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(Revision of
IEEE Std 1210-1996)

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IEEE Standard Tests for Determining Compatibility of Cable-Pulling Lubricants With Wire and Cable

IEEE Power Engineering Society

Sponsored by the
Insulated Conductors Committee

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Approved 2 February 2005

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Abstract: Criteria and test methods for determining the compatibility of cable-pulling lubricants (compounds) with cable jacket or other exterior cable covering are described in this standard. Cable-pulling lubricants are used to lower the friction on cable as it is pulled into conduit, duct, or directionally bored holes. Compatibility is important because lubricants should not negatively interact with the cables they lubricate. Compatibility of lubricants with a variety of common cable coverings is considered.
Keywords: cable, cable covering, cable jacket, cable pulling, compatibility, compound, dielectric withstand, immersion testing, lubricants, physical properties, volume resistance measurement, wire

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Introduction

This introduction is not part of IEEE Std 1210-2004, IEEE Standard Tests for Determining Compatibility of Cable-Pulling Lubricants With Wire and Cable.

Cable-pulling lubricants (compounds) are used to lower the tension on cable as it is pulled into conduit, duct, or directionally bored holes. These friction reducers play an important part in minimizing physical damage to cable as it is installed.

It is important that lubricants do not negatively affect the cables they lubricate. Conventional oils and greases are generally not suitable pulling lubricants because they can swell and weaken plastic jackets and insulations.

The purpose of this standard is to provide criteria and test methods for determining the compatibility of cable-pulling lubricants with cable jacket or other exterior cable covering. Until now, the evaluation of this compatibility was done on a nonstandard basis.

It should be noted that compatibility of lubricants with cable coverings is the only subject for the standard; other important performance criteria for lubricants, such as friction reduction, toxicity, combustibility, and so on, are not discussed.

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Contents

IEEE Standard Tests for Determining Compatibility of Cable-Pulling Lubricants With Wire and Cable

1. Overview

1.1 Scope

This standard applies to cable-pulling lubricants (compounds) and the testing and analysis of their interaction with wire and cable. Cable-pulling lubricants are used to lower the friction on cables when they are installed (pulled) into conduits, ducts, or directionally bored holes. These lubricants and/or their residues are in direct contact with the cable exterior covering and may remain so for the life of the cable. Cable-pulling lubricants should be compatible with the cable. They should not interfere with the function of any component of the cable system that they contact.

Compatibility of cable-pulling lubricants with cable coverings is the only subject of this standard. Other important performance criteria for cable-pulling lubricants, such as friction reduction, toxicity, combustibility, and so on, are not discussed.

This standard uses accepted cable performance standards whenever possible. Relevant standards are cited in the text and listed in Clause 2 and Annex A.

1.2 Purpose

This standard describes tests for determining the compatibility of cable-pulling lubricants with cable jacket or other exterior cable coverings. Compatibility of cable-pulling lubricants with a variety of common cable coverings is considered.

Often, testing is confined to the effect of the lubricant on the physical properties of the jacket. When the electrical properties, such as dielectric withstand voltage or electrical resistivity, are important, the evaluation also includes these properties.

2. References

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

ANSI/UL 44-1999, Standard for Thermoset-Insulated Wires and Cables.[1]

ANSI/UL 83-2003, Standard For Thermoplastic-Insulated Wires and Cables.

ANSI/UL 1581-2001, Reference Standard for Electrical Wires, Cables, and Flexible Cords.

ASTM D412-98a(2002)e1, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension.[2]

ASTM D4703-2003, Standard Practice for Compression Molding Themoplastic Materials into Test Specimens, Plaques, or Sheets.

ASTM D1693-2001, Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

ICEA T-25-425-1981, Guide for Establishing Stability of Volume Resistivity for Conducting Polymeric Compounds of Power Cables.[3]

3. Physical property effects

3.1 General

Evaluation shall consist of immersing cable jacket *samples* in the cable-pulling lubricant and heat-aging the *samples* while immersed *in lubricant* at the specified temperatures for the specified durations. Physical property changes shall be determined as compared with heat-aged and unaged comparison samples. The heat-aged comparison samples shall be water-immersed (for cables suitable for use in a wet or damp environment) or air-aged (for cables not so suited).

