

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

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Abstract: Specific test requirements for qualifying electrical resistance heating cables for commercial service and a basis for electrical and thermal design are provided. Heater characteristics are addressed and installation and maintenance requirements are detailed. Recommendations and requirements for unclassified heating cable applications are provided.

Keywords: design, electrical resistance, heater, heating cable, heat tracing, installation, maintenance, testing

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Introduction

(This introduction is not a part of IEEE Std 515.1-1995, IEEE Recommended Practice for the Testing, Design Installation, and Maintenance of Electrical Resistance Heat Tracing for Commercial Applications.)

The utilization of electrical resistance heat tracing in the commercial construction industry has increased steadily due to the availability of more reliable products and more efficient operation. The need exists for broad-based technical information about electrical resistance heat tracing systems. In the construction industry, these systems are used for temperature maintenance of domestic hot water, general freeze protection of piping and drain lines, roof and gutter deicing, snow melting of concrete and asphalt embankments, frost heave protection of freezer floors in cold storage warehouses, and floor warming as an enhancement for the comfort of office personnel. The approval process for these systems provides the basis for this recommended practice.

This recommended practice provides specific test requirements for qualifying electrical resistance heating cables for commercial construction and a basis for electrical and thermal design. Type and routine production tests are outlined in this recommended practice and address such subjects as mechanical durability, resistance to moisture, and electrical and thermal ratings. This recommended practice outlines specific recommendations dealing with the installation of electrical resistance heat tracing systems for the intended use.

This recommended practice was developed by members of the 515.1 Working Group, with technical input from a panel of invited experts. The expertise of the panel members within their respective engineering firms includes the development of specifications and circuit designs for electrical resistance heat tracing for one or all of the applications included herein.

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

1. Overview

1.1 Scope

This recommended practice provides detailed recommendations for the testing, design, installation, and maintenance of electrical resistance heat tracing in commercial applications. Commercial applications include installations inside and outside of commercial business buildings, such as office buildings, hospitals, and airports. Typical applications include freeze water pipes; temperature maintenance of hot water piping and other lines and tubing; protection of sprinkler systems; roof, gutter, and pavement deicing; and other applications as shown in table 1. The recommendation also include test criteria to determine the suitability of heating cables and fittings that are utilized for these applications.

Commercial applications involving hazardous (classified) locations *should meet* the requirements in IEEE Std 515-1989¹ in addition to the requirements in this document.

1.2 Purpose

The provisions of this recommended practice should ensure that adequate material temperatures are maintained, and that electrical, thermal, mechanical, and water-exclusion durability are provided to the heat tracing system. In addition, it should provide that under normal use the products will exhibit long term performance reliability without damage to the user or surroundings. This recommended practice is a supplement to those provisions outlined in ANSI/NFPA 70-1993, Articles 426 and 427.

¹Information on reference can be found in clause 2.

2. References

This recommended practice shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ANSI/NEMA 250-1991, Enclosures for Electrical Equipment (1000 Volts Maximum).²

ANSI/NFPA 70-1993, National Electrical Code (NEC).³

ANSI/UL 50-1987, Cabinets and Boxes.⁴

ASTM D5025-91, Specification for a Laboratory Burner Used for Small-Scale Burning Tests in Plastic Materials.⁵

ASTM D5207-91, Practice for Calibration for 20 mm and 125 mm Test Flames for Small-Scale Burning Tests on Plastic Materials.

ASTM G26-93, Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials.

IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI).⁶

IEEE Std 515-1989, IEEE Recommended Practice for the Testing, design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications (ANSI).

3. Definitions

The following definitions apply to the subject matter presented in this recommended practice. Electrical and electronic terms used in this recommended practice are defined in IEEE Std 100-1992 .

3.1 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.

3.2 connections: In-line and tee splices that are designed to join heating cables or heating cables and power leads.

3.3 dry location: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

3.4 electrical resistance heat tracing: The utilization of electric heating cables, other electric heating devices, and support components that are externally applied and used to reduce or eliminate ice build-up, to prevent the freezing of pipes or surfaces, or to maintain a pipe or surface at a prescribed temperature.

3.5 end termination: The termination applied to the end of the heating cable, opposite the power supply end.

3.6 factory fabricated: A heating cable assembled by the manufacturer, including terminations and connections.

3.7 field assembled: Heating cable supplied in bulk form with terminating components and connections to be assembled by field personnel.

²ANSI/NEMA publications are available from the National Electrical manufacture Association, 2101 L Street NW, Suite 300, washington, DC 20037, USA.

