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SUBJECT 1588

**OUTLINE OF INVESTIGATION
FOR
ROOF AND GUTTER DE-ICING CABLE UNITS**

Issue Number 4

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FOREWORD

A. This Outline of Investigation contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Outline of Investigation. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of these requirements by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Outline of Investigation will not necessarily be judged to comply with the Outline of Investigation if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this Outline of Investigation, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this Outline of Investigation. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this Outline of Investigation does not comply with this Outline of Investigation. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Outline of Investigation.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgement given with due consideration to the necessary limitations of practical operation and state of the art at the time the Outline of Investigation is processed. UL shall not be responsible to anyone for the use of or reliance upon this Outline of Investigation by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Outline of Investigation.

F. Many tests required by the Outline of Investigations of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 This outline covers roof and gutter de-icing cable units intended for permanent connection. These cable units are intended for use in accordance with Article 426 of the National Electrical Code, NFPA 70.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this outline shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this outline; or
- b) Is superseded by a requirement in this outline.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this outline shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

5 Heating Conductors

5.1 The heating conductors of other than a metallic-sheathed roof and gutter de-icing cable shall be insulated with a compound acceptable for use at 75°C (167°F) or higher in dry locations and 60°C (140°F) or higher in wet locations. The average thickness of the insulation shall not be less than 0.762 mm (0.030 inch) with a minimum of 0.686 mm (0.027 inch) at any one point. Magnesium oxide suitable for the purpose is acceptable as an insulating compound for use with metallic sheathed cables.

6 Grounding Component

6.1 The heating section of a roof and gutter de-icing cable shall be provided with a grounding component which consists of a metallic sheath or a metallic braid. In the case of a metallic braid, provision shall be made for connecting the braid to the branch-circuit grounding means by a means such as:

- a) A grounding lead 14 AWG minimum bare or green insulated copper wire;
- b) A fitting that surrounds the cable and mechanically secures the braid; or
- c) A lug to be crimped onto the pigtailed braid and then secured to a grounding screw in the supply junction box.

If the heating section consists of more than one conductor, the grounding component may be incorporated on each conductor or all conductors may be enclosed within a common sheath or braid. The grounding component shall have an ampacity not less than that of 18 AWG copper conductor.

6.2 If the grounding component consists of a braid, it shall provide at least 50 percent coverage as determined according to the following formula:

$$\text{Percent coverage} = 100 (2F - F^2)$$

in which:

$$F = \frac{NPd}{\sin a}; (0 \leq F \leq 1)$$

a – Angle of braid with axis of cable

$$\tan \sigma = \frac{2\pi DP}{C}$$

d – Diameter of individual braid wires in inches

C – Number of carriers

D – Diameter under shield in inches

N – Number of wires per carrier

P – Picks per inch

7 Outer Jacket

7.1 A weather-resistant jacket shall be provided over a metal braid used as a grounding component.

Exception: An outer jacket is not required to be provided over a metal braid in units which demonstrate acceptable performance after being subjected to long term environmental exposure, in addition to complying with the performance requirements.

8 Nonheating Leads

8.1 The heating section shall be connected to nonheating leads of a weather-resistant type. Instructions provided with each unit shall instruct the installer to physically protect the nonheating leads by installing them in a rigid metal or nonmetallic raceway.

8.2 Heating conductors that are intended for use as nonheating leads as well shall be investigated for use as leads. At any point within the junction box in which such leads are connected to branch-circuit wiring, the temperature rise during the temperature test (see 12.3.1) of the cable unit shall not exceed 35°C (63°F). If during the temperature test any point within the junction box attains a temperature higher than 60°C (140°F), the installation instruction in 14.1(b) shall include "For supply connections, use wires suitable for at least ...°C (...°F)." or an equivalent statement with the temperature value as follows:

Test temperature in junction box	Temperature to use in instruction
Over 60°C (140°F) but not over 75°C (167°F)	75°C (167°F)
Over 75°C (167°F) but not over 90°C (194°F)	90°C (194°F)

9 Installation Components

9.1 Suitable installation components shall be available for each system for proper installation. Component parts constructed of metal shall be corrosion resistant. Exposed nonmetallic component parts shall be constructed of weather resistant materials.