To accurately establish a lubricant's compatibility with a cable jacket, priority should be given to testing the specific cable jacket and lubricant that are intended for use because the lubricant on generic types of cable jackets can vary significantly.

Reported results shall include the date of testing and identification of and specific information about the cable and jacket compound tested.

3.2 Lubricant on cable jacket

When tested on the jackets at the temperatures and times noted in Table 1, in accordance with the immersion test of Clause 5, the lubricant shall not affect the jacket in excess of the requirements specified in Table 1.

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[1]UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/).
[2]ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).
[3]ICEA publications are available from ICEA, P.O. Box 20048, Minneapolis, MN 55420, USA (http://www.icea.org/).

Table 1—Cable jacket requirements

Properties	PVC	LDPE[a] LLDPE[a] MDPE[b] HDPE[b]	CPE	CR	NBR/ PVC	CSPE	CPE -XL	PP	TPE	Low Smoke Halogen Free			Semiconducting	
										Thermoplastic Type 1	Thermoset Type 1	Thermoset Type 2	Type 1	Type 2
Immerse at (°C ± 1 °C)	100	100	121	100	100	100	100	121	121	100	121	121	100	121
Immerse for (hours)	120	48	168	168	168	168	168	168	168	168	168	168	48	168
Retained tensile strength, % minimum of unimmersed and unaged comparison	85	75	85	50	50	85	85	75	75	75	75	85	85	75
Retained elongation at rupture, % minimum of unimmersed and unaged comparison	60	75	50	50	50	65	65	75	75	60	60	75		75
Minimum elongation at rupture %	-	-	-	-	-	-	-	-	-	-	-	-	100	-
Retained tensile strength and elongation at rupture, % minimum of immersed in water/air and heat-aged comparison	85	85	85	85	85	85	85	85	85	85	85	85	85	85
After environmental stress crack test immersed in lubricant at 50 °C ± 1 °C for 48 hours, Maximum % of samples cracked	-	0	-	-	-	-	-	-	-	-	-	-	-	-
After immersion test at 50 °C ± 1 °C for 30 days Retained tensile and elongation at rupture, % minimum of immersed in water/air and heat-aged comparison	85	85	85	85	85	85	85	85	85	85	85	85	85	85

NOTE—CPE, Chlorinated Polyethylene; CPE-XL, Cross-Linked Chlorinated Polyethylene; CR, Polychloroprene Rubber; CSPE, Chlorosulfonated Polyethylene Rubber; HDPE, High-Density Polyethylene; LDPE, Low-Density Polyethylene; LLDPE, Linear Low-Density Polyethylene; MDPE, Medium-Density Polyethylene; NBR, Nitrile Rubber; PP, Polypropylene; PVC, Polyvinylchloride; TPE, Thermoplastic Elastomer.

[a]Use condition A as defined in ASTM D1693-2001.
[b]Use condition B as defined in ASTM D1693-2001.

4. Electrical property effects

4.1 General

This clause shall only apply when the lubricant is used on coverings that are semiconducting or on unshielded cables with exposed primary insulation (building wire or special-purpose cables).

4.2 Lubricant on semiconducting jackets or exposed semiconducting shields

The lubricant shall not cause the volume resistivity to exceed AEIC specifications (see CS6-00 [B1]–CS8-93 [B3]) or ICEA standards (see ANSI/ICEA S-93-639/NEMA WC74-2000 [B4]–ANSI/ICEA S-96-659/NEMA WC71-1999 [B9] and ICEA S-73-532/NEMA WC57-1990 [B11].[4] The lubricants shall demonstrate stability over a minimum 42-day test before the final high-temperature test. The final high-temperature test includes temperatures (see 4.4, Table 3) to represent the transient high temperatures possible from overloading.