³ANSI/NFPA publications are available from Publication Sales, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

⁴ANSI/UL publications are available from Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, USA

⁵ASTM publications are available from the Customer Service Department, American society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.

⁶IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

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

3.9 high profile: Terminations or connections designed for use outside of thermal insulation, or away from the surface being heated.

3.10 high-resistance sheath: A metallic covering with a characteristic resistance at a level high enough to prevent usage as an effective ground path. More specifically, it is a metallic covering that either does not have a conductance greater than or equal to that of the largest conductor under evaluation, based on the resistance of an equivalent sized copper conductor, or is incapable of passing an overcurrent test at levels of 1.10, 1.35, and 2.00 times the maximum branch circuit overcurrent protection for 7 h, 1 h, and 2 min, respectively.

3.11 jacket: A polymeric sheath, sometimes fabric reinforced, applied over the insulation or core of a cable.

3.12 low profile: Terminations or connections designed to be an integral part of the heating cable.

3.13 maximum exposure temperature: The highest temperature to which a component of the heat-tracing system may be exposed either continuously or for a specified period of time.

3.14 maximum maintain temperature: Specified maximum temperature of a surface or process which the heat tracing is capable of maintaining continuously.

3.15 metallic covering: A metal sheath or braid used to provide physical protection for heating cable and, usually, to provide an electrical ground path.

3.16 operating voltage: The actual voltage applied to the heating cable when in service.

3.17 overjacket: A polymeric sheath, sometimes fabric reinforced, applied over the metallic covering.

3.18 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.

3.19 power connection: The connection between the heating cable and incoming power.

3.20 rated output: Total power or power/unit length of heating cable, at rated voltage or current, maintain temperature, and length, normally expressed as W/m or W/ft.

3.21 rated voltage: The voltage to which the operating characteristics of the heating cable are referred.

3.22 routine test: A test that is carried out by the manufacturer of the heating cable on all cables during or after the production process.

3.23 series heating cable: Heating elements that are electrically connected in series with a single current path and have a specific resistance at a given temperature for a given length.

3.24 sheath: A continuous covering for a cable.

3.25 sheath temperature: The temperature of the outermost sheath that may be exposed to the surrounding atmosphere.

3.26 start-up current: The transient current of a heating cable immediately following energization.

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

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

3.29 type test: A test or series of tests carried out on heating cables and accessories, representative of a type, to determine compliance of the design, construction, and manufacturing methods within the requirements of the specified standard (in this case, IEEE Std 515.1-1995).

3.30 weather barrier: Material that, when installed on the outer surface of thermal insulation, protects the insulation from water or other liquids; physical damage caused by sleet, wind, or mechanical abuse; and deterioration caused by solar radiation or atmospheric contamination.

4. General product testing

4.1 Type test—general requirements

Products intended for use in commercial applications should meet the requirements of the type tests given in 4.2. Products intended for type B, C, and D applications (as defined in table 1) should also meet the requirements of 4.3, 4.4, and 4.5, respectively.

Terminations and connections to be installed as an integral part of the heating cable, whether intended to be factory fabricated or field assembled, should be subjected to the same type tests as the heating cable, except where otherwise noted. These should include low-profile power connections, splices, and end terminations, as well as gland fittings or seals where a cable enters a termination enclosure.

Tests should be conducted at room temperature between 10 °C and 40 °C (50–104 °F) unless otherwise noted.

4.2 Type test—insulated surfaces

Heat tracing systems intended for installations on thermally-insulated surfaces, such as insulated pipes, tanks, and tubing (type A applications as defined in table 1) should meet the requirements of 4.2.1–4.2.15.

4.2.1 Dielectric test

The dielectric test should be performed on a minimum 15 m (50 ft) sample length of bulk heating cable in accordance with the following:

Rated voltage	Test voltage (Vac rms)
<30 Vrms	500
<60 Vdc	500
≥30 Vrms	$2E + 1000$
≥60 Vdc	$\sqrt{2E} + 1000$

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

Table 1—Commercial cable installation type

Installation type	Type definition	Examples of type	Reference clause for general testing requirements
A	Insulated surfaces (including pipe)	Hot water lines Freeze protection Sprinkler systems Grease lines Fuel oil lines Pre-insulated pipe Below grade tracing	4.1 and 4.2
B	Outdoor exposed areas	Roof deicing Gutter and down spouts deicing Catch basins and drains	4.1, 4.2, and 4.3
C	Installations with embedded tracing	Embedded snow melting Embedded frost heave protection Embedded floor warming Embedded energy storage systems Embedded door frames	4.1, 4.2, and 4.4
D	Installations with tracing inside of conduit or piping	Snow melting cable in conduit Frost heave protection in conduit Floor warming in conduit Energy storage systems in conduit Enclosed drains and culverts	4.1, 4.2, and 4.5

The test voltage should be applied between the conductors and the metallic covering, or a specially applied conductive metal tape or braid. Alternatively, for heating cables without a metallic covering, the dielectric test may be conducted by submerging the cable in tap water at room temperature (resistivity of tap water typically 50 000 Ωcm). The test voltage should be applied between the conductors and the water.

