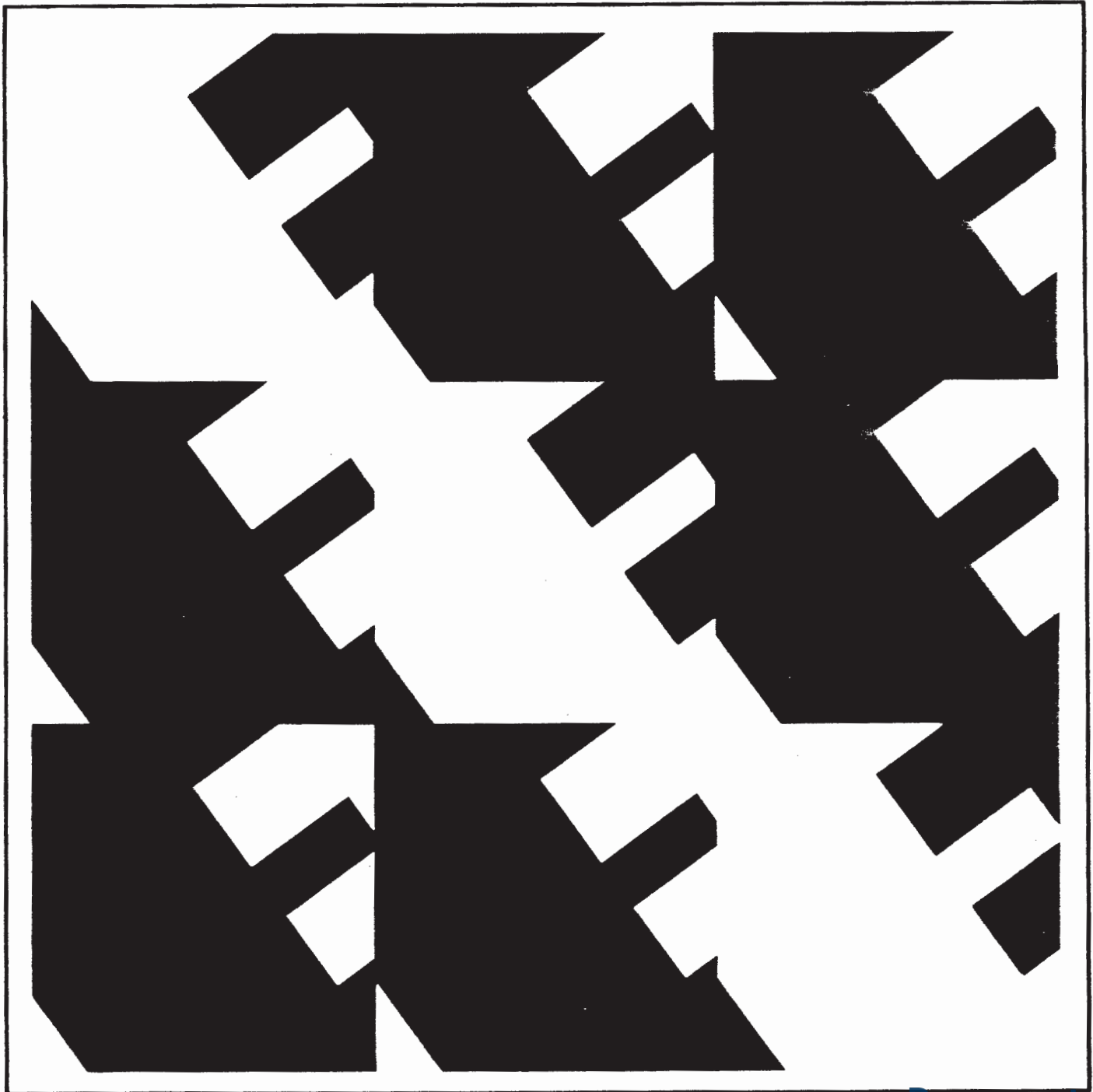


IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Systems for Nuclear Power Generating Stations

IEEE Std 622-1979



Published by The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, New York 10017
November 1979