4.3 Determining stability of lubricant on semiconducting materials (IEEE Std 1026™-1995 [B12])

When tested according to Table 2 and Clause 5, for a minimum duration of 42 days, the effect of the lubricant on the semiconducting material shall show stability if it meets Equation (1):

$$3\log_{10}\rho_n \quad \log_{10}\rho_{(n-14)} + \log_{10}\rho_{(n-28)} + \log_{10}\rho_{(n-42)} + 0.3 \qquad (1)$$

where ρ is the volume resistivity measured in accordance with 5.7 on days n, n-14, n-28, and n-42

NOTE — When n = 42 days, the 1-day ρ reading should be used for ρ(n-42).[5]

Volume resistivity readings shall be made on a schedule as follows: Samples shall be pre-aged for 18 h at the temperature specified in Table 2 and then cooled before the initial (0) reading.

Table 2—Aging temperature for volume resistivity samples

Sample type	75°C rated cable	90°C rated cable
Conducting jacket	75 °C ± 2 °C	90 °C ± 2 °C
Exposed insulation shield	75 °C ± 2 °C	90 °C ± 2 °C

Initial (0), 1, 3, 7, 14, 28, and 42 days' aging shall be done at the temperature specified in Table 2. All samples will be cooled to 20–30 °C (±2 °C of the same temperature for all readings) to measure resistance and then returned to the oven for additional aging. In all cases, readings shall not be taken sooner than four hours after removal from the oven.

If, at the 42-day reading, stability is not demonstrated as defined in Equation (1), then aging shall be continued and readings shall be made at additional 14-day intervals until stability is attained, or for 92 days.

[4]The numbers in brackets correspond to those of the bibliography in Annex A.
[5]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the guide.

All volume resistivity calculations shall be recorded, including the initial (unaged) ρ_o and final ρ_n. If any volume resistivity determined during the aging was greater than the final ρ_n, then the ratio of those resistivities shall be determined as in Equation (2):

$$K = \frac{\rho_G}{\rho_n} \tag{2}$$

where

K is the ratio (always greater than 1)

ρ_G is the greatest volume resistivity measured

ρ_n is the final volume resistivity measured

4.4 Final high-temperature volume resistivity test (ANSI/ICEA S-97-682 [B6], AEIC CS6-96 [B1], AEIC CS7-93 [B2], and IEEE Std 1026-1995 [B12])

On completion of the stability tests and attainment of stability, a final volume resistivity shall be determined in accordance with Clause 5 at the test temperatures in Table 3.

Table 3—Final volume resistivity test temperature and maximums

Sample type	Test temperature	Maximum volume resistivity
Conductive jacket	75 °C ± 2 °C and 90 °C ± 2 °C	500 Ω m 500 Ω m
Exposed insulation shield on thermoplastic insulation	75 °C ± 2 °C and 90 °C ± 2 °C	500 Ω m 500 Ω m
Exposed insulation shield on thermoset insulation	90 °C ± 2 °C and 110 °C ± 2 °C	500 Ω m 500 Ω m

In no case shall the volume resistivity determined at the final test temperature, or any volume resistivity determined in 4.3, or K times the volume resistivity at the final test temperature (see Equation (2) for determination of K), exceed the maximum values given in Table 3.

4.5 Lubricant on exposed thermoplastic primary insulation

When tested on exposed thermoplastic primary insulation in accordance with the dielectric voltage-withstand test of Clause 5, the lubricant shall not affect the exposed insulation so that the insulation cannot withstand, for 60 s, without breakdown, the essentially sinusoidal root-mean-square (rms) test potentials given in Table 4 (ANSI/UL 83-2003).[6] Tests can be run on any conductor size in Table 4 to meet the requirements of this section for that exposed insulation type.

[6]Information on references can be found in Clause 2.