4.2.2 Insulation resistance test

The insulation resistance should be measured on the above sample after the dielectric test specified in 4.2.1 is completed. The resistance of the insulation should be measured between conductors and the metallic covering, or a specially applied conductive metal tape or braid, by means of dc voltage of 500 V. For heating cables without a metallic covering, the dielectric test may be conducted by submerging the cable in tap water at room temperature (resistivity of tap water typically 50 000 Ωcm). The test voltage should be applied between the conductors and the water. The measured value should not be less than 50 M Ω for all cases.

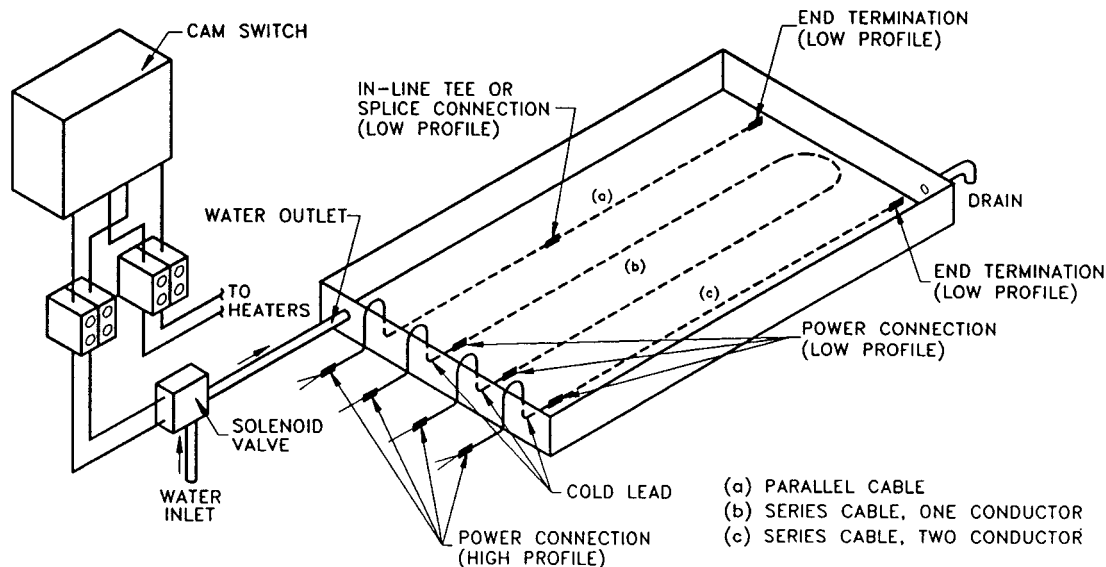


Figure 1—Heating cable termination test apparatus

4.2.3 Water resistance test

A minimum 3 m (10 ft) sample, including terminations and connections, should be immersed in water at 10–25 °C (50–77 °F) for a period of 336 h (14 days).⁷ After the conditioning period, the sample should be subjected to the dielectric voltage outlined in 4.2.1 for 1 min without dielectric breakdown.

4.2.4 Terminations and connections resistance to water test

A sample of heating cable at least 3 m (10 ft) in length with factory- or field-assembled terminations and connections (as specified in 4.1) should be placed in a water flow and drain apparatus as shown in figure 1.⁸ Water flow should be initiated until the heating cable, terminations, and connections are completely covered. At that point, the water flow is stopped and the cable is energized. The apparatus is then drained. The total time from the initiation of water flow to the completion of draining should be no greater than 4.5 min. The cable will continue to be energized for 30 s after the water has been drained. At that point, water flow is initiated for the second cycle and the cable is de-energized. The test should be continued for 300 cycles. After completion, the dielectric voltage outlined in 4.2.1 should be applied for 1 min without dielectric breakdown.

4.2.5 Elevated temperature exposure test

A minimum 3 m (10 ft) sample, including connections and terminations, should be placed in a forced-air convection oven. The oven temperature should be set to a level 25 °C ± 5 °C (45 °F ± 9 °F) above the maximum exposure temperature declared by the manufacturer. This level of exposure should be maintained for a period of 336 h (14 d).