Documents

Document Sharing Hub

Use limited to: Tsinghua University. Downloaded on February 25, 2026 at 20:33:10 UTC from IEEE Xplore. Restrictions apply. SH07583

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

Sponsor
Power Generation Committee
of the
IEEE Power Engineering Society

© Copyright 1979 by

The Institute of Electrical and Electronics Engineers, Inc

*No part of this publication may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.*

Approved December 14, 1978

IEEE Standards Board

Joseph L. Koepfinger, *Chairman*

Irvin N. Howell, Jr, *Vice Chairman*

Ivan G. Easton, *Secretary*

William E. Andrus
C. N. Berglund
Edward J. Cohen
Warren H. Cook
David B. Dobson
R. O. Duncan
Charles W. Flint

Jay Forster
Ralph I. Hauser
Loering M. Johnson
Irving Kolodny
William R. Kruesi
Thomas J. Martin
John E. May

Donald T. Michael
Voss A. Moore
William S. Morgan
Robert L. Pritchard
Blair A. Rowley
Ralph M. Showers
B. W. Whittington



Foreword

(This Foreword is not a part of IEEE Std 622-1979, IEEE Recommended Practice for the Design and Installation of Electric Pipe Heating Systems for Nuclear Power Generating Stations.)

The realization that electric pipe heating systems play an important role in the normal operation of both nuclear and non-nuclear processes in nuclear power generating stations is now coming of age. This is apparent by the increased amount of space being devoted to electric pipe heating in station technical specifications, system descriptions, and operating criteria. Such electric pipe heating systems are applied on borated water systems and on water treatment systems such as caustic. Since boric acid and caustics in water will crystalize or precipitate out of the solution, depending on their concentrations at temperatures above ambient, and since such crystallization can make the piping system inoperable for normal operation, electric pipe heating systems are required to keep the solutions and piping systems in a state to perform their intended functions. Electric pipe heating systems may also be applied on piping located outdoors at nuclear generating stations for the purpose of preventing the piping systems from freezing. It should be noted that each and all of these piping systems can include valves, pumps, strainers, tanks, and instrumentation components that can be rendered inoperable due to solutions crystalizing or freezing. Therefore, a definite need exists within the nuclear power industry for recommendations that provide a uniform method for the design and installation of electric pipe heating systems that meet the requirements for rendering reliable operation of the piping system. Without such recommendations, station reliability may be jeopardized.

IEEE Std 622-1979 presents such recommendations and covers topics such as identification of piping systems to be heated, temperature requirements, heater design considerations, pipe heating systems design (including control and monitoring), power systems design, installation of electric pipe heating systems, testing of the systems, and maintenance considerations.

Since electric pipe heating systems are interrelated with electric power and alarm systems, 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 or any other IEEE standard.

Electric pipe heating systems play an important role in the normal operation of nuclear generating stations. Therefore, redundant circuit and heater considerations with respect to station reliability are covered in this recommended practice along with alarm considerations. IEEE Std 622-1979 recommends that electric pipe heating systems not be classified as Class 1E systems and that critical process control systems be powered from reliable station power sources. If these reliable power sources are the engineered safety features (ESF) buses, then the electric pipe heating systems should be powered through suitable isolation devices in accordance with IEEE Std 308-1978, Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations, and IEEE Std 384-1977, Standard Criteria for Independence of Class 1E Equipment and Circuits.

The recommendation for not classifying electric pipe heating systems as Class 1E is based on station operating criteria. In its investigation of electric pipe heating systems for critical process piping, the working group could find no evidence that a properly designed system would come under a Class 1E classification for proper performance. Electric pipe heating systems that are applied on reactor injection piping systems do not perform any safety functions either during or after a postulated loss of coolant accident (LOCA). Instead, electric pipe heating systems render such piping systems operable during normal station operation and thus are not needed during or after a postulated LOCA. For further discussion and technical explanations on normal and accident station operations with respect to electric pipe heating systems, reference should be made to Appendix B of this document.

Comments, suggestions, and requests for interpretation may be addressed to:

Secretary
IEEE Standards Board
The Institute of Electrical and Electronics Engineers, Inc
345 East 47th Street
New York, New York 10017

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 Trace Heating Systems, Station Design Subcommittee of the Power Generation Committee.

