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(Revision of
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1067™

IEEE Guide for In-Service Use, Care, Maintenance, and Testing of Conductive Clothing for Use on Voltages up to 765 kV ac and ±750 kV dc

IEEE Power Engineering Society

Sponsored by the
Transmission and Distribution Committee

IEEE

3 Park Avenue, New York, NY 10016-5997, USA

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Approved 14 February 2005

IEEE-SA Standards Board

Abstract: General recommendations for the in-service care, maintenance, and testing of the conductive clothing worn by workers to perform work in high-voltage fields are presented.
Keywords: clothing, conductivity, energized, maintenance, power lines

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Introduction

(This introduction is not part of IEEE Std 1067-2005, IEEE Guide for In-Service Use, Care, Maintenance, and Testing of Conductive Clothing for Use on Voltages up to 765 kV ac and ±750 kV dc.)

Conductive clothing provides a shield around the worker's body that minimizes discomfort due to the electric field.

The original development and testing of conductive suits dates back to the early 1960s.

The success of these suits in relieving the worker from discomfort while working on lines up through 765 kV ac and ±750 kV dc has played an important role in the successful operation, maintenance, and continuity of service of these extremely high-voltage (EHV) lines.

A number of member companies within IEEE's Engineering in the Safety, Maintenance, and Operations of Lines (ESMOL) Subcommittee made it known that an in-service guide was needed to inspect and test conductive suits before a worker went up to the energized conductor.

Prior to drafting the first publication of this guide, a survey of the user community was conducted to determine if such a guide was needed and also to solicit user procedures for the purpose of sharing information. It was evident that little technical information was available. It was also learned, however, that information was needed. ESMOL was encouraged to research the subject and to summarize its findings in a guide.

This guide was revised to reflect advancements in the manufacturing and testing of conductive clothing. It is intended that the contents of this guide will be modified as future needs dictate. Suggestions for improvements and additions are welcome.

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IEEE Guide for In-Service Use, Care, Maintenance, and Testing of Conductive Clothing for Use on Voltages up to 765 kV ac and ±750 kV dc

1. Overview

1.1 Scope

This guide provides recommendations for the in-service visual inspection, use, care, maintenance, and electrical testing of conductive clothing, including suits, gloves, socks, and boots, for use during linework on voltages up to 765 kV ac and ±750 kV dc.

Testing pertains only to nondestructive electrical tests that can be performed periodically to check if there is any reduction in the conductivity of the clothing.

1.2 Purpose

The purpose of this guide is to present, in one document, sufficient details of presently used methods and techniques to provide for inspection, care, maintenance, and field testing. This guide also presents a new method of testing conductive clothing.

This guide is intended to direct attention to appropriate standards and regulations relating to the care or testing of conductive clothing.

It is not intended that this guide should replace present proven company procedures, nor imply that these recommendations are superior to existing practices and therefore should be universally adopted as company standards. This compilation of many accepted practices is presented specifically in the form of a guide to be used by those utilities that are seeking guidance in establishing methods and procedures for the use, care, maintenance, and testing of conductive clothing.

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2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI/SIA A92.2-2001, Vehicle-Mounted Elevating and Rotating Aerial Devices.[1]

IEC 60895:2002, Specification for Conductive Clothing for Live Working at Nominal Voltage up to 800 kV ac and ±600 kV dc, Ed. 2.0 .[2]

IEC 60212:1971, Standard conditions for use prior to and during the testing of solid electrical insulating materials, Ed. 2.0.

IEC 60456:2003, Clothes washing machines for household use—Methods for measuring the performance, Ed. 4.0.

IEC/TR2 61318:1994, Live working—Guidelines for quality assurance plans.

ISO 3175:1995, Textiles—Evaluation of stability to machine dry-cleaning.[3]

ISO 6330:2000, Textiles—Domestic washing and drying procedures for textile testing.