A straight length of the conditioned heating cable (without terminations or connections) should be wound six close turns around a mandrel having a radius equal to one of the following two criteria:

- a) Six times the diameter of the primary bending plane or thickness of the heating cable
- b) The manufacturer's stated minimum bend radius

⁷Terminations and connections for systems intended strictly for use in dry and accessible locations are not subject to this test.

⁸See footnote 7.

While still on the mandrel, the sample, except at one end where the conductors are exposed, should be submerged in tap water at 10–25 °C (50–77 °F) for 5 min. While still in the tap water, the dielectric voltage outlined in 4.2.1 should be applied for 1 min without dielectric breakdown. Overjackets subjected to this procedure should have a dielectric voltage of 500 Vac applied across the overjacket, between the metallic covering and water, for 1 min without dielectric breakdown.

4.2.6 Performance after thermal aging

Three randomly selected cable samples representing the maximum rated output of all cables under evaluation should be tested. If the set of cables has different levels of rated voltages, then the cables selected should represent the lowest rated voltage level and the maximum rated output. Three randomly selected cable samples representing the maximum rated voltage and the minimum rated output should also be tested.

Samples should be terminated according to the manufacturer's specifications, such that an effective heating length of at least 0.61 m (2 ft) is provided. Before determining the initial values, the samples should be conditioned by exposure to the aging temperature of the test for 120 h $\pm$ 24 h. The aging temperature should be the maximum declared maintain temperature of the heating cable. The initial output of the samples is then to be determined by one of the three methods given in 4.2.11, with the exceptions of sample length and number of test temperature points for the procedure in 4.2.11, item c). For this case, the heating cable should be evaluated at rated voltage and at the manufacturer's stated reference temperature for rated output. The rated output should be equal to or greater than the manufacturer's stated rated output.

The cable samples should be maintained at the specified aging temperature to a $\pm$ 1 °C ($\pm$ 2 °F) tolerance for 5000 h. The cables should be operated at rated output for series cable or rated voltage for parallel cable. The power supply should be attached to a 15 min cycle timer such that the cables are energized for 12 min and de-energized for 3 min. At the end of the 5000 h period, the output of the samples should be determined by the same procedure as utilized for the initial readings. The percent change relative to the initial output should be calculated. These values should not show a change of more than 25% or 6.5 W/m (2 W/ft), whichever is less, from the initial wading. For a parallel cable with zones, all zones should remain functional.

4.2.7 Flammability test

A flammability test should be performed on samples of heating cables, terminations, and connections. The full range of sizes should be capable of complying with the test. The test should be conducted in a three-sided metal cabinet having dimensions of 30 cm (12 in) wide, 35 cm (14 in) deep, and 65 cm (25 in) high. The cabinet in which the test is conducted should be in a draft-free room or chamber. A specimen of heating cable at least 46 cm (18 in) in length should be supported in a vertical position. A gummed kraft paper indicator should be wrapped once around the specimen such that it projects 2 cm (0.75 in) from the specimen.

The paper indicator should be positioned 25 cm (10 in) above the point at which the inner blue cone of the flame contacts the specimen. In addition, a layer of dry, untreated surgical cotton not more than 0.6 cm (0.25 in) in depth should be placed underneath the sample, such that the distance from the cotton to the point of the flame application is 23–24 cm (9–9.5 in).