Table 4—RMS test potential in volts—thermoplastic-exposed insulation

Conductor size	Type			
	THW, THWN, THHN (600 V)	T, TW (600 V)	FEP, FEPB (600 V)	TFE (600 V)
14-9 AWG	2000	1500	2000	2000
8-2 AWG	2000	2000	2000	2000
1-4/0 AWG	2500	2500	—	2000
250–500 kcmil	3000	3000	—	—
550–1000 kcmil	3500	3500	—	—
1100–2000 kcmil	4000	4000	—	—

LEGEND
- T thermoplastic insulation, usually PVC
- W moisture resistant
- H heat resistant, rated for a maximum continuous operating temperature of 75 °C
- HH high heat resistant, rated for a maximum continuous operating temperature of 90 °C
- N outer overall jacket of nylon or equivalent material
- FEP fluorinated ethylene propylene insulation rated for a continuous maximum operating temperature of 200 °C
- FEPB same as FEP, but cable has an overall braid, usually fiberglass
- TFE tetrafluoroeththylene insulation rated for a continuous maximum operating temperature of 250 °C

NOTE—Voltage values from ANSI/UL 83-2003.

4.6 Lubricant on exposed thermoset primary insulation

When tested on exposed thermoset primary insulation in accordance with the dielectric voltage-withstand test of Clause 5, the lubricant shall not affect the exposed insulation so that the insulation cannot withstand, for 60 s, without breakdown, the essentially sinusoidal rms test potentials given in Table 5 (ANSI/UL 44-1999). Tests can be run on any conductor size in Table 5 to meet the requirements of this subclause for that exposed insulation type.

5. Testing and test methods

5.1 General

Tests shall be performed using the cable-pulling lubricant and the jacket for which compatibility is being determined. Both lubricant and jacket samples should be representative and selected at random.

Table 5—RMS potential in volts—thermoset exposed insulation

Conductor size	Type			
	RHW, RHH, XHHW, SA (600 V)	**RH (600 V)**	**RH, RHW, RHH (2000 V)**	**SIS (600 V)**
13-11 AWG	3000	2000	6000	3000
10, 9 AWG	3000	3000	6000	3000
8 AWG	3500	3500	6000	3500
7 AWG	3500	3500	7500	3500
6-2 AWG	3500	3500	7500	3500
1-4/0 AWG	4000	4000	9000	4000
250–500 kcmil	5000	5000	10000	—
550–1000 kcmil	6000	6000	11000	—
1100–2000 kcmil	7000	7000	11000	—

LEGEND

X	thermoset cross-linked polyethylene insulation
R	thermoset rubber insulation
S	silicone (thermoset) insulation
A	previously asbestos, now fiberglass or similar material
W	moisture resistant
H	heat resistant, rated for a maximum continuous operating temperature of 75 °C
HH	high heat resistant, rated for a maximum continuous operating temperature of 90 °C
HHW	a maximum continuous operating temperature of 75 °C in wet locations and 90 °C in dry locations
SIS	switchboard wire rated for a continuous maximum operating temperature of 90 °C

NOTE—Voltage values from ANSI/UL 44-1999.

5.2 Jacket test specimens for the immersion/physical property tests

Specimens shall be taken from completed wire or cable. Fifteen specimens of the jacket shall be taken for the test. Three will serve as unimmersed and unaged comparison samples, three will be immersed in lubricant at the first temperature, three will be immersed at the second temperature, three will serve as the aged in air/water comparison samples at the first temperature, and three will serve as the aged in air/water comparison at the second temperature.

The specimens shall be segment cut with a sharp knife or with a Die C or D, as specified by ASTM D412-98a(2002)e1. The specimens shall be cut parallel to the cable axis and shall not have a cross-sectional area greater than 16.1 mm^2 or less than 4.8 mm^2 after irregularities, corrugations, and reinforcing members have been removed. If necessary, surface irregularities shall be removed so that the specimens are smooth and of uniform thickness.

5.3 Tensile strength and elongation test

Physical tests shall be performed at room temperature (20–28 °C) on a tensile testing machine that is in accordance with ASTM D412-98a(2002)e1.