At the time this document was approved, the members of the working group were:

D. E. Roberts, *Chairman*

G. P. Alexander
R. O. Bylin
J. J. Dennehy
W. C. Leslie

J. T. Mattox
R. A. McInturff
R. M. Oehlschlaeger
R. S. Schoellkopf

The working group would like to offer a special acknowledgement to a former and founding member, Mr. D. O. Brown, for his expertise, contribution and guidance in the preparation of this document.

At the time this document was approved, the members of the Power Generation Committee were:

E. F. Chelotti, *Chairman*

J. B. Sullivan, *Vice-Chairman*

M. I. Olken, *Secretary*

H. T. Akers
J. C. Appiarius
M. S. Baldwin
I. B. Berezowski
R. J. Breen
F. L. Brennan
P. G. Brown
E. W. Brunton
R. P. Butner
H. E. Church, Jr
R. A. Clark, Jr
C. H. Claridge
R. S. Coleman
J. W. Colwell
E. A. Cooper
R. E. Cotta
M. L. Crenshaw
R. S. Darke
F. P. DeMello
S. W. Denton
A. C. Dolbec
G. R. Engman
V. F. Estcourt
C. A. Falcone
A. H. Ferber
J. J. Ferencsik
A. H. Foss

E. T. Gross
J. R. Hall
H. E. Head
A. J. Hornfeck
L. M. Hovey
J. S. Joyce
E. F. Kaprielian
F. Keay
P. R. Keep
K. K. Khana
P. R. Landrieu
A. Lehrkind
H. E. Lokay
J. T. Madill
J. D. Mather
O. S. Mazzoni
T. M. McMahon
J. L. Mills
W. S. Morgan
P. A. Nevins
P. M. Niskode
R. E. Penn
R. A. Peterson
J. D. Plaxco
R. J. Reiman
R. G. Rizzo

F. D. Robbins
D. E. Roberts
M. P. Roller
W. J. Rom
J. D. Rosenblatt
H. M. Rustebakke
W. G. Schwartz
J. J. Seibert
N. W. Simons
M. N. Sprouse
A. J. Spurgin
R. B. Squires
B. J. Stables
J. V. Stephens
G. I. Stillman
V. T. Sulzberger
M. Temoshok
S. Tjepkema
D. Tondi, Jr.
R. H. Waltman
E. J. Warchol
M. Warren
K. L. West
J. P. Whooley
R. F. Willett
C. J. Wylie
R. Zweigler

Contents

SECTION	PAGE
1. Scope.....	7
1.1 Purpose.....	7
2. References.....	7
3. Definitions.....	7
4. Design of Electric Pipe Heating Systems.....	8
4.1 Identification of Requirements.....	9
4.2 Heater Design Considerations.....	12
4.3 Power System Design Considerations.....	16
4.4 Temperature Control Considerations.....	17
4.5 Alarm Considerations.....	19
4.6 Finished Drawings and Documents.....	20
5. Installation of Electric Pipe Heating Systems.....	21
5.1 General.....	21
5.2 Distribution and Use of Drawings at the Installation Site.....	21
5.3 Receiving of Materials.....	21
5.4 Installation of Materials.....	21
5.5 Startup Testing for Critical Process Control Systems.....	22
6. Maintenance of Electric Pipe Heating Systems.....	23
6.1 Record Keeping.....	23
6.2 Heater, Alarm and Temperature Controller Circuit Checks.....	23
6.3 Inspections.....	23
6.4 Periodic Testing.....	23
FIGURES	
Fig 1 Series Heater.....	15
Fig 2 Parallel Heaters.....	15
Fig 3 Typical One-Line Diagram of Electric Pipe Heating System.....	18
TABLES	
Table 1 Example of a Typical Line List.....	13
APPENDIXES	
Appendix A Temperature and Solubility Tables and Curves of Borated Water, Caustic Soda and Sodium Pentaborate Systems.....	24
Appendix B The Function of Electric Pipe Heating Systems Required to Support Engineered Safety Features Piping Systems.....	26
B1. Introduction.....	26
B2. Postulated Conditions.....	26
B3. General Industry Technical Specifications.....	28
APPENDIX FIGURES	
Fig A1 Boric Acid Solubility Curve.....	25
Fig A2 Sodium Pentaborate Solubility Curve.....	25
APPENDIX TABLES	
Table A1 Typical Temperature Parameters for Boric Acid.....	24
Table A2 Typical Temperature Parameters for Sodium Hydroxide (Caustic Soda).....	24
Table B1 Station Operational Modes.....	27