PERFORMANCE

10 General

10.1 In determining the performance acceptability, a roof and gutter de-icing cable shall comply with both heating cable and complete system tests. Unless otherwise indicated, the ambient temperature is to be $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$) for the tests.

Exception: Cable which has been previously found to comply with equivalent requirements may be exempt from applicable portions of the test program.

10.2 For test purposes, the voltage that is mentioned as "V" in 12.3.1, 12.5.1, and 12.10.1 is to be as specified in Table 10.1.

Table 10.1
Test voltage

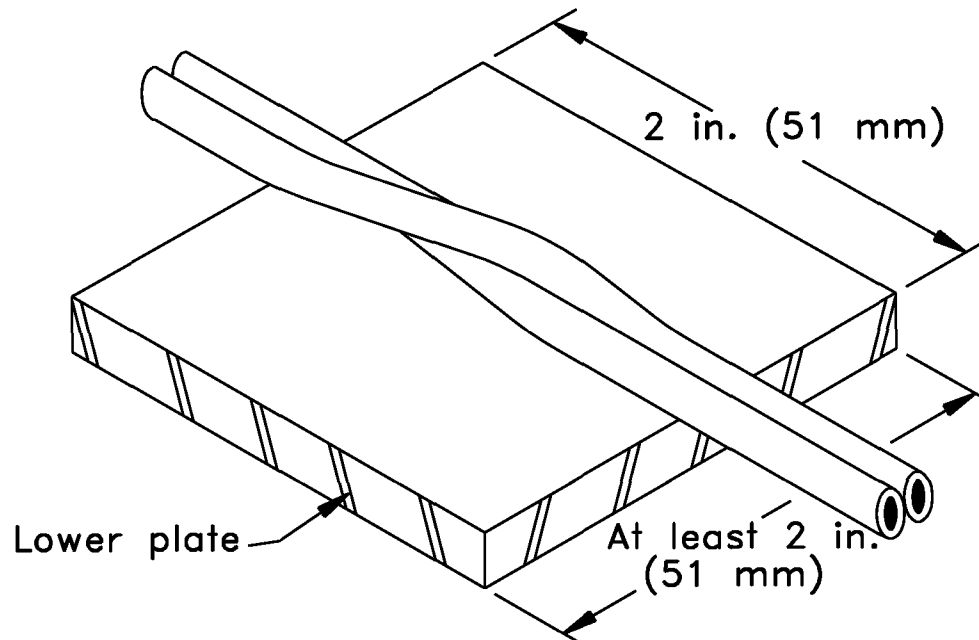
Marked rating in volts	V
95 or less	The marked voltage (the highest value of a range if so marked)
Over 95 but not over 120	120
Over 120 but less than 220	The marked voltage (the highest value of a range if so marked)
At least 220 but not over 240	240

11 Heating Cable Tests

11.1 Crushing test

11.1.1 The heating section of a roof and gutter de-icing cable shall demonstrate resistance to crushing equal to 907 kg (2000 pounds). Samples of the cable are to be placed separately in a compression machine between flat, rigid steel plates mounted horizontally and parallel to each other. As shown in Figure 11.1, the dimensions of each plate are to be 51 mm (2 inches) in the horizontal direction (width) parallel to the longitudinal axis of the cable and 51 mm (2 inches) or more in the horizontal direction perpendicular to the longitudinal axis of the cable. The upper plate is to move down at the rate of 12.7 mm (1/2 inch) per minute and the lower plate is to be stationary. The crushing is to be continued until either of the conductors electrically contacts grounding component or one of the steel plates or the other conductor, as indicated by a means such as a low voltage buzzer. The force at electrical contact is to be recorded and the average of ten readings is to be noted. If the heating section is of two conductors, it is to be twisted for 180 degrees so as to cause the conductors to overlap when performing this test. As shown in Figure 11.1, the twist is to extend throughout the full 51 mm (2-inches) width of the steel plates.