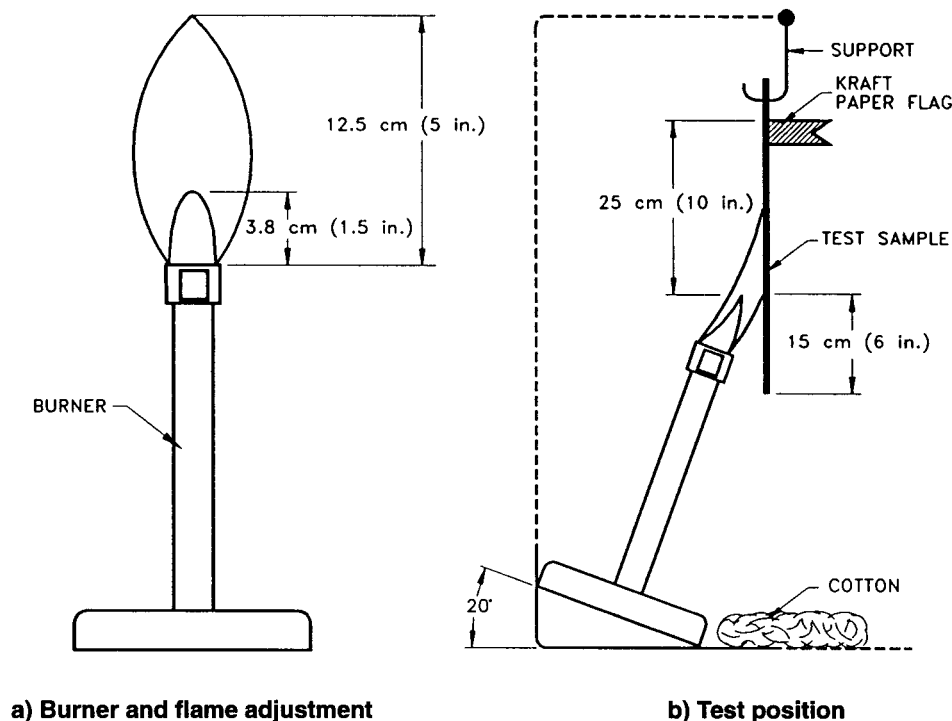


Figure 2—Flammability test

A standard laboratory burner, as described in ASTM D5025-91, should be used for the test. The gas flame produced by the burner is to be calibrated as described in ASTM D5207-91. The fuel should be methane, propane, or natural gas, and should be of a grade suitable for calibration to the ASTM D5207-91 procedure.

As shown in figure 2, the flame should be adjusted to a 12.5 cm (5 in) length with a 3.8 cm (1.5 in) inner blue cone. The burner should be tilted to an angle of 20° from the vertical and the flame applied to the heating cable so that the tip of the inner blue cone of the flame touches the specimen at a point 25 cm (10 in) below the kraft paper flame indicator and approximately 15 cm (6 in) from the bottom of the specimen. For termination assemblies, the flame should be set such that it will contact the material at the most vulnerable point. Clamps used to support the specimen should be above the paper indicator and at least 8 cm (3 in) below the point of flame application.

The flame should be brought up to the heating cable in such a manner that the vertical plane containing the major axis of the burner tube should be at right angles to the specimen. The flame should be applied for 15 s, then removed for 15 s, until five such applications have been made.

The test results should be considered satisfactory if the heating cable does not

- Support combustion for more than 1 min after the fifth application of the flame
- Burn more than 25% of the extended kraft paper
- Ignite the cotton from burning falling particles

4.2.8 Deformation test

A sample of heating cable at least 20 cm (8 in) in length, as well as a sample of each type of termination and connection as defined in 4.1, should be used for testing. The ends of each sample should be stripped back, and sealed if necessary, to expose the conductors. Each sample should be placed on top and at right angles to a 0.6 cm (0.25 in) diameter steel rod, resting on a rigid flat steel support. Proof loading should 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 10×10 cm (3.94×3.94 in).

The proof load should be applied by means of the pressure plate and should be either a gravitational force load of 102 kg (225 lb) or an equivalent mechanical force load. After 30 s and with the proof loading continuously applied, the dielectric voltage outlined in 4.2.1 should be applied for 1 min without dielectric breakdown.

The test voltage should be applied between the heating cable conductors and the metallic covering, or where a metallic covering is not provided, between tile conductors and the steel rod.

4.2.9 Impact test

The impact test should be conducted on a sample of the heating cable and a sample of each type of termination and connection—both of which are conditioned along with a hardened steel plate for a minimum of 4 h at the manufacturer's minimum recommended installation temperature.

After conditioning and while still at the minimum recommended installation temperature, each component of the sample should be individually positioned on the steel plate. A 5.1 cm (2 in) diameter cylindrical steel plunger with smoothly rounded edges, having a mass of 1.8 kg (4 lb), should be allowed to free fall from a height of 76 cm (30 in), resulting in an impact energy of 13.6 J (10 ft·lb). The impacted portion of each sample should be immersed in tap water at room temperature for 5 min, and the dielectric voltage outlined in 4.2.1 should be applied for 1 min without dielectric breakdown. Overjackets subjected to this procedure should have a dielectric voltage of 500 Vac applied between the metallic covering and water for 1 min without dielectric breakdown.