The test specimens, prepared in accordance with 5.2, shall be marked with gauge marks that are 25 mm apart. The jaws of the testing machine shall be a maximum of 100 mm apart. The separation speed shall be 500 mm/min continued until the specimen breaks. However, if the test specimen is polyethylene, the maximum jaw separation will be 63 mm and the speed will be 50 mm/min. The tensile strength shall be calculated from the force at break and the cross-sectional area of the *unstretched* specimen.

Elongation at break shall be determined at the same time as tensile strength. The distance between the gauge marks at break shall be measured and used to calculate the elongation at break as in Equation (3):

$$E = \frac{(G_R - G_O)}{G_O \times 100} \tag{3}$$

where

E is the elongation at break

G_R is the gauge mark distance at rupture

G_O is the original gauge mark distance

Results of tensile and elongation tests will be the average from three specimens called for in 5.2 at the various aging conditions. Specimen length and type, gauge mark distance, and jaw separation and speed will be recorded with the results.

5.4 Heated lubricant immersion method

The purpose of the heated immersion of the specimens in the cable-pulling lubricant is to determine the effect of the lubricant on the cable jacket material. The lubricant should be used in the same form and concentration that it would be used in pulling cable.

A 350 ml volume of lubricant shall be placed in a glass desiccator with an opening in the lid for a No. 8 rubber stopper. The desiccator shall have a flange I.D. of 200 mm and a chamber depth of 125 mm.[7] The 350 ml shall fill the desiccator to a lubricant depth of approximately 10 mm.

[7]Pyrex® Brand 3100200 desiccator and lid, or equivalent.

The three physical test specimens called for in 5.2 shall be completely immersed in the lubricant.

The lid shall be placed on the desiccator, and a No. 8, one-hole, rubber stopper (hole diameter of 5 mm) shall be placed in the lid opening. Volatiles in the lubricant can slowly escape through the stopper, as they do from a conduit.

The desiccator, with immersed test specimens, will be heated for the specified time and temperature (refer to Table 1) in a fresh-air-circulating oven.

At the end of the test period, the specimens shall be removed from the desiccator. They shall be carefully and thoroughly washed with tap water to remove lubricant residue and then blotted dry. The specimens shall be allowed to rest at room temperature for a minimum of 48 h and a maximum of 96 h before physical testing. The tensile and elongation of the samples shall then be determined in accordance with 5.3. The physical properties of the comparison samples shall be determined at the same time.

5.5 Heated water/air immersion method

The purpose of the heated immersion of the specimens in water (for cable suitable for wet or damp locations) or air is to provide a comparison sample for the lubricant-immersed samples described in 5.4.

The procedure is the same as in 5.4 except that either distilled water or nothing is placed in the glass desiccator.

The aging for the water-/air-immersed samples should be identical to the lubricant-immersed samples and should be performed at the same time.

The conditioning before physical testing shall also be identical to the lubricant-immersed samples.

5.6 Environmental stress cracking test

Except as noted here, this test shall be conducted in accordance with Condition A or Condition B, as specified in ASTM D1693-2001 and Clause 3.

The test specimens shall come from platen moldings of polyethylene jacket material taken from completed cable. The temperature of the newly molded samples shall be lowered at the rate specified in ASTM D4703-2002, Procedure C. Ten samples shall be razor slit (ASTM D1693-2001, Condition A or Condition B) and completely immersed in lubricant in a test tube 200 mm long and 32 mm in diameter. An additional set of 10 control samples shall be similarly slit and completely immersed in distilled water in a similar test tube. Both test tubes shall be sealed with a foil-covered cork. At the end of the test period, both sets of specimens shall be removed, allowed to cool to room temperature, and inspected for cracking. No interim inspection is necessary. The water-immersed control samples provide perspective on reasons for cracking if any occurs.

5.7 Volume resistivity test procedure for lubricants on semiconducting jackets/shields

The lubricant (or its residue) must remain in contact with the semiconducting jacket or exposed semiconducting insulation shield for the 42-day (or longer) duration of the test. Two types of tests are described: one when the lubricant will stay in place by itself on conductive jacket or shield and the other when the lubricant will not stay in place (too fluid to maintain a 3 mm thick coating girdling the cable).