ASTM F-1959/F-1959M-04—Standard Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing.[4]

ASTM F-1958/F-1958M-05—Standard Test Method for Determining the Ignitability of Non-Flame Resistance Materials for Clothing by Electric Arc Exposure Method Using Mannequins.

3. Technical considerations

3.1 General

Conductive clothing is used to provide an electrical shield around the worker's body that minimizes discomfort due to the electric field associated with EHV line work. During barehand work, the worker is bonded to the conductor or device to keep the worker at the same potential.

The wearer should be made responsible for the care and condition of the conductive clothing. Training should be provided in the inspection and care of conductive clothing.

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[1]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/).

[2]IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http:// www.ansi.org/).

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[4]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/).

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3.2 Suits, jackets, and trousers

Conductive suits (see Figure 1) should at all times be the outermost garment, except that leather protective gloves can be worn over the conductive gloves for protection (see 3.4.1).

CAUTION

Do not wear other clothing over conductive clothing. Clothing worn over conductive clothing may burn when conduction occurs, and burning can result in serious injury to both the wearer and coworkers.

When dressed in the conductive clothing, it is important that all the different pieces of conductive clothing are well bonded together. This can be verified by a second worker. Trousers and jackets from different manufacturers may be interchanged so long as they are of the same generic fabric type. However, if there is discomfort, clothing of the same manufacturer should be used. If discomfort persists, the suit should be inspected and tested. Conductive socks worn with conductive clothing will properly bond the worker through the soles of the conductive boots. If bootstraps (leg straps) are supplied with the boots, these may be bonded to the suit for a better connection. This is especially true if conductive socks are not worn.

When putting on the hood, make sure that it is fitted over the lip of the hardhat so that the face is shielded. Otherwise, the face can be subject to discomfort. The hood should be secured to the lip of the hardhat.

3.2.1 Bonding strap(s) leads

The bonding straps are intended to keep the worker at the same potential as the worksite and maintain continuity between the various pieces of the suit. When doing barehand work, a minimum of one strap should be connected to the bucket shield when working from an aerial device, to the conductor when working from an insulated ladder, or to a cart or platform (see also ANSI/SIA A92.2-2001).[5]

If, at any time, two straps are to be connected to a conductor, it is essential to personal safety that they be connected to the *same* side of such items as splicing sleeves, etc., where a difference of potential could exist.

Multiple workers should always be at the same potential where they can come into contact with each other.

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

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Figure 1—Proper wearing of the suit

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3.3 Conductive boots

If conductive boots are used, the soles of the boots should be clean before stepping onto the bucket shield, platform, or conductor cart.

Conductive boots (when soles are in contact with the structure) will mitigate electric field effects (annoying spark discharges) to workers working from structures.

3.4 Conductive gloves

Conductive gloves must be bonded to the jacket to prevent discharges across the boundary of the glove and jacket.

3.4.1 Leather gloves

Leather gloves may be worn over the conductive gloves to protect them from rapid wear.

Leather gloves should be clean and free of pin holes.

3.5 Conductive socks

Conductive socks must be bonded to the pant leg.

4. Care of conductive clothing

4.1 General

The integrity of the conductive clothing is essential. It is, therefore, the responsibility of the wearer to exercise extra care while handling and wearing the clothing. Tears, holes, or other deformities of the material can result in discomfort and should be reported and repaired according to accepted practice (see Clause 5).

The boots, especially the soles, should be kept clean and in good repair.

Conductive clothing and/or conductive footwear should not be used for any purpose other than that for which they were designed.

4.2 Storage

Conductive clothing should not be stored while damp from perspiration or other moisture. Suits, gloves, and socks should be stored in a dustproof breathable container, such as a canvas or vinyl bag or briefcase, in order to allow any moisture in the conductive clothing to dry, rather than cause molding. The storage container should be distinctive and should be stored in a location safe from heat, moisture, and damage by other stored items. Care should be taken in transport.

