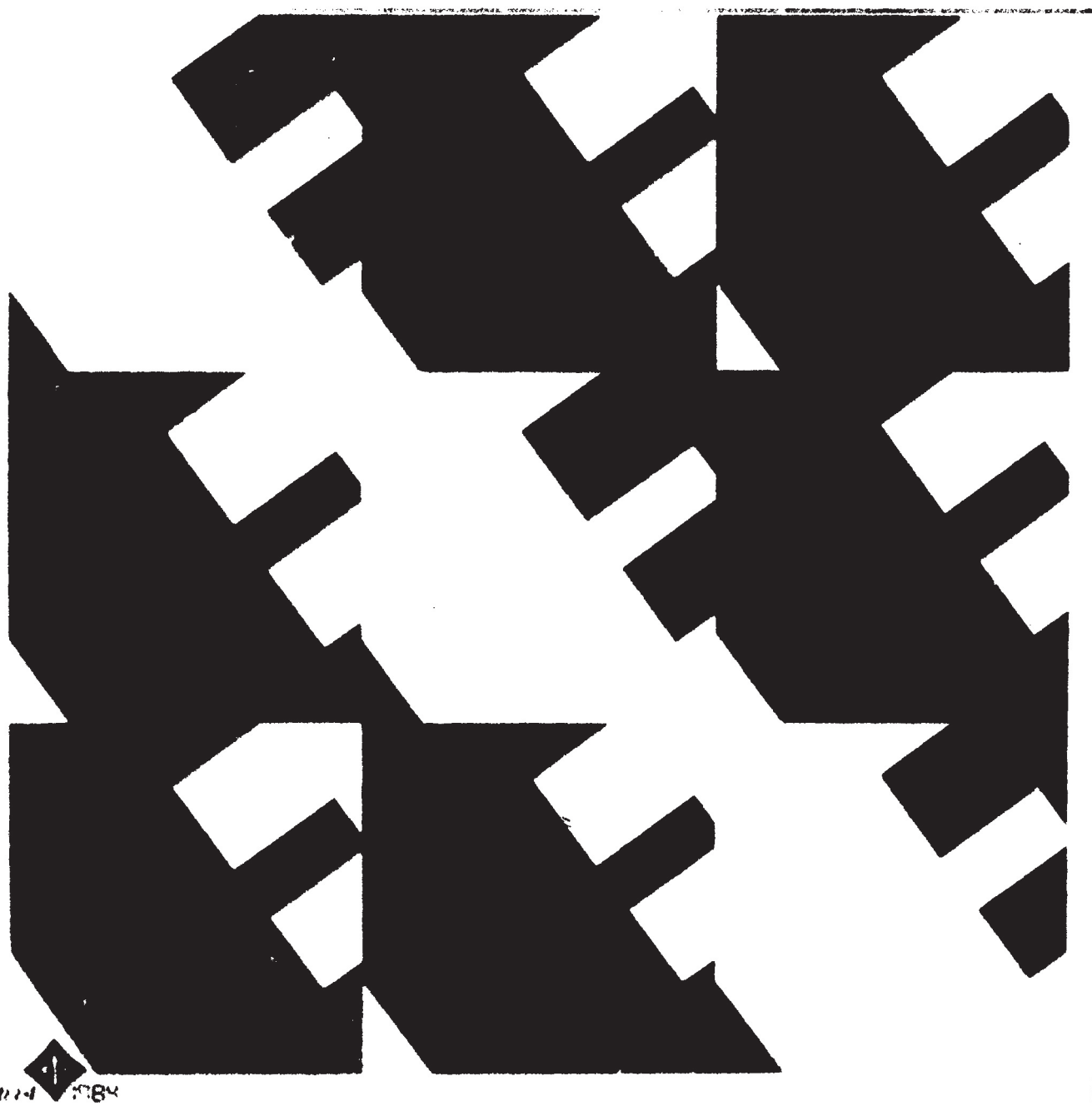


IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

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IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

**Sponsor
Petroleum and Chemical Industry Committee
of the
Industry Applications Society**

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Foreword

(This Foreword is not a part of IEEE Std 515-1983, IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.)

The utilization of electrical resistance heat tracing by industry has steadily increased because of the availability of more reliable products and efficient operation. The need for broad-based technical information about electrical resistance heat-tracing systems and uniformity in the approval process for these systems provides the necessity for this recommended practice.