5.7.1 Volume resistivity tests on semiconducting jackets/shields when lubricants are self-supporting

Two samples shall be prepared as in 5.7.3.1 or 5.7.3.2, one with lubricant and the other without lubricant to serve as a comparison. Resistance measurements shall be taken using either the two-point method with an ohmmeter or the four-point method with current and potential electrodes. These tests shall be conducted as described in ICEA T-25-425-1981. An initial reading shall be taken for both specimens before they are oven-aged. All additional readings are to be taken at the temperatures and times specified in 4.3 and 4.4.

Convert the resistance measurements taken above to volume resistivity using Equation (4):

$$\rho(n,t) = \frac{R(D^2 - d^2)}{400L} \tag{4}$$

where

- ρ is the volume resistivity, in Ω m
- R is the measured resistance, in Ω
- D is the diameter over the conducting component, in cm
- d is the diameter under the conducting component, in cm
- L is the distance between the potential electrodes, in cm
- n is the day from start of aging
- t is the temperature at which resistivity was read

5.7.2 Volume resistivity tests on semiconducting jackets/shields when lubricants are not self-supporting

Two samples shall be prepared as in 5.7.3.3, one to be immersed in lubricant and the other to be aged in air as a comparison.

Immerse one sample completely in lubricant at the conditions called for in 4.3 and 4.4 and test via the same method as in 5.7.1. The second sample should be air aged at the same conditions.

Convert the resistance measurements taken to volume resistivity using Equation (5):

$$\rho(n,t) = \frac{RWT}{100L} \tag{5}$$

where

- ρ is the volume resistivity, in Ω m
- R is the measured resistance, in Ω
- W is the average width of the cut specimen (before immersion), in cm
- T is the thickness of specimen (before immersion), in cm
- L is the distance between the potential electrodes, in cm
- n is the day from start of aging
- t is the temperature at which resistivity was read

5.7.3 Specimens for volume resistivity tests (stability and final high temperature)

Three types of specimens are described as follows:

a) When the lubricant will stay in place by itself on semiconducting jacket
b) When the lubricant will stay in place by itself on semiconducting shield

c) When the lubricant will not stay in place (too fluid to maintain a 3 mm thick coating girdling the cable).

5.7.3.1 Specimens for semiconducting jacket and self-supporting lubricants

Test specimens shall be prepared in the following way: Cut two cable specimens 230 mm long. Remove the semiconducting jacket and all other coverings from the cable to expose the dielectric. Cut the semiconducting jacket so that it fits snugly over the dielectric with edges butting (gap no greater than 2 mm). Bind the jacket to the cable core using splicing tape on the outside 2 cm of both ends. Cut two pieces of cross-linked polyethylene, heat-shrinkable tubing, 158 mm in length, that is between 65% and 85% of the diameter of the cable when the tubing is fully recovered. Paint two bands of conducting silver paint 6 mm wide at a separation of 165 mm (centered on the 230 mm specimen). Mark the center 50 mm of the specimen on one specimen only, and place a lubricant coating of approximately 3 mm thickness completely around the cable in this 50 mm area. The second specimen serves as a control with no lubricant exposure. Shrink the tubing over the specimen working inward from both edges. Final appearance and dimensions are shown in Figure 1. As an alternative to heat-shrink tubing, self-adhering silicone rubber tape can also be wrapped to form the containment pocket shown in Figure 1.