4.2.10 Cold bend test

The apparatus used for the bend test should be as represented in figure 3, with the radius of the steel mandrels as shown, or with the radius equal to the manufacturer's stated minimum bend radius. A sample of heating cable without terminations and connections should be fixed in the apparatus as shown. The apparatus and sample should be placed in a refrigerated compartment and maintained at the minimum recommended installation temperature for a period of not less than 4 h. At the end of this period, the sample should be fixed in the apparatus as shown in figure 3. The sample should then be bent 90° around one of the bending mandrels, then bent through 180° in the opposite direction over the second bending mandrel and then straightened to its original position. All the bending operations should be carried out in the same plane. This cycle of operations should be performed knee times. When this has been completed, the sample should be immersed in tap water at room temperature for 5 min, and then the dielectric voltage outlined in 4.2.1 should be applied for 1 min without dielectric breakdown.

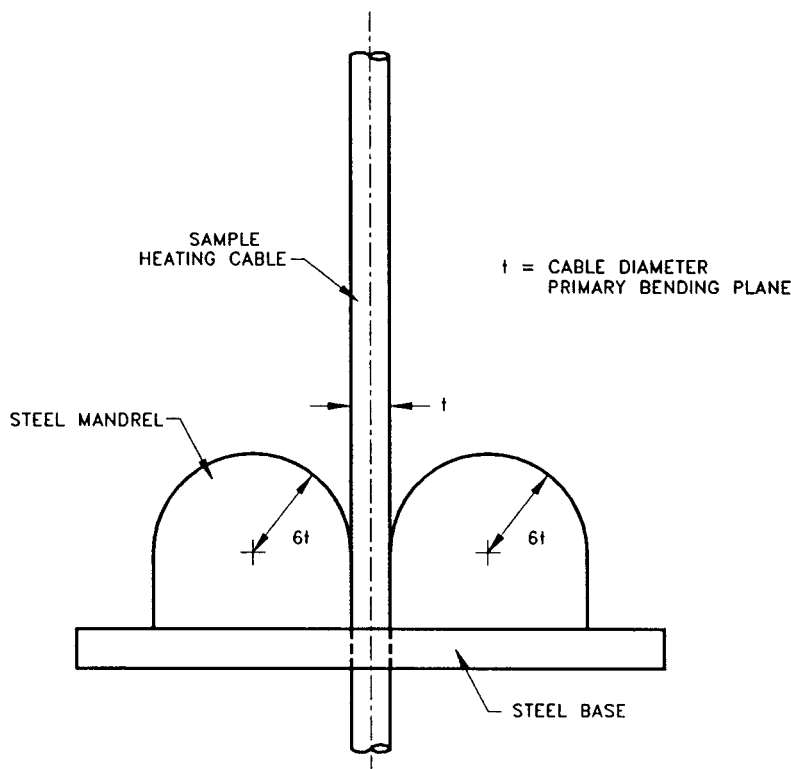


Figure 3—Cold bend test apparatus

4.2.11 Verification of rated output

The rated output of the heating cable should be verified by one of the following three methods:

- Conductance—the measured ac conductance per unit length at a specified temperature should be within the manufacturer's declared tolerance.
- Resistance—the measured dc resistance per unit length at a specified temperature should be within the manufacturer's declared tolerance.
- Thermal—heating cables that change power output with temperature should be measured by the installation of a 3–6 m (10–20 ft) sample on a schedule 40 carbon steel pipe of 5.1 cm (2 in) diameter or greater, as shown in figure 4. The cable should be installed in accordance with the manufacturer's instructions. The test apparatus should be completely covered with a fiberglass thermal insulation of 2.5 cm (1 in) or equivalent.

A suitable heat transfer fluid in the liquid phase should be circulated through the pipe at a sufficient rate to establish turbulent flow corresponding to a Reynolds number greater than 2300. This will establish negligible temperature difference between the fluid and the pipe temperature. Sufficient means should be utilized to maintain constant temperature of the heat transfer fluid. These parameters should be verified by thermocouples placed at the entry and exit ends of the pipe. Flow velocity should be sufficient so that the fluid temperature will not differ by more than 2 °C (3.6 °F) from end to end.