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

1. Scope

IEEE Std 622-1979 provides recommended practices for designing and installing electric pipe heating systems in nuclear power generating stations. These electric pipe heating systems are applied, both for critical process temperature control and for process temperature control on mechanical piping systems that carry borated water, caustic soda and other solutions. Electric pipe heating systems are also applied on water piping systems to prevent them from freezing in cold weather. The recommendations include identification of requirements, heater design considerations, power systems design considerations, temperature control considerations, alarm considerations, finished drawings and documents, installation of materials, startup testing, temperature tests, and maintenance of electric pipe heating systems.

1.1 Purpose. The purpose of this document is to provide recommendations that may be used in the design, installation, and maintenance of electric pipe heating systems as applied to mechanical piping systems. These recommendations are intended to ensure that the piping systems will be maintained at specified operating temperatures, which in turn will ensure that the piping systems' fluids will be available not only during station operation, but also during normal shutdown.

2. References

When the following standards referred to in this document are superseded by a revision, the revision shall apply.

ANSI N45.2.2-1972, Packaging, Shipping, Receiving, Storage, and Handling of Items for Nuclear Power Plants (during the Construction Phase).

ANSI/IEEE Std 100-1977, Standard Dictionary of Electrical and Electronics Terms.

IEEE Std 308-1978, Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

IEEE Std 380-1975, Definitions of Terms Used in IEEE Standards on Nuclear Power Generating Stations.

IEEE Std 384-1977, Standard Criteria for Independence of Class 1E Equipment and Circuits.

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 definitions of terms or phrases used in this document may be found by referring to ANSI/IEEE Std 100-1977, Standard Dictionary of Electrical and Electronics Terms, and IEEE Std 380-1975, Definitions of Terms Used in IEEE Nuclear Power Generating Stations Standards.

base line data. Information retained for the purpose of evaluation against repeated information in order to establish trends in parameters.

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 the prede-

terminated value. Controllers, as used in electric pipe heating systems, regulate temperatures on the system and can be referred to as *temperature controllers* or *thermostats*. Controllers can be mechanical (bulb, bimetallic) or electrical (thermocouple, RTD, thermistor).

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. An example of an important or critical mechanical piping system would be the safety injection system.

electrical insulation, insulation (cable). A part that is relied upon to insulate the conductor from other conductors or conducting parts or from ground. Electrical insulation as related to electric pipe heating systems includes that part of a heater that electrically insulates the current carrying conductor(s) from the sheath material.

electric pipe heating system. A system of components and devices consisting of electric heaters, controllers, sensors, dedicated power systems components such as transformers, panelboards, cables and system alarm devices (as required), which, when taken together as a system, is used to increase or maintain the temperature of fluids in mechanical pipes, valves, pumps, tanks, instrumentation, etc. Electric pipe heating systems are sometimes referred to as *heat tracing* or *trace heating systems*.

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 outdoor piping, pumps, valves, tanks, instrumentation, etc., such as water lines.

heater, electric heater, heating element. A length of resistance material connected between terminals and used to generate heat electrically. Heaters, as used in this application, can take the form of cables with various sheath materials, blankets, and pads.

heat sink. A part that absorbs heat. Heat sinks, as related to electric pipe heating systems, are those masses of materials that are directly

connected to mechanical piping, valves, tanks, etc that can absorb the heat generated by heaters, thus reducing the effect of the heater. Typical heat sinks can be pipe hangers, valve operators, 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.

redundant, redundancy. The introduction of auxiliary elements and components to a system to perform the same function as other elements in the system for the purpose of improving reliability. Redundant electric pipe heating systems consist of two heaters and two controllers, each with its own sensor, supplied from two power systems, all independent of each other but all applied to the same mechanical piping, valves, tanks, etc. Redundant electric pipe heating systems are referred to as *primary* and *backup* in this recommended practice.

sensor, sensing element. The first system element that responds quantitatively to the measurand 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. Sensors can be mechanical (bulb, bimetallic) or electrical (thermocouple, RTD, thermistor).

thermal insulation. A material having a relatively high resistance to heat flow and used primarily to retard the flow of heat.