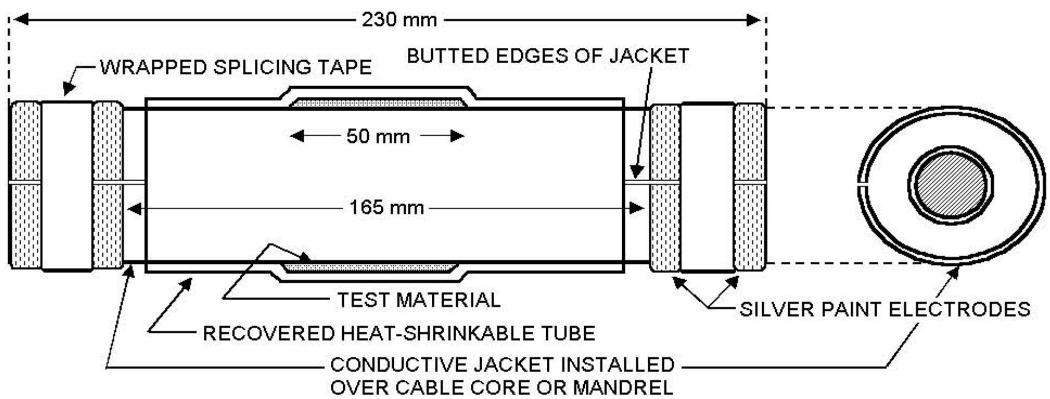

Figure 1—Specimen for self-supporting lubricants—conductive jacket

Test both specimens at the conditions specified in 4.3 and 4.4 and by the method in 5.7.1.

5.7.3.2 Specimens for semiconducting insulation shield with self-supporting lubricants

Test specimens shall be prepared in the following way: Cut two cable specimens 230 mm long. Remove all coverings down to the semiconducting insulation shield (in most cases, the concentric neutral wires are the only coverings that need to be removed). Cut two pieces of cross-linked polyethylene, heat-shrinkable tubing (without internal sealant) to 158 mm in length. Choose heat-shrinkable tubing that is between 65% and 85% of the diameter of the cable when the tubing is fully recovered. Paint two bands of conducting silver paint 6 mm wide at a separation of 165 mm (centered on the 230 mm specimen). Mark the center 50 mm of the specimen on one specimen only, and place a lubricant coating of approximately 3 mm thickness completely around the cable in this 50 mm area. The second specimen serves as a control with no lubricant exposure. Shrink the tubing over the specimen working inward from both edges. Final appearance and dimensions are shown in Figure 2. As an alternative to heat shrink tubing, self-adhering silicone rubber tape can also be wrapped to form the containment pocket shown in Figure 2.

Test both specimens at the conditions specified in 4.3 and 4.4 and by the method in 5.7.1.

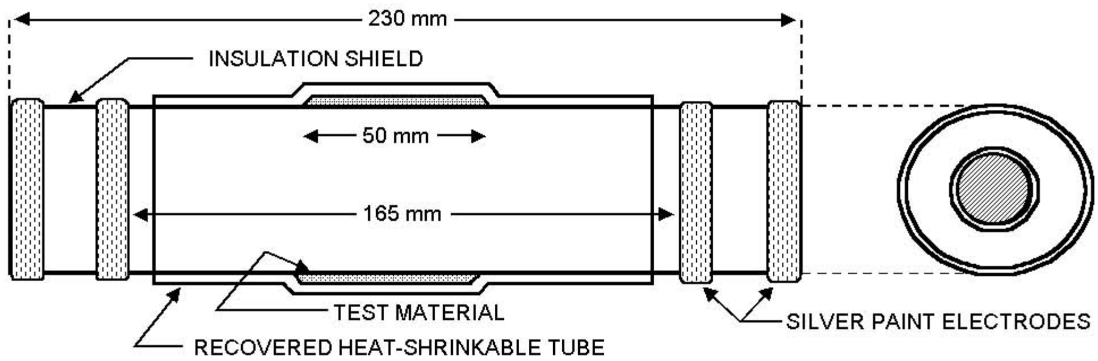

Figure 2—Specimen for self-supporting lubricants—exposed insulation shield

5.7.3.3 Specimens for semiconducting jackets/shields when lubricants are not self-supporting—immersion test

Test specimens shall be prepared in the following way: Cut two test specimens for testing from the conductive component of the cable with the long dimension parallel to the conductor. Cut strips of material 190 mm ± 3 mm long by 10 mm ± 1 mm wide. Apply silver electrodes as shown in Figure 3 with the potential electrodes at a separation of 100 mm and the current electrodes at a separation of 180 mm.