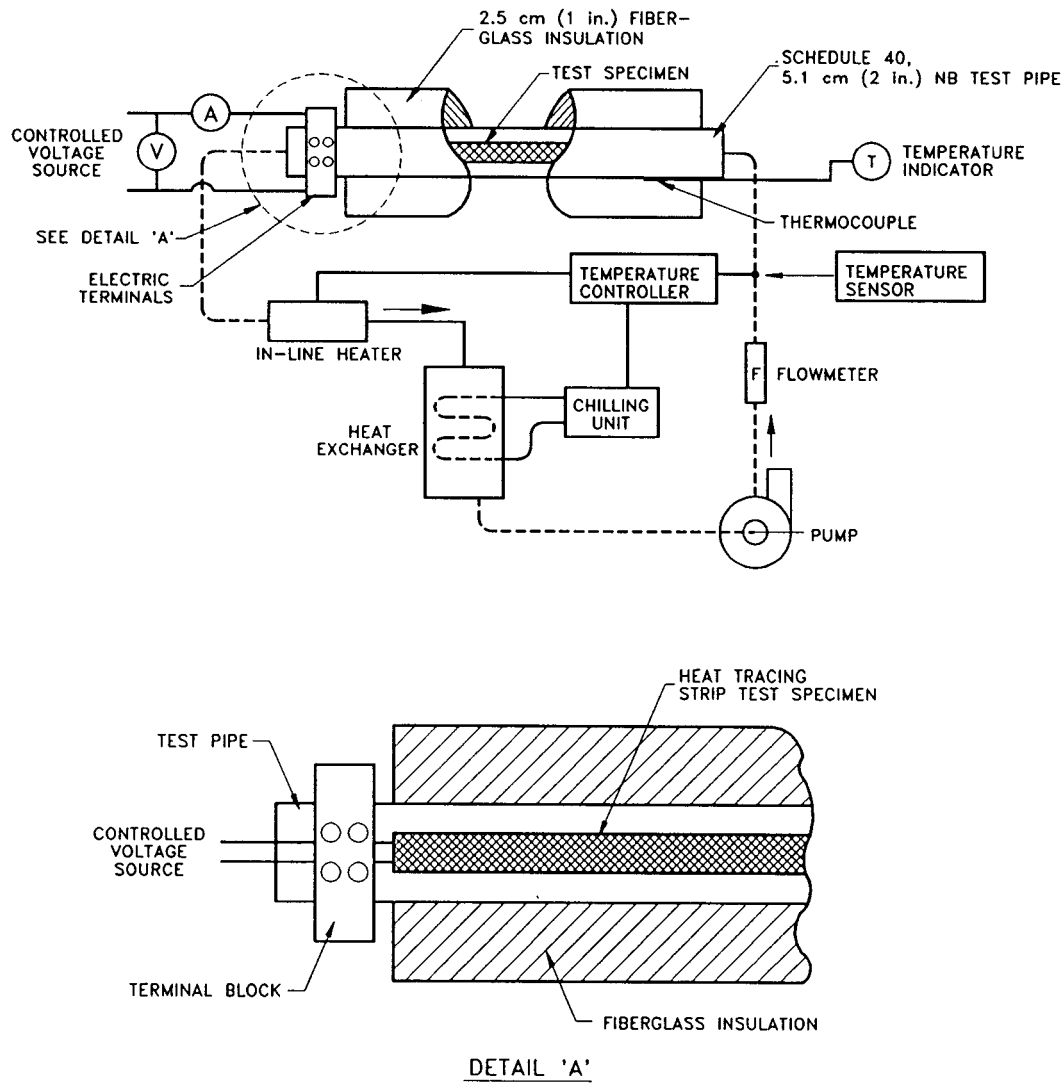


Figure 4—Verification of rated output

The thermal output of the heating cable should be measured at three pipe temperatures over the heater operating range. The heating cable should be powered at its rated voltage and allowed to attain equilibrium. The voltage, current, and fluid temperature should be recorded at each test temperature. Determinations should be made on knee separate samples. The resulting values should be within the manufacturer's declared tolerances.

4.2.12 Verification of start-up current

This test is applicable to heating cables that change output with temperature. The start-up current of the heating cable should be measured at the manufacturer's minimum designated start-up temperature. A sample of heating cable at least 1 m (3 ft) in length is installed in accordance with the manufacturer's instructions on a minimum 5.1 cm (2 in) diameter fluid-filled steel pipe or solid rod. The testing apparatus should be completely covered with thermal insulation and conditioned at the test temperature for at least 4 h. (The apparatus described in 4.2.11 can be used for this test.)

After the conditioning period, med voltage should be applied and the time/current characteristics should be recorded from time zero to at least 120 s. The start-up current reported should be the highest current response of three samples. This time-current characteristic should not be more than the value declared by the manufacturer.

4.2.13 Verification of metallic covering conductivity

A metallic covering should meet the requirements of 4.2.13.1, 4.2.13.2, or 4.2.13.3.

4.2.13.1 Grounded metallic covering—low impedance

If a metallic covering is intended to be a ground path, then the dc conductance should not be less than the conductance of the largest conductor under evaluation, based on the resistance of an equivalent mm² (AWG) copper conductor, but in no case less than 0.81mm² (18 AWG). This measurement should be performed with an ohmmeter and a specimen of sufficient length to provide an accurate reading within the meter's capability. The conductance per unit length should be established by taking the reciprocal of the resistance measured and multiplying it by the specimen length.

