as base line data.

Series resistance heater cables are usually designed, tagged and marked for specific pipe segments. Permanent metal tags are usually attached to the cold lead of each cable. These tags should contain the cable catalog number, circuit designation, and manufacturer's serial identification number. Other circuit information may be on the tags such as length, voltage, current and power. The metal tags should not be removed from the heater cables. After each heater cable or circuit has been physically inspected for any shipping and handling damage, each cable should receive a continuity check and an appropriate insulation resistance test[3]. Any cable that tests less than the manufacturer's minimum insulation resistance value should be rejected for use. In each continuity and insulation resistance test, measurement values should be recorded as part of the base line data file.

5.2 Preinsulation Testing. After the series resistance heater cables have been installed on the piping systems, but before any thermal insulation has been installed, the heater circuits should have a continuity check and an insulation resistance test. These tests can be performed on individual heater cables or on multiple cables that make up individual circuits. If a lower than manufacturer's recommended megohm reading exists on the cables or circuits, a check should be made of all associated junction boxes and pigtail leads to ensure they are free of moisture, and the test should be repeated to isolate the defect.

5.2.1 Visual Inspection. The heating cable should be checked for signs of mechanical damage. If damage is seen, either replace the entire cable or replace the damaged section and install a connection splice as per manufacturer's recommendations. An inspection should also be made of all connections, including those to the power source, to be sure they are correctly assembled and installed. Inspect the temperature probe to ensure that the heating cable is not touching the prove or is in too close of proximity to it. Preinsulation testing should be repeated.

5.2.2 Insulation Resistance. An insulation resistance test should be performed in accordance with Appendix A.

5.3 Performance Testing. As a final check after the thermal insulation has been installed but before energizing the electric heat tracing circuits, a insulation resistance test should be performed on the cables. This ensures that no damage to the heating cables has occurred during the insulation process. After the final insulation resistance tests, the electric heat tracing system should be energized. At this time, each circuit should be checked and voltage and current recorded and checked against the design data for the circuit. Values recorded should be within manufacturer's recommendation of the design values.

After the electric heat tracing circuits have been energized, a suitable amount of time should be allowed for the system to heat up and stabilize. Empty piping should be up to minimum temperature within 24 h. Filled piping may take as long as two to three days to stabilize depending on the fluid and if any specific heat up requirements were designed into the system.

After the electric heat tracing system has stabilized, the formal temperature performance test should be performed. This involves estimating or actually measuring temperatures on the system. There are several ways to approach this as follows:

5.3.1 Temperature Controller Method. A rough method of estimating pipe temperature

[3]Commonly referred to as "Megger" (trade name of James G. Biddle Co).

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can be accomplished by using the line sensing temperature controller. The set point knob can be slowly rotated back and forth while observing the *on* and *off* clicks. The temperature on the pipe can be assumed to be in the range of these clicks (unless the sensor has been incorrectly installed too close to a heating cable).

5.3.2 Contact Probe Method. A more accurate method of test for pipe temperature is to insert a contact thermometer or pyrometer through the insulation to a point where it touches the pipe. Care should be taken to ensure that pipe temperature and not heater cable temperature is being measured. Also, care must be taken to ensure that the hole created by the probe is properly sealed after the probe is removed to prevent moisture intrusion to the thermal insulation.

5.3.3 Test Point Method. An accurate evaluation of system temperatures can be accomplished by installing permanent sensor test points along the pipe at periodic spacings. These test points are installed at the same time as the heater cables are installed. The test points are thus readily available for temperature measurements at any time and without the need to disturb the thermal insulation.

After the electric heat tracing system has stabilized, a full test and recording of pipe temperatures should be performed. This should verify the design based on the ambient temperature the system to which the system is exposed. Temperature readings including ambient temperatures and pipe temperatures should be recorded in the base line data files along with current and voltage measurements for each heating circuit.

If the electric heat tracing system fails to come up to temperature, and the circuit voltage and current reading agree with the design data, likely sources of a problem may be wet thermal insulation, gaps in the insulation, or additional heat sinks not included in the original design.