IEEE Std 515-1983 provides the specific test requirements for qualifying electrical resistance heating cables for industrial service, and provides the basis for electrical and thermal design. Type and routine production tests are outlined in this recommended practice and address such topics as mechanical durability, resistance to moisture, and electrical and thermal ratings. This recommended practice outlines specific recommendations for the utilization of thermal insulation systems in conjunction with electrical resistance heat tracing. Installation and maintenance requirements are detailed and include electrical and mechanical requirements, along with those management functions which should be considered.

Detailed technical information and equations with examples on the thermal relationships important to electrical resistance heat tracing are presented in the Appendixes.

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IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

1. Scope

This recommended practice provides recommendations for the testing, design, installation, and maintenance of electrical resistance heat tracing in general industries as applied to mechanical piping and equipment. The electrical resistance heat tracing is in the form of series-heating cables and parallel-heating cables. The recommendations also include test criteria to determine the suitability of heating cables which are utilized for these applications.

2. Purpose

The provisions of this recommended practice should ensure that process, fluid, or material temperatures are maintained and provide electrical, thermal, and mechanical durability to the heat tracing system, such that in normal use its performance is reliable and without danger to the user or surroundings. This recommended practice is a supplement to those provisions outlined in ANSI/NFPA 70-1981 [3]¹, Article 427.

3. References

- [1] ANSI/ASTM C450-76, Recommended Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.²
- [2] ANSI/ASTM C585-76, Recommended

Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).

[3] ANSI/NFPA 70-1981, National Electrical Code.³

[4] FEDERAL ENERGY ADMINISTRATION. Economic Thickness for Industrial Insulation. *Energy Conservation Paper* no 46, Aug, 1976.

[5] NFPA, 325M-1977, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.

[6] TURNER, WILLIAM C., and MALLOY, JOHN F. *Handbook of Thermal Insulation Design Economics for Pipes and Equipment*. Robert E. Kruger Publishing Company, McGraw-Hill Book Company: New York, 1980.

4. Definitions

The following definitions apply to the subject matter presented in this recommended practice.

ambient temperature. The temperature surrounding the object under consideration. Where electrical heating cable is enclosed in thermal insulation, the ambient temperature is the temperature exterior to the thermal insulation.

cold-end terminations (CET). The termination applied to the end of a heating cable where the power is supplied.

¹The numbers in brackets correspond to the references listed in Section 3 of this recommended practice.

²ANSI documents are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

³The National Electrical Code is published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. Copies are also available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

cold lead. An electrically insulated conductor used to connect a heating conductor to the branch-circuit conductors and designed so as not to produce any appreciable heat.

conductor temperature. The temperature of the heat-producing element.

dead leg. A segment of process piping that is not in the normal flow pattern.

factory fabricated. A heating cable assembled by the manufacturer, including hot- and cold-end terminations and cold lead.

field assembled. Heating cable supplied in bulk form with terminating components to be assembled (terminated) by field personnel.

heat loss. A quantitative value of energy flow from a pipe, vessel, or equipment to the surrounding ambient.

heat sink. A part that conducts and dissipates heat away from the pipe or equipment. Heat sinks, as related to pipe heating systems, can be pipe supports, valve operators, etc.

heat tracing. The utilization of electric heating cables, other electric heating devices, and support components that are externally applied and used to maintain or raise the temperature of fluids in piping and associated equipment.

heat-transfer aids. Thermally conductive materials, such as metallic foils or heat-transfer cements, used to increase the heat-transfer rates from the heating cables to the process piping or equipment.

high-limit temperature. The maximum allowable heat-tracing system temperature.

hot-end termination (HET). The termination applied to the end of a heating cable, opposite where the power is supplied.

jacket. A thermoplastic or thermosetting plastic covering, sometimes fabric reinforced, applied over the insulation, core, metallic sheath, or armor of a cable.

maintain temperature. Specified temperature of the fluid or process material which the heat tracing is designed to hold at equilibrium under specified design conditions.

maximum exposure temperature. The highest temperature to which a device in the heat-

tracing system may be exposed for a given period of time.

metallic outer covering. A metal sheath or braid used to provide physical protection for heating cable and, in some cases, to provide an electrical ground path.