4.3 Cleaning

The conductive clothing should be washed in accordance with the manufacturer's recommendations. The conductive clothing may be dried in an automatic dryer on low heat (absent manufacturer instructions to the contrary) or air dried. Fabric softeners should never be used in cleaning.

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Suits may be uncomfortably hot to the touch when removed from the dryer.

The life of the clothing may be prolonged by hand washing with a *mild* detergent and air drying. Suits that are heavily soiled with grease or oil should be dry-cleaned.

Socks and gloves should be hand washed in lukewarm water using a mild detergent. Thoroughly rinse and wring out to remove excess water. Hang to dry. They are quick drying and should be ready to wear in about 8 hours.

5. Patching and repair of conductive clothing

Snags and rips can be sewed with flame-retardant thread. Generally, such holes can be repaired without negative effects by using a patch of the same type of fabric, and stitching a 24.5-mm (1 in) overlap with flame-retardant thread. The conductive clothing should be visually inspected and electrically tested after any repair to insure that the repair is adequate.

NOTE—When the clothing is beyond repair and must be retired from service, it is recommended that it be returned to the manufacturer, along with a history of its use, to provide a database for future review.[6]

Socks and gloves are not repairable.

6. Visual inspection before use (field testing)

6.1 General

The suit should be carefully inspected before each use. Stretching a single layer of the fabric and inspecting with a lighted background should show excessive wear. Tears and rips are not acceptable under any circumstances and especially if the suit is being used at EHV voltage**.**

Garments with very high ohm resistance can be and have been safely used where the electric field exposure is low. A resistance value of 400 ohms has been established as a practical limit for barehand work at the highest voltage (800 kV).

It is recognized that washing can change the properties of the material. It has been shown that an increase in resistance can be detected after three to four washings. Therefore, it is recommended that a periodic test period consider the number and cleaning method used (see Clause 7).

The second and more important consideration is the voltage from the suit to nonbonded parts of the body. EPRI TR-104640 [B1][7] found that a suit-to-neck voltage of 0.45 V could result in uncomfortable discharges. Discharges probably give a more realistic method for determining the serviceability of the garment. If the wearer is not bonded to the suit, a 400-ohm suit could develop 0.4 V in an 800 kV field. If the clothing components are not bonded, discharges to the worker can develop.

Many companies use worker perception to determine when a suit should be thoroughly examined, replaced, or tested. While worker perception should always be a significant factor in determining whether to replace or test a suit, more routine and standardized replacement and testing procedures are recommended.

[6]Notes in text, tables, and figures of a standard are given for information only, and do not contain requirements needed to implement the standard.

[7]The numbers in brackets correspond to those of the bibliography in Annex C.

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Suits with a range of resistance values can be worn in a safe manner, but bonding is essential for comfort.

6.2 Clothing

The clothing should be inspected to make sure that it is not damaged and that the tail connection is secure. A visual inspection should be made of the complete clothing to ensure that all component parts fit together.

Zip fasteners, metal press studs, and metal hooks and eyes (gallows straps on suspenders) should be checked to ensure that they are correctly inserted and that nothing prevents them from making good electrical contact. The stitching should be examined to ensure that it is continuous and that the two or more pieces being joined are in good electrical contact.

Adjustable cloth fasteners may be used to eliminate the need for metal fasteners.

The straps between the boots to the calf should be inspected for breaks that would disrupt electrical continuity. Straps should be replaced if they fail to reliably provide electrical continuity. The soles of the boots should be checked for dirt or contaminants. The soles should be kept clean.

Continuity between the leg strap, if used, and the sole of the boot should be ensured.

Gloves and socks should be inspected for damage.

6.3 Bonding strap continuity check

It is suggested that continuity of the bonding straps to the suit components be checked periodically in the field and checked against the baseline. A digital ohmmeter may be used and records kept. If the measurement reaches three times the original readings, the suit should be carefully examined and laboratory tested.

NOTE—The manufacturer's original test sheet should be maintained.