Figure 11.1
Crushing test



S3524

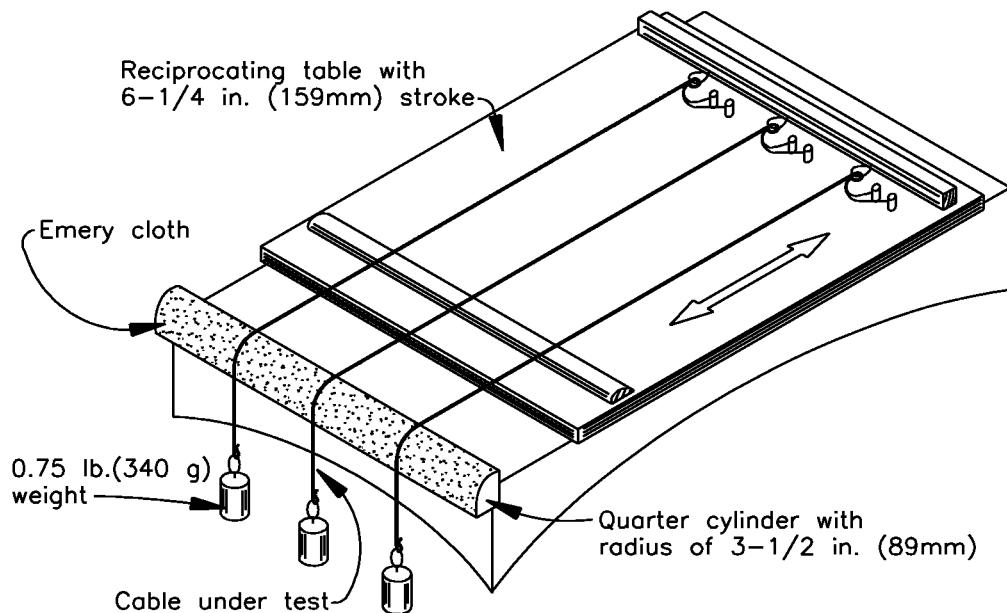
11.2 Impact test

11.2.1 The heating section of a roof and gutter de-icing cable shall resist an impact of at least 13.6 J (10 foot-pounds) on a flat surface and at least 6.8 J (5 foot-pounds) on a 19.1 mm (3/4-inch) drill rod without causing more than two failures in either case. Samples of the heating section are to be subjected to the impact of a free falling flat faced 31.8 mm (1-1/4 inch) diameter cylindrical 2.3 kg (5 pounds) steel weight. Ten trials per specimen are to be made with the weight dropped from a specific height. For each trial, a new section of each specimen is to be laid on a flat surface and on a 19.1 mm (3/4 inch) diameter drill rod. The weight is to be dropped from increasing heights in increments of 152 mm (1/2 foot), starting at 152 mm (1/2 foot) elevation. The height is to be increased until at least one but no more than two failures of the insulation occurs in ten trials. Failure is defined as either a rupture of the insulation through which the conductors are visible, or electrical contact of the conductors to the equipment or to each other is noted, as indicated as by a 3 watt neon lamp connected in series with the conductor under test, the metallic braid, and 120 volts ac supply.

11.3 Abrasion test

11.3.1 The heating section of a roof and gutter de-icing cable shall resist at least 2500 cycles of abrasion. Six straight untwisted specimens of the heating cable, with any cosmetic overall jacket removed, are to be attached to a horizontal reciprocating table while the table is at one end of its travel. The other end of each specimen is to be attached to a weight that exerts 3/4 of a Newton (pound force). Each specimen is to be laid over a 1/4 cylinder to whose outer surface an unused sheet of grade 1/2 (medium) emery cloth is attached. The radius of the surface of the emery cloth is to be 88.9 mm (3.5 inches). Refer to Figure 11.2. The longitudinal axis of the cylinder is to be horizontal and perpendicular to each of the vertical planes that contain the specimens as they move and are abraded by the emery cloth. The table is to be started in its horizontal reciprocating motion at the rate of approximately 30 cycles per minute, each cycle consisting of one complete back and forth motion with a stroke of approximately 159 mm (6-1/4 inches). The table is to be stopped every 50 cycles and the emery cloth is to be slightly shifted to one side so that in subsequent cycles, each specimen is abraded by a fresh surface of the cloth. The cable is not acceptable if the metal grounding braid is exposed unless the grounding braid has been evaluated and found acceptable for exterior/interior use. In constructions with no outer jacket, the cable is not acceptable if the strands of the grounding braid are opened.