over-size insulation. A term applied to thermal insulation when the inside diameter of the thermal insulation must be larger than the nominal outside diameter of a particular pipe so as to accommodate the heating cable.

parallel heating cable. Heating elements that are electrically connected in parallel, either continuously or in zones, so that watt density per lineal length is maintained irrespective of any change in length for the continuous type or for any number of discrete zones.

rated output. Total wattage or watt/unit length of heating cable, at rated voltage, temperature and length.

rated voltage. The voltage to which operating and performance characteristics of heating cables are referred.

routine test. A test which is carried out by the manufacturer of the heating cable during the production process.

runaway pipe temperature. The highest equilibrium pipe temperature that occurs when the heating cable is continuously energized at the maximum ambient.

series heater. Heating elements that are designed to have a specific resistance at a given temperature for a given length.

sheath. The outermost continuous covering for a cable.

sheath temperature. The temperature of the outermost continuous covering that may be exposed to the surrounding atmosphere.

temperature sensor (sensing element). A device that responds to temperature and provides an electrical signal or mechanical operation.

thermal insulation. Material having air- or gas-filled pockets, void spaces, or heat-reflective surfaces which, when properly applied, will retard the transfer of heat with reasonable effectiveness under ordinary conditions.

type test. A test or series of tests carried out on

equipment, representative of a type, to determine compliance of the design, construction, and manufacturing methods within the requirements of this recommended practice.

watt density. Thermal output of heating cable in watts per unit area.

weather barrier. Material that, when installed on the outer surface of thermal insulation, protects the insulation from weather, such as rain, snow, sleet, wind, solar radiation, or atmospheric contamination, and physical damage.

5. General Product Testing

5.1 Type Test. The following tests are intended to qualify a particular heating cable construction for the applications within the scope of this recommended practice. A sample of heating cable at least 3 m (10 ft) in length, unless otherwise specified, should be selected for testing.

5.1.1 Dielectric Test. The dielectric test should be performed by the manufacturer on heating cables in accordance with the following table:

Voltage Class	Test Voltage (V rms)
< 30 V rms	500
< 60 V dc	500
≥ 30 V rms	$2E + 1000$
≥ 60 V dc	$\sqrt{2}E + 1000$

The test where E = rated voltage should be applied at a rate of rise neither less than 100 V nor more than 200 V/s and maintained for 1 min without dielectric breakdown. The test voltage waveform should be essentially sinusoidal, with a frequency of 45 Hz to 65 Hz.

The test voltage should be applied between each heating conductor and the metallic covering, or a specially applied conductive metal tape or braid.

5.1.2 Insulation Resistance Test. The insulation resistance should be measured on the sample immediately after the voltage test specified in 5.1.1. The resistance of the insulation should be measured between conductors and the metallic outer covering, or a specially applied conductive metal tape or braid, by

means of dc voltage of 500 V. The measured value should not be less than 50 MΩ.

5.1.3 Water-Resistance Test. A sample should be immersed (except at terminations, or ends where the conductors are exposed) in water at 10 °C–25 °C (50 °F–77 °F) for a period of 14 days.

Within 1 h after conditioning as above, the sample should be subjected to the dielectric test outlined in 5.1.1.

5.1.4 Dielectric Test at Elevated Temperatures. A sample should be placed in a forced-circulation air oven. The oven should be heated to, and maintained at, a temperature of 25 °C ± 5 °C (77 °F ± 9 °F) higher than the maximum exposure temperature declared by the manufacturer for a period of 14 days.

The sample should, after removal from the air oven, and when cooled to room temperature, show no cracks when examined with normal vision and when wound six close turns around a metal mandrel having a radius equal to six times the diameter, or primary bending plane over the insulation. While still on the mandrel, the sample, except at terminations or ends where the conductor is exposed, should be submerged in a 5% saltwater solution at 10 °C–25 °C (50 °C–77 °F) for 5 min. While still in the salt water, the dielectric test outlined in 5.1.1 should be applied.

5.1.5 Deformation Test. A sample, 200 mm (8 in) in length, should be used for testing. The ends of the unterminated samples should be stripped back to expose the conductors. The sample should be placed on top and at right angles to a 6 mm (0.25 in) diameter steel rod, resting on a flat steel support. Proof loading shall be gradually applied without shock at the point of intersection of the specimen and the steel rod by means of a rigid square pressure plate having face dimensions of 100 mm (3.937 in) × 100 mm (3.937 in).