5.4 Periodic Testing and Surveillance. A periodic visual inspection of the piping system should be made to confirm the thermal insulation integrity and detect possible heater damage. Testing should include measuring and recording of voltage, current, and temperature on a per circuit basis. Freeze protection electric heat tracing systems should be surveyed and tested prior to the winter season. Process control systems and critical process control systems should be checked more frequently.

6. Parallel Resistance Heater Cable Tests

This section defines the recommended procedures that should be used for testing and commissioning parallel resistance heating systems which include constant wattage and variable wattage heating cables.

6.1 Receipt of Materials Testing. Receipt and inspection of parallel resistance heating cable should be performed per the recommendations of the manufacturer. Logging of materials should be in accordance with 5.1.

6.2 Preinsulation Testing. After the heating cable and connectors have been installed on the pipe, but before the installation of the thermal insulation, the following procedures should be followed:

6.2.1 Visual Inspection. The heating cable should be checked for signs of mechanical damage. If damage is seen, the entire cable should be replaced or the damaged section should be cut out and a connection splice installed per manufacturer's recommendations. Inspect the temperature probe to ensure that the heating cable is not touching the prove or is in too close of proximity to it. An inspection should also be made of all connections, including those to the power source, to be sure they are correctly assembled and installed.

6.2.2 Insulation Resistance Testing. Insulation resistance testing should be performed in accordance with Appendix A.

6.3 Performance Testing. A visual check should be made to inspect the piping, thermal insulation, weather barrier, and electrical connections. This check is to ensure that no physical damage has occurred. Each circuit should be tested in accordance with Appendix A.

After the circuit megohm tests, the system may be energized and tested as follows:

6.3.1 Ambient Sensing Temperature Controller Systems. If the ambient temperature is higher than the desired temperature

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controller setting, the setting should be turned up high enough to turn the system on. Care should be taken not to exceed system temperature limits. Then, each circuit should be measured for voltage, current, ambient temperature and temperature controller set point. These measurements should be recorded in the base line data file and compared to the design parameters. After the entire system has been checked out, all temperature controller set points should be returned to the design temperature.

6.3.2 Line Sensing Temperature Controller Systems. The temperature controller should be set to the design temperature or to a setting high enough to turn the circuits on if the pipe temperature is higher than the control temperature. Each circuit should then be measured for voltage and current. It is recommended that actual pipe temperature be measured using the contact probe method described in 5.3.2. Voltage and current readings along with ambient and pipe temperature measurements should be recorded as part of the base line data file and compared against the design requirements.

6.4 Periodic Testing and Surveillance. Periodic inspections of each circuit's voltage and current should be made, along with ambient and pipe temperatures, to confirm the performance of the heating systems. Data obtained should be placed on file. Freeze protection systems should be surveyed and tested prior to the winter season. Process control systems should be checked more frequently.

7. Mechanical Temperature Controller Tests

This section covers receipt of materials testing, preinsulation testing, temperature performance testing, and periodic testing and surveillance methods for mechanical temperature controllers. These include bulb and bellows or bimetallic thermostats.

7.1 Receipt of Materials Testing. On receipt of the temperature controllers, the controllers should be checked against the applicable specification and procurement documents, and also a verification should be made that applicable and complete instruction manuals have been received. A detailed review of the instruction manuals should be made to determine any special handling or storage requirements. Each mechanical temperature controller should be visually inspected and checked for any physical damage, rust, or corrosion.

7.2 Preinsulation Testing. After the temperature controller has been installed along with its associated sensor, verification should be made that the components have been located, mounted and connected in accordance to the latest approved drawings and instruction manual. Sensor capillaries should be inspected to ensure they have not been coiled too tightly and that they do not have any kinks in them. Inspect the temperature probe to ensure that the heating cable is not touching the probe or is in too close of proximity to it. Inspection should be made of heater cable leads entering the controller to ensure that they are properly connected. The heating controller and circuit can then be energized. The controller setting, if adjustable, should then be set high enough to turn on the circuit. A current reading should then be taken to verify that power has been applied to the heating cable. After this verification has been made, the controller setting should be lowered until power to the heating cable is turned off.