Figure 11.2
Abrasion test



S3525

11.4 Cold-bend test

11.4.1 The nonmetallic parts (any cosmetic jacket is to be removed) of the heating section of a roof and gutter de-icing cable shall not show any surface or internal cracks when a specimen that is not over 15.9 mm (0.625 inch) in diameter or in length of minor axis and that has been subjected, for 4 hours to a temperature of $-30 \pm 2^\circ\text{C}$ ($-22 \pm 3.6^\circ\text{F}$), is wound six complete turns (flatwise in the case of a flat cable)

around a mandrel with a diameter as indicated in Table 11.1 while the mandrel and specimen are at the test temperature. Larger specimens are to be wound for one complete turn around the mandrel. The winding is to be done at a uniform rate of 3 seconds per turn and successive turns are to be in contact with one another.

Table 11.1
Mandrel diameter

Type of cable	Mandrel diameter = measured diameter or length of minor axis of finished cable times the multiplying factor 8 or 5 as appropriate from below
Braided with jacket	8
Braided	5
NOTE – Mandrels are to have diameters that are integral multiples of 3.2 mm (0.125 inch). If the result of the calculation is 12.7 mm (0.5 inch) or less, a 12.7 mm (0.5 inch) mandrel is to be used. If the result of the calculation is over 12.7 mm (0.5 inch), the result is to be rounded off to the next higher integral multiple of 3.2 mm (0.125 inch) and a mandrel of that diameter is to be used.	

11.5 Flame test

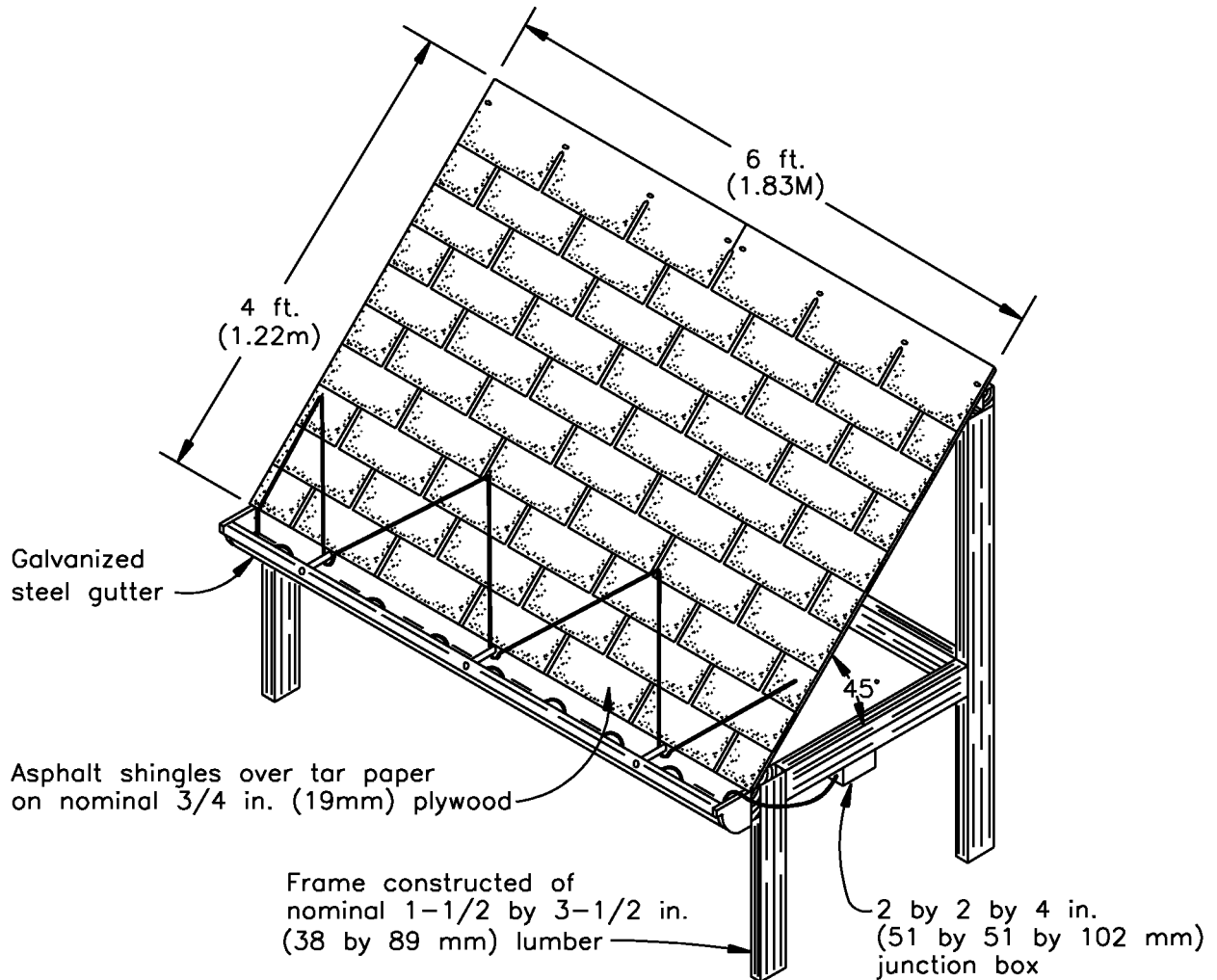
11.5.1 The heating section of a roof and gutter de-icing cable shall comply with the VW-1 (Vertical-Specimen) Flame Test located within the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