4. Design of Electric Pipe Heating Systems

The function of an electric pipe heating system is to provide, to an insulated mechanical piping system, heat that will maintain the fluid in the system within its specified operating temperature range. On some occasions, heatup of the fluid to its operating temperature range may be required. Various thermal, physical, mechanical, electrical, and operational design parameters should be considered to ensure proper design of the electric pipe heating system. The mechanical and electrical properties

of the heating system should not be impaired by continuous or intermittent operation under the environmental and operating conditions specified.

4.1 Identification of Requirements. An electric pipe heating system design should clearly identify the thermal, physical, mechanical, electrical, and system associated requirements such as hazardous and corrosive environments.

4.1.1 Piping and Related Equipment to be Heated. To determine the heating requirements of a mechanical piping system, it is necessary to know the following:

- (1) Lowest expected ambient temperature
- (2) Desired maintain temperature
- (3) Maximum operating temperature
- (4) Pipe size, length, and material
- (5) Type and number of valves
- (6) Type and number of pipe joints
- (7) Type and number of hangers and supports
- (8) Flow patterns
- (9) Insulation thickness and dimensions
- (10) Insulation *K* factor
- (11) Heatup requirements
- (12) Type of control
- (13) Wind factor (if outdoors)
- (14) High and low alarm points (when required)
- (15) Number, size, and length of vertical pipe runs

It is important to determine specifically any additional heat required for pipe hangers, supports, and restraints that cannot be completely or properly insulated to avoid their being heat sinks. Small tanks, pumps, and other irregular surfaces may require separate enclosures, heaters, and controls for system integrity and maintenance considerations. Large insulated tanks may use surface, immersion, or circulation type heaters. Equipment such as *canned* pumps that utilize heated enclosures should have provisions for heat release when the pumps are running. Other lines that may require heating are instrument, drain and sample lines. Unheated piping that interfaces with piping to be heated can create a large heat sink. Thus heating circuits may be necessary to heat portions of the interface piping.

Special consideration should be given when heating plastic pipe to ensure that the maximum sheath temperature of the heater is below the maximum allowable temperature of the

pipe material. Since the thermal conductivity of plastic is much lower than that of steel, the electric pipe heating design should take into consideration this resistance to heat flow through the pipe wall.

4.1.2 Heater Requirements. Heater requirements should take the following into consideration:

4.1.2.1 Maintained Process Temperature. Some process systems require that the fluids being carried by the pipe be *maintained* at a temperature consistent with the temperature at which the fluid enters the system, the solubility level of the fluid or its viscosity, or both, and the end-use requirements.

Examples of such process systems are:

- (1) Boron recovery
- (2) Safety injection
- (3) Chemical and volume control
- (4) Liquid waste disposal
- (5) Sodium pentaborate
- (6) Sodium
- (7) Solid waste disposal
- (8) Waste management
- (9) Caustic soda
- (10) Standby liquid control
- (11) Fuel oil
- (12) Containment gas analysis

The amount of heat applied to maintain a fluid at a given temperature should be sufficient to replace the losses through the thermal insulation and heat sinks at a temperature above the controller turnoff point.

Any static piping system with a requirement for maintained process heating may be initially filled at operating temperature, or considerable time (days) allowed for heatup.

4.1.2.2 Heatup Requirements. Some process systems require that the fluids be increased in temperature. When electric pipe heating systems are used in such capacities, it is necessary to supply additional heat above that required to maintain the operating temperature. The extent of the additional heating will depend on the maximum temperature required, the lowest starting temperature, the process flow rate, the length of time specified to reach the heatup temperature, and the specific heat of the process, pipe, and insulation.

4.1.2.3 Freeze Protection Requirements. Where process or storage systems are subject to temperatures that can fall below the freezing temperatures of the fluid, it becomes necessary