7. Periodic nondestructive testing (laboratory)

For companies that want to conduct a laboratory test, this guide presents a new method that was recently developed by the Conductive Clothing Task Force of the ESMOL Subcommittee. Laboratory tests can be conducted periodically to evaluate the effect of aging and wear. The period, to be determined by the company, is established by the field visual inspection and measurements as well as the age and electric field strength during use. It is recommended that the garment be laboratory tested for the highest line voltage the garment will be exposed to whenever the garment becomes uncomfortable, when the garment exceeds the bonding strap continuity test criteria or when the service time or washing frequency exceeds the values indicated in 7.5.

Resistance provides some indication of the protective properties of the garment. EPRI TR-104640 [B1] gives one way to consider the limiting resistance of a garment. The maximum acceptable body current is considered to be the perception level for 50% of the population as 1.1 mA. The model developed can be used to estimate the maximum suit resistance that would result in the perception current level in the parallel worker's body. The relative suit resistance values shown in Table 1 will limit the body current to 1 mA. (The suit resistance values for dc voltage workers or workers on the structure can be as much as 10 times higher than that of the energized worker using the barehand method (see references in Clause 2).

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Table 1—Maximum suit resistances as a function of line voltages

Line voltage (kV)	Resistance (ohms)
800	400
550	615
365	888
242	1333
121	2667

NOTE—This table reflects 60 Hz ac voltage (see references using 1 mA). Modern garment material will normally test at an average of less than 100 ohms; so that value can be used as a benchmark for "concern." Any significant increase above 100 ohms is an indication of change on the garment affecting the resistance. Readings of 400 ohms should be considered the limit for use at 800 kV by the barehand method.

7.1 Preparation of the garment for test

The garment may be hung in a simulated wearing position on a mannequin, or a "stickman" (see Annex A), or laid flat on a table. Weights of 2.27 kg (5 lb) should be hung from the ankle and wrist cuffs to assure thread contact and for test repeatability. Tests have shown that the weights are approximately equivalent to the "stretch" while wearing and working.

Resistance values for the jacket and trousers should be measured separately. The overall resistance is measured with the jacket and trousers bonded together.

7.2 Electrodes

The recommended electrode may be made from clothespins of the type used for clamping rubber-insulating blankets around insulators. The inside surface of the clamp may be lined with a conductive metallic foil that has an adhesive on one side.

The conductive side of the electrode (jaws in contact with the material) should be used to make contact with the cloth.

7.3 Test method

Either ac or dc voltage supply may be used to measure the resistance, but dc may be easier and as accurate when measuring the resistance when these procedures are followed.

Tests have shown that a calibrated digital multimeter will provide acceptable readings when used in accordance with these test procedures.

7.4 Test procedure

Electrodes should be placed approximately 50 mm (2 in) back from any seam or edge of the garment. Each electrode should contact the top and bottom layer of the cloth.

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Resistance measurements can be made with the garment on a mannequin, on a simulated frame, or flat on a table. When the table method is used, the table must not have metallic edges that can short the material.

If the garment is laid on a table with the ankle and wrist cuffs overhanging the edge, 2.27-kg (5-lb) weights are attached to the cuffs during measurements to provide a constant "stretch" on the garment. A 2.27-kg (5-lb) weight is also used to assure contact between the jacket and trousers. Readings are taken after a short time (30 s) for meter stabilization.

The weights should also be used for measurements on a mannequin or stickman method to provide the same effect as wearing the garment.

Install electrodes about 50 mm (2 in) from edge or seam.

Connect the multimeter and read after 30 s or after the readings stabilize.