12 Complete-System Tests

12.1 Installation test

12.1.1 Using the manufacturer's installation instructions and recommended mounting components, a system is to be installed on a roof section to verify that the instructions and mounting components are adequate for proper installation. The roof section is to consist of a 1.22 m (4 feet) by 1.83 m (6 feet) section of plywood, 19 mm (3/4 of an inch thick), mounted at an angle of 45 degrees to the horizontal, and covered with tar paper and asphalt shingles. A 101.6 mm (4 inch) wide galvanized steel gutter section, 1.83 m (6 feet) long, is to be secured along the edge of the roof section. Refer to Figure 12.1 for a typical installation layout.

Figure 12.1
Typical test setup



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The supply wiring is not shown. It may be whatever is convenient for the test and need not be representative of an actual installation.

12.2 Input test

12.2.1 At an ambient temperature of 0°C (32°F), the stable-operation ampere input to a roof and gutter de-icing cable unit shall not be more than 110 percent of the marked input.

12.2.2 For a cable unit of the self-regulating type, and as a referee method for a cable unit with a metal heating conductor, the stable-operation measured ampere input to a representative horizontal straight length surrounded by circulating water or air maintained at 0°C (32°F) shall not be more than 110 percent of the marked input.

12.3 Temperature test

12.3.1 A sample of the cable unit is to be installed on the roof section described in the Installation Test, 12.1. The unit is to be connected to a variable 60 hertz source of supply adjusted to V (see 10.2). Operation is to be continued until thermal equilibrium is attained. No material shall attain a temperature higher than its rating. In addition, no external surface of the heating cable assembly shall operate in excess of the temperature rating of the insulation and in no case in excess of 90°C (194°F). See 8.2.

12.4 Thermal protection

12.4.1 External surfaces of the cable unit which operate at temperature exceeding 60°C (140°F) shall be physically guarded, isolated, or thermally insulated to protect personnel in the area.

12.5 Dielectric voltage-withstand test

12.5.1 Following the Temperature Test, with the sample at thermal equilibrium, a test potential as indicated in (a) or (b) below is to be applied between current-carrying parts of the heating cable and the grounding component for 1 minute in the following manner: starting at zero, the potential is to be gradually increased to the maximum test value and maintained at that potential for 1 minute. There shall be no indication of dielectric breakdown. The test potential is to be:

- a) An a-c rms potential of 2V (see 10.2) plus 1000 volts; or
- b) A d-c potential of $\sqrt{2} \times 2V$ (see 10.2) plus 1414 volts dc.