4.2.13.2 Grounded metallic covering—other than low impedance

Alternatively, the metallic covering may be evaluated by installing a 3 m (10 ft) long sample of heating cable on a flat horizontal surface that is both non-combustible and electrically non-conductive. The heating cable should be installed in three parallel runs and should not be kinked or crossed over itself. The distance between parallel runs should be 15 cm (6 in). A thermocouple should be affixed to the surface of the sample in the middle run to measure the sheath temperature. Four layers of cheesecloth should then be laid over the entire heating cable and thermocouple installation.

A 50 or 60 Hz variable voltage source should be connected across the ends of the metallic covering. A voltmeter and ammeter should be connected to measure the voltage and current of the test circuit. The variable voltage supply should be adjusted so that a three-stage test current, equal to the multiplier shown below times the maximum allowable branch circuit overcurrent protection specified by the manufacturer to which the unit can be connected in use, will flow through the metallic covering for the times specified below:

Test current = multiplier × maximum branch circuit overcurrent protection

<u>Stage</u>	<u>Multiplier</u>	<u>Test time</u>
1	1.10	7 h
2	1.35	1 h
3	2.00	2 min

The results of the test should be acceptable based on all of the following criteria:

- a) The cheesecloth does not ignite or smolder
- b) The cable insulation has no visible damage
- c) The sheath temperature does not exceed 200 °C as measured by the surface thermocouple

4.2.13.3 Bonding of metallic coverings

Metallic coverings not intended as a ground path (high resistance metallic sheath) should, however, be bonded to ground. Further, the heating cable package markings and set markings should conform to 5.2 and 5.3, respectively.

4.2.14 Strain relief test for fittings

Fittings designed to terminate exposed heating cables directly to an exposed enclosure should be subjected to strain relief testing. One sample of each strain relief fitting will be subjected to the test. The specimens will consist of at least 30 cm (12 in) of heating cable attached to the subject fitting according to the manufacturer's instructions. A steady load of 9 kg (20 lb) for conductors smaller than 0.81 mm² (18 AWG) and 16 kg (35 lb) for all other cases is to be gradually applied between the heating cable and fitting. The load should be maintained for a period of 1 min. As a result of this test, the heating cable should not loosen or separate by more than 1 mm (0.039 in) from the fitting, and there should be no damage to the conductors, insulation, or fitting.

4.2.15 Enclosure considerations

Enclosures, mounting brackets, and associated components should be evaluated for their intended environments in accordance with ANSI/NEMA 250-1991 and ANSI/UL 50-1987, or should be approved for use with the heating cable by a nationally recognized testing authority.

4.3 Type test—outdoor exposed surfaces

Deciding of outdoor exposed surfaces (such as roof surfaces, gutters, and downspouts) requires the use of electric heat tracing systems that can meet severe environmental constraints. In addition to the type tests described in 4.2, systems for use in outdoor locations (type B applications as defined in table 1) should also meet the requirements of 4.3.1–4.3.5.

4.3.1 Increased moisture resistance test

A minimum 3 m (10 ft) sample, including terminations and connections, should be immersed in water at 10–25 °C (50–77 °F) for a period of 2000 h (12 weeks).

After conditioning as above, the sample should be subjected to the dielectric voltage outlined in 4.2.1 for 1 min without dielectric breakdown.

4.3.2 UV and condensation test

A sample of heating cable, approximately 30 cm (12 in) in length, should be hung vertically in the drum of a xenon-arc light-exposure apparatus as described in ASTM G26-93.

The procedure should be as described in ASTM G26-93 for a total period of 500 h. The cycle should be set for 102 min of light and 18 min of combined light and water spray. At the end of this time, the sample should be removed from the chamber and subjected to the cold bend test in 4.2.10. The dielectric test is to be applied only to the outermost jacket.

4.3.3 Resistance to cutting test

A sample of heating cable, at least 20 cm (8 in) in length, should be used for testing. The sample should be placed on top of a rigid flat steel support. A cutting surface with a 0.25 mm (0.010 in) radius edge should be mounted to a piston hanging above the sample such that the cutting surface is at a right angle to the sample. An ohmmeter should be attached to the cable conductors shorted together, and to the metal cutting surface.

A proof load of 445 N (100 lb) is to be gradually applied to the sample. The cutting edge should not cut through to the conductors of the cable, as indicated by the ohmmeter.