The mechanical temperature controller should then be set to the design temperature of the circuit. If the ambient is lower than the temperature setting, energize the circuit and apply heat to the sensor until the power is removed from the heating cable. If the ambient is above the temperature setting, energize the circuit by cooling the sensor until power is turned on to the circuit. This verifies that the thermostat responds to changing temperatures. Heating of the sensors should be by hot air gun, cooling should be by water, by ice bath or by freon spray.

7.3 Performance Testing. At this point in the testing sequence, the temperature controllers should be checked for any physical damage that might have occurred during thermal insulation of the lines. The remaining testing of the controller is done in conjunction with the circuit testing as outlined in 5.3 and 6.3.

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7.4 Periodic Testing and Surveillance. Temperature controllers should be inspected for damage and proper operation as their respective heating circuits are checked.

8. Electronic Temperature Controller Tests

Like mechanical temperature controllers, electronic controllers should be handled and tested to ensure a reliable installation.

8.1 Receipt of Materials Testing. The inspections and testing criteria for receipt of electronic controllers should be the same as outlined in 7.1. At no time should electronic temperature controllers be tested with a megohm meter.

8.2 Preinsulation Testing. After the electronic temperature controllers have been installed along with their associated sensor, verification should be made that the components have been located, mounted and connected in accordance with the latest approved drawings and instruction manual. Inspect the temperature probe to ensure that the heating cable is not touching the prove or is in too close of proximity to it. The heating controller sensors can then be checked as follows:

8.2.1 Resistance Temperature Detector (RTD) Sensors. RTD sensors should be measured for continuity and resistance. Pipe temperature should be measured with a calibrated thermometer. The measured resistance reading should then be compared to the appropriate resistance to temperature conversion table to verify RTD performance.

8.2.2 Thermocouple Sensors. Thermocouple output voltage should be measured with a millivoltmeter. Pipe temperature should be measured with a calibrated thermometer. The measured voltage reading should be compared to the appropriate voltage to temperature conversion table to verify thermocouple performance.

8.2.3 Thermistor Sensors. Thermistor sensors should be measured for continuity and resistance. Pipe temperature should be measured with a calibrated thermometer. The measured thermistor resistance should be compared to the appropriate resistance to temperatures conversion table to verify thermistor performance.

A final step to the preinsulation testing is to set the electronic temperature controller to energize the heating circuit. This should be verified by a current measurement on the circuit. The temperature controller should then be returned to the design setpoint.

8.3 Performance Testing. At this point in the testing sequence, the temperature controllers should be checked for any physical damage that might have occurred during installation of thermal insulation. The remaining testing of the controller is done in conjunction with the circuit testing as outlined in 5.3 and 6.3.

8.4 Periodic Testing and Surveillance. Temperature controllers should be inspected for damage and proper operation as their respective heating circuits are checked.

9. Control, Monitoring, and Alarm Panel Testing

Since electric heat tracing system control, monitoring and alarm panels are the focal point for system activity, proper handling and testing of the panels is important to ensure correct system operation.

9.1 Receipt of Materials Testing. Upon receipt of control, monitoring and alarm panels, they should immediately be checked for any damage that might have occurred during shipping and handling. They should also be checked against any specifications and procurement documents to ensure that they are complete. A visual inspection should then be made of the panels to ensure that all components are securely mounted and clearly marked. The latest approved drawings should be used to check the panel layouts and wire termination points to ensure they agree.

9.2 Preinsulation Testing. This test is not applicable for control and alarm panels, as their installation sequence may be different than for heater cable and individual controller installations. Ensure temperature sensors to be used have been checked and have been properly installed. Inspect the

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temperature probe to ensure that the heating cable is not touching the prove or is in too close of proximity to it.

9.3 Performance Testing. A visual check of the panel should be made for physical damage and proper electrical connections. The panel can then be energized and each circuit can be energized. A check should be made on all controller set points to ensure that they are at design temperature. The entire electric heat tracing system being controlled from the panel should then be allowed to stabilize. After stabilization, each individual circuit should be measured for voltage, current, ambient temperature, and pipe temperature, and this data should be compared with the design data and entered into the base line data file. Note that pipe temperature may be measured using the methods described in 5.3.