12.6 Ground-fault current test

12.6.1 The cable unit is to be placed on a flat, horizontal surface that is noncombustible and electrically nonconductive. The cable unit is to be laid out without any kinks or crossovers and in essentially the pattern indicated in the Installation Test. The laid-out unit is to be draped with four layers of cheesecloth. One nonheating lead and the ground lead are to be connected to a 60 hertz variable source of supply. A fault is to be created in the heating section of the cable by making a connection between the heating element (one conductor) and the grounding component at a point located by the number of feet from the nonheating lead splice indicated in the following table:

Resistance of heating wire (1 conductor) in ohms per foot	Test specimen length in feet (m)
Over 1.6	1 (0.305 m)
1.6 or less	5 (1.524 m)

12.6.2 The variable supply is to be adjusted to deliver the percentage of current of the maximum branch-circuit overcurrent protection to which the unit will be connected in use and for the length of time indicated in the following table:

1-foot fault current ^a	Test current	Test time
Under 1.1 times ^b	a	7 hours
1.1 times ^b and over, but not over 1.35 times ^b	1.1 times ^b	7 hours
	a	1 hour
1.35 times ^b and over but not over 2 times ^b	1.1 times ^b	7 hours
	1.35 times ^b	1 hour
	a	2 minutes
Over 2 times ^b	1.1 times ^b	7 hours
	1.35 times ^b	1 hour
	2 times ^b	2 minutes

^a Current drawn by a single heating conductor short-circuited to the grounding component at a point located 304.8 mm (12 inches) from the nonheating-lead splice.

^b Current of the marked maximum branch-circuit overcurrent protection.

12.6.3 During any test, opening of the heater wire is acceptable but opening of the grounding component shall not open. External surfaces of the cable shall not exceed 200°C (392°F) as determined by thermocouples affixed to the cable.

12.7 Lead pull-out test

12.7.1 A force of 156 N (35 pounds) is to be applied to the nonheating leads and grounding conductor for 1 minute in a direction such as to pull the leads out of the heating cable. The force is to be applied on a complete assembly if the conductors are within an outer jacket. If single leads are accessible, the force is to be applied on each single lead, one at a time. The leads shall not be pulled out as a result of this test.

12.8 Weatherometer tests

12.8.1 Unless the exposed insulation of the heating cable or outer protective jacket has been previously evaluated for weather resistance, a sample of the insulation or outer jacket shall be subjected to 720 hours of xenon-arc or carbon-arc conditioning as described in the Carbon-Arc and Xenon-Arc Tests located within the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581. Conditioned samples are to be subjected to tensile strength and elongation measurements and shall retain at least 80 percent of these properties when compared to unconditioned samples.

12.8.2 Unless exposed component nonmetallic parts of the heating cable system other than the heating section have been previously evaluated for weather resistance, they are to be subjected to a weatherometer test of 720 hours duration. Suitability is to be determined by comparison to unconditioned samples and consideration of the intended function of the part. Where splice enclosures are required to be evaluated, the test samples are to be constructed as indicated in the manufacturer's instruction and subjected to the Splice-Insulation/Insulation-Resistance test, 12.11, following conditioning.

12.9 Tension test

12.9.1 A 31.75 kg (70 pound) weight intended to simulate a 51 mm (2 inch) by 101.6 mm (4 inch) by 6.10 m (20 feet) long section of ice is to be suspended from the free end of the heating section while the other end of a 0.91-m (3-feet) portion is secured tightly. The test duration shall be 1 hour. There shall be no breakage of the conductors or braid and no damage to the insulation.

12.10 Severe-use test

12.10.1 A sample is to be mounted on a roof section as described in the Installation Test and draped with four 0.305-meter-square (1-foot-square) layers of cheesecloth. A portion of the sample is to be routed through a horizontal 1.83-m (6-foot) section of galvanized steel gutter and, from the end of the gutter, is to be routed into a vertically mounted 0.91-m (3-feet) section of galvanized steel downspout. A 3-ampere fuse is to be connected between the grounding member of the cable assembly and the supply source ground. The sample is then to be energized from a variable 60 hertz source of supply adjusted to 1.1 times V (see 10.2) and operated for 7 hours. Following the test, the dielectric voltage-withstand test is to be repeated. There shall be no charring or burning of the cheesecloth and no indication of dielectric breakdown. The roof surfaces in contact with the cable shall not exceed 125°C (257°F) as determined by the thermocouples affixed to the roof at points under the cable.