Measurements are to be taken as follows (see Figure 2):

a) **Jacket**
   1) Wrist cuff to wrist cuff
   2) Hood to waist
   3) Left bonding strap to suit attachment point 150 mm (6 in)
   4) Right bonding strap to suit attachment point 150 mm (6 in)

b) **Trousers**
   1) Ankle cuff to ankle cuff

c) **Complete suit**
   1) Left wrist cuff to opposite ankle cuff
   2) Right wrist cuff to opposite ankle cuff
   3) Hood to ankle cuff

7.5 Test Frequency

The test frequency on each garment depends on the use and the electric fields that the work is performed in For maximum fields (765 kV barehand work), laboratory tests should be made at least every 5 years or after the first five washings and after each three subsequent washings to develop a history of that garment's resistance changes or variations.

Retest is recommended after any repair.

8. Record keeping

The essential minimum information to be retained is as follows:

a) Identification of the jacket and trousers by the manufacturer's company identification name or number and resistance values supplied by the manufacturer

NOTE—The purchaser can specify that the manufacturer will provide a durable label with a suit number on the jacket and trousers. A document, identified by the manufacturer's number, should be provided with the clothing to indicate the date of the test and the resistance value according to the details of this guide.

b) Date

c) Use information—voltages and hours, if possible

d) Injection current

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e) Resistance calculation or ohmmeter reading
f) Name and model of meter
g) Condition of apparel (i.e., new, used, soiled, worn, torn, etc.)
h) Number of washings
i) Worker's reported comfort or discomfort and at what operating voltage

A sample of a suggested data sheet is shown in Figure 2. The data sheet can be used in conjunction with the Worker Conductive Suit Questionnaire in Annex B.

NOTE—The ESMOL Subcommittee is gathering additional statistics on the performance of conductive clothing and would appreciate copies of the test data and questionnaire being forwarded to the Chair of the IEEE ESMOL Subcommittee, c/o IEEE Standards Department, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

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In-Service Conductive Suit Test Report

Suit manufacturer:	Suit ID:
Suit condition:	User:
Temperature:	Test number:
Humidity:	Test date:
Number of washings to date:	Test position: table, frame, mannequin
Worker Response Comfort Level:	

Measurement locations	Voltage	Injected value	Manufacturer initial values (new suit) (ohms)	Measured (ohms)
Jackets				
Wrist cuff to wrist cuff				
Hood to waist				
End of left bonding strap to 150 mm (6 in) away from suit attachment pt 150 mm (6 in)				
End of right bonding strap to 150 mm (6 in) away from suit attachment pt 150 mm (6 in)				
Trousers				
Ankle to ankle cuff				
Complete suit				
Left wrist cuff to opposite ankle cuff				
Right wrist cuff to opposite ankle cuff				
Hood to ankle cuff				
Overall suit average				

Test instrument(s) used: _____

Calibration date: _____

Calibration due: _____

Observations/comments:

_____

_____

Figure 2—Sample data sheet

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Annex A

(informative)

Stickman diagram

This drawing shows the dimensions that can be used for a mannequin ("stickman") as described in 7.1. The garment can be hung on the stickman during testing to obtain consistent laboratory conditions for the positioning of the clothing.