9.4 Periodic Testing and Surveillance. Control, monitoring and alarm panels should be periodically checked for trash, or foreign material. This process should also include a check of proper relay and indicating light operation along with a check of all electrical connections. Freeze protection panels should be checked prior to the winter season. Process control systems and critical process control systems should be checked more frequently.

10. Bibliography

[B1] ANSI/ASME NQA-2-1986. Quality Assurance Requirements for Nuclear Power Plants.

[B2] ANSI/IEEE Std 622-1987. IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Stations.

[B3] ANSI/IEEE Std 622A-1984. IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems for Power Generating Stations.

[B4] IEEE Std 515-1983. IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.

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Appendixes

(These Appendixes are not a part of IEEE Std 622B-1988, IEEE Recommended Practice for Testing and Startup Procedures for Electric Heat Tracing Systems for Power Generating Stations, but are included solely for the purposes of information.)

Appendix A

Electrical Insulation Resistance Test for Heating Cables

Step 1: Visually inspect the heater cable for signs of mechanical damage. If damage is seen, either replace the heater cable, or repair the heater cable.

Step 2: Inspect the insulation resistance of the circuit using a megohm meter[4]. 500 VDC is recommended. Always perform this test at the power connections using the following procedure:

a) Open circuit and disconnect temperature controller if installed.

b) Connect megohm meter negative lead to heater cable metallic shield (or pipe if using unshielded cable).

c) Connect megohm meter positive lead to the heater conductors (both conductors simultaneously if possible, alternatively, connect the lead to one conductor than repeat the procedure for the other conductor).

d) Apply voltage for 1 min.

e) Record the resistance level in the Base Line Data File.

f) Discharge phase connections to ground with a suitable grounding rod if meter does not self-discharge. Disconnect.

g) Reconnect circuit and temperature controller if previously installed.

NOTE: Insulation resistance testing may damage solid state components. Ensure that they are disconnected before this test if performed.

NOTE: For megohm purposes an adequate ground path must be available.

[4]Commonly referred to as "Megger" (trade name of James G. Biddle Co).

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Appendix B
Periodic Testing and Surveillance

MAINTENANCE CHECKS FOR _____ MONTH _____ YEAR _____		CIRCUIT NO							
No signs of overheating, moisture, or corrosion, etc.	Initial								
	Date								
Proper electrical connection, ground, and bus wire insulated from connector box.	Initial								
	Date								
Controllers set properly and capillaries are protected.	Initial								
	Date								
Insulation resistance test (bypass controller if applicable).	Reading								
	Initial								
	Date								
Circuit voltage.	Panel								
	Ckt end								
All boxes, controllers, and end seals have been resealed.	Initial								
	Date								
End seal locations are marked on the insulation lagging.	Initial								
	Date								

REMARKS AND COMMENTS								

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Appendix C
Troubleshooting Guide

Symptom	Possible Cause	Remedy
No heat	Loss of power	Restore power
	Controller failure	Repair or replace
	Series heater open	Replace
Low system temperature	Low voltage	Adjust
	Heat sinks	Insulate or remove
	Low temperature of inlet fluid	Raise temperature
	Setpoint changed	Reset
	Ambient temperature lower than design	Raise the voltage or replace heater cable
	Deteriorated parallel Heater cable	Replace
	Improper sensor location	Relocate
Low temperature in sections	Wet or damaged insulation	Replace or repair
	Parallel heater, Open element	Replace or repair
	Heat sinks	Insulate or remove
High system temperature	Controller w/fail close mode	Replace sensor or controller
	Controller on continuously	Check setpoint or replace sensor or controller
	High fluid temperature controller off	Reset high alarm for fluid condition
	Improper sensor location	relocate sensor
Excessive cycling	Heater cable rating too high (overdesign)	Lower voltage or replace cable
	High ambient temperature	Reset controller
	High voltage	Lower voltage
	Improper sensor location	Relocate sensor
Temperature varies	Improper flow patterns	Relocate heaters to match flow pattern

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