12.11 Splice-insulation/insulation-resistance test

12.11.1 Six samples of the sections of the cable unit which include the hot-to-cold lead splice connection and a 0.91 m (3 feet) length each of the heating section and nonheating section are to be used for this test. Three of the samples are to be placed in a full-draft circulating-air oven maintained at a uniform temperature of 100°C (212°F) for 10 days. The samples are then to be removed from the oven and allowed to cool to room temperature for 24 hours. The three conditioned samples and the three unconditioned samples are then to be immersed in tap water at a temperature of 50°C (122°F) such that both ends of each sample are out of the water. Where splice enclosures are also being evaluated for weather resistance, three additional samples which have been subjected to the weatherometer exposure test are also to be tested. Insulation resistance measurements are to be taken between the conductor of the cold lead and the water by impressing a 250 volt dc potential across the circuit. The measurements are to be made after 24 hours, 7 days, and weekly thereafter for a minimum of 6 weeks. During the time between the readings, 600 volts ac is to be impressed between the cold lead conductor and the water.

12.11.2 As the construction of splice connections can vary extensively, each proposed construction will be judged on its own merit. However, it is expected that a graphical analysis of the periodic readings will not show a severe degradation of insulation resistance which would indicate excessive water absorption; however, in no case shall the insulation resistance be less than 0.1 megohm.

12.12 Splice-enclosure mechanical evaluation

12.12.1 The splice enclosure of a roof and gutter de-icing cable unit, an integral component (whether intended to be factory fabricated or field assembled), and a system component, such as a junction box or terminal block, shall display mechanical characteristics as specified in Section 11, Heating Cable Tests, comparable to the heating section of the assembly.

MARKINGS

13 Cable Unit

13.1 Each cable unit shall have a permanent marking located on, or secured to, the nonheating leads at a point not more than 3 inches from the free end of the nonheating leads, which specifies the manufacturer's name or trademark, catalog number, electrical rating in volts and watts or amperes. See 14.1 (b) and (g).

INSTRUCTIONS

14 Installation Instructions

14.1 Instructions shall be provided with each assembly and shall include all of the following:

- a) The following statement: "Two copies of a caution notice indicating the presence of electric de-icing and snow-melting equipment on the premises are packed with this unit. One notice must be posted at the fuse or circuit-breaker panel and the other on or next to the on/off control for the cable unit. Both notices must be clearly visible." or other statements to the same effect.
- b) The maximum size of the branch circuit (not less than 125 percent of the ampere load of the cable unit or units). See 8.2.
- c) Installation methods showing routing and securing of cable units to avoid exposure to possible mechanical abuse such as from ladders.
- d) Specification of the minimum bend radius of metallic sheathed cable.
- e) Instructions for proper installation of a typical system, including a detailed list of all specific parts (mounting clips and the like) needed. The instructions shall include pictorial illustrations.
- f) The following specific statements or the equivalent:
 - 1) "Protect all cable that protrudes past the lower opening of the downspout."
 - 2) "Do not cross or overlap cable heating section." (This statement may be omitted in the case of any cable unit shown by test not to exceed the prescribed temperature limits.)
 - 3) "Use only watertight construction or enclosure Type 3, 3S, 4, 4X, 6, or 6P junction box when installing."
 - 4) "Make certain the gutters and downspouts are free of leaves and other debris prior to the winter season."
- g) An installation instruction indicating that the nonheating leads may be shortened shall include a statement to the effect that the markings in 13.1 must be retained.
- h) An installation instruction requiring ground-fault protection of equipment be provided for fixed outdoor electric de-icing and snow-melting equipment.

Exception: Equipment utilizing mineral-insulated, metal sheathed cable embedded in a noncombustible medium is not required to comply with (h).

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