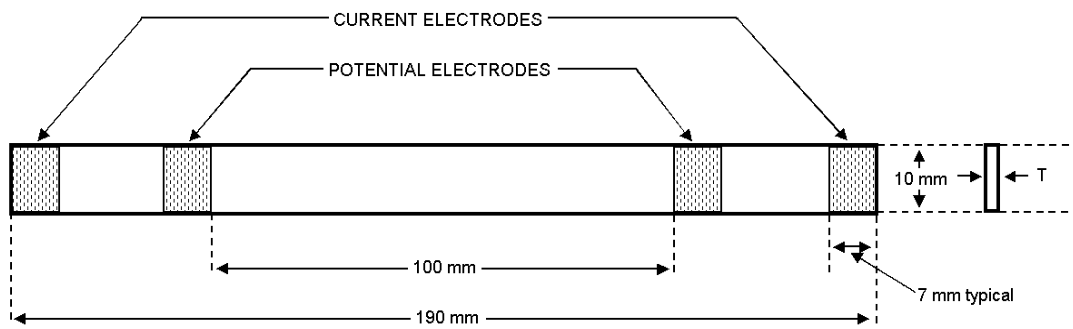

Figure 3—Specimen for non-self-supporting lubricants

5.8 Dielectric voltage withstand test in water

The test shall be run in accordance with ANSI/UL 1581-2001, Section 820, and the conditions in 4.5 or 4.6 with the following exceptions: A 3.04 m piece of cable shall be coiled for the test. The coil shall undergo the lubricant immersion preparation described in 5.8.1. The sample shall then be immersed in the water tank for 6 h before the test potential is applied.

5.8.1 Preparation of samples for the dielectric voltage withstand test in water

A 3.04 m length of wire or cable shall be used for the test. The wire shall be coiled and immersed in the lubricant (closed container) for 30 days at 49 °C ± 2 °C. The coil shall then be removed from the lubricant, carefully and thoroughly washed, and allowed to dry for a minimum of 48 h and maximum of 96 h before the test.

Annex A

(informative)

Bibliography

[B1] AEIC CS6-96, Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69 kV.[8]

[B2] AEIC CS7-93, Specifications for Crosslinked Polyethylene Insulated Shielded Power Cables Rated 69 through 138 kV.

[B3] AEIC CS8-00, Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV.

[B4] ANSI/ICEA S-93-639/NEMA WC74-2000, Shielded Power Cables 5,000–46,000 V.[9]

[B5] ANSI/ICEA S-94-649-2000, Concentric Neutral Cables Rated 5 Through 46 kV.

[B6] ANSI/ICEA S-97-682-2000, Utility Shielded Power Cable Rated 5 Through 46 kV.

[B7] ANSI/ICEA S-105-692-2000, 600 V Single Layer Thermoset Insulated Utility Underground Distribution Cables.

[B8] ANSI/ICEA S-95-658/ NEMA WC70-1999, Nonshielded Power Cables Rated 200 V or less.

[B9] ANSI/ICEA S-96-659/NEMA WC71-1999, Nonshielded Power Cables Rated 2001–5000.

[B10] ASTM D257-1999, Test Methods for DC Resistance or Conductance of Insulating Materials.[10]

[B11] ICEA S-73-532/NEMA WC57-1995, Standard for Control Cables.[11]

[B12] IEEE Std 1026-1995, IEEE Recommended Practice for Test Methods for Determination of Compatibility of Materials With Conductive Polymeric Insulation Shields and Jackets.[12]

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[8]AEIC publications are available from the Association of Edison Illuminating Companies, 600 N. 18th Street, P. O. Box 2641, Birmingham, AL 35291-0992, USA (http://www.aeic.org/). AEIC publications are also available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112-5704, USA (http://global.ihs.com/).

[9]ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[10]ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).

[11]ICEA publications are available from ICEA, P.O. Box 20048, Minneapolis, MN 55420, USA (http://www.icea.org/).

[12]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).