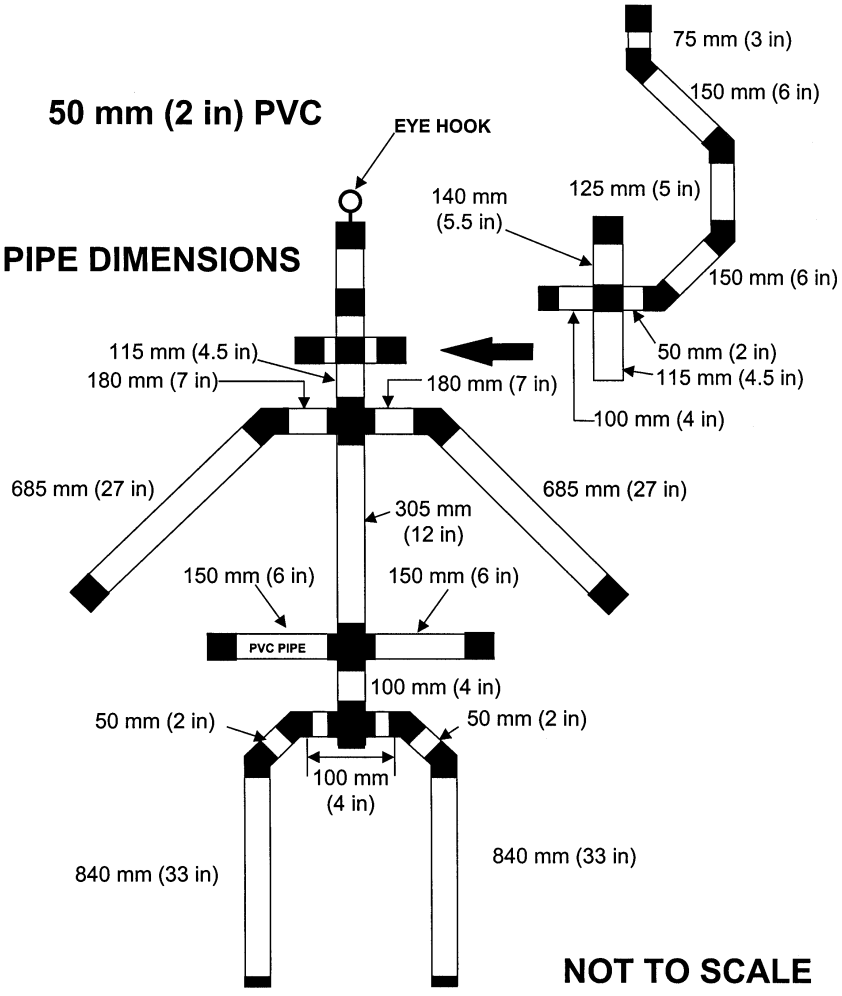


Figure A.1—Dimensions for building a mannequin for testing suits

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Annex B

(informative)

Worker conductive suit questionnaire (used with sample data sheet)

Suit Jacket Number:	Suit Pants Number:

Worker Comfort

1. On the scale below, please rate the suit's comfort level

No perception				Painful
1	2	3	4	5

2. Have you felt any spark discharges (e.g., "biting")? Yes ___No ___
   If yes, where? _____
   _____
   _____
   _____

3. If the suit is "biting" (spark discharges), please check at what voltage(s).

138 kV	230 kV	345 kV	500 kV	765 kV

Under what type of work? Check all that apply.

Barehand	Bucket	On ladder	On structure
On conductor	Other (identify)		

Care of the Suit

4. Please estimate the number of times you washed the suit. _____
5. How many years have you personally used this suit? _____
6. Are you familiar with the manufacturer's washing instructions? Yes __ No __
7. Do you follow the manufacturer's washing instructions? Yes __ No __
8. How do you get grease or similar stains out of the suit?

_____
_____
_____

9. Do you inspect the suit prior to each use? Yes __ No __

THANK YOU for taking the time to respond.

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Annex C

(informative)

Bibliography

[B1] EPRI TR-104640, Project RP2472-99, *Electrical Performance of Conductive Suits,* Final Report, Hotte, P. W., and Gela, G.

[B2] Hotte, P. W., Gela, G., Mitchell, Jr., J. D., and Lyons, P. F., "Electrical Performance of Conductive Suits," ESMO-95 TP-05.

[B3] IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition, New York, Institute of Electrical and Electronics Engineers, Inc.

[B4] "Service Aged Conductive Clothing Measurements," ESMOL Task Force Revision of IEEE Std 1067-1996, *ESMO 2000 Proceedings, 2000 IEEE 9th International Conference on Transmission & Distribution Construction, Operations & Live Line Maintenance Proceedings,* pages 182–185.

[B5] Vincent, C., Bourdages, M., Nguyen, D.H., Boissomneault, R., Lapierre, S., and Hansel, M., "Properties of Conductive Material (Fabric) under AC and DC Conditions," *ICOLIM 2002 Proceedings,* Hydro Quebec, pages 157–162.

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