The proof load to be applied by means of the pressure plate shall be either a gravitational force load of 102 kg (225 lb) or a mechanical force load of 1 kPa (225 lbf/in²). After not less than 30 s and with the proof loading continuously applied, the dielectric test outlined in 5.1.1 should be conducted.

The test voltage should be applied between each heating conductor and the metallic covering, or where metallic covering is not provided, between each heating conductor and the steel rod.

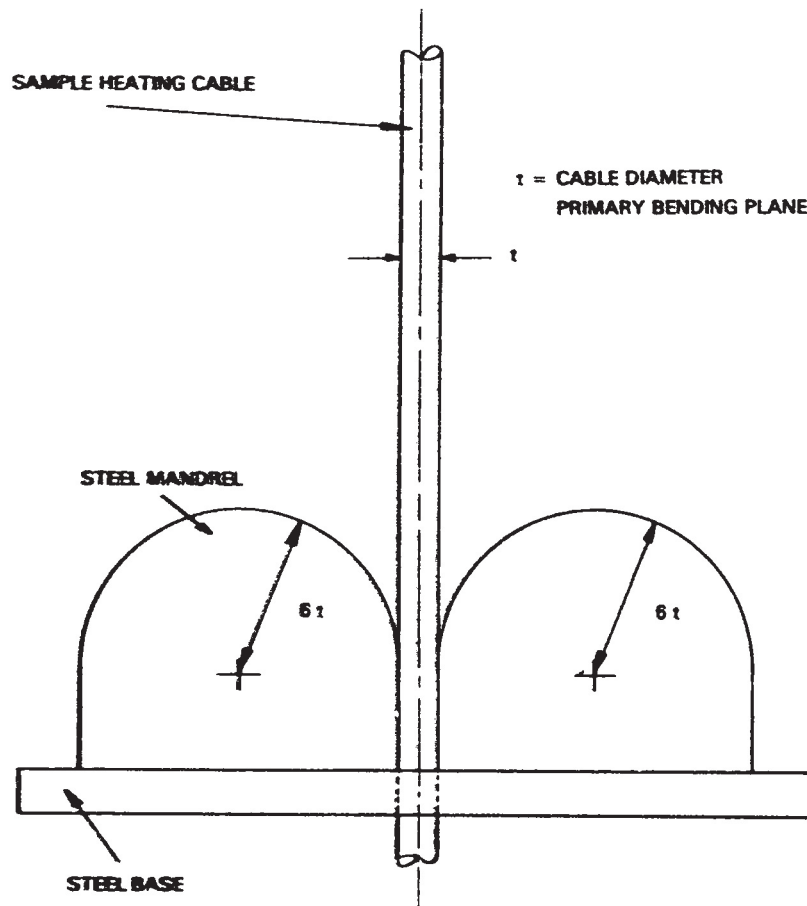


Fig 1
Cold Bend Test Apparatus

5.1.6 Impact Test. This test should be conducted on a sample which is positioned on a hardened steel plate and conditioned to the manufacturer's minimum recommended installation temperature.

After conditioning, a sample should be subjected to the impact forces of a 5.08 cm (2 in) diameter cylindrical steel plunger with smoothly rounded edges, having a mass of 1.8 kg (4 lb) and allowed to free fall from a height of 76.2 cm (30 in). With the 1.8 kg (4 lb) weight resting on the sample, the dielectric test outlined in 5.1.1 should be conducted. The voltage should be applied between each heating conductor and the test weight (and steel plate) with no breakdown. After testing, the sheath should not show cracks when examined with normal vision.

5.1.7 Cold Bend Test. The apparatus used for the bend test should be as represented in Fig 1.

A sample of heating cable or cold lead should be fixed in the apparatus as shown in Fig 1. With the test sample in position, the apparatus should be placed in a refrigerated compartment and maintained at the lowest installation temperature recommended by the manufacturer for a period of not less than 4 h. At the end of this period, and with the sample maintained at the minimum installation temperature, the sample should be bent through 90° around one of the bending mandrels, then bent through 180° in the opposite direction over the second bending mandrel and straightened to its original position. All the bending operations should be carried out in the same plane. This cycle of operations should be performed three times.

After completion of the above, the sample should be submerged in a 5% saltwater solution