IEEE Std 1067-1996
(Revision of IEEE Std 1067-1990)

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

Sponsor

**Transmission and Distribution Committee
of the
IEEE Power Engineering Society**

Approved 21 March 1996

IEEE Standards Board

Abstract: Recommendations are provided for the in-service use, care, maintenance, and electrical testing of conductive clothing, including suits, gloves, socks, and boots, for use on voltages up to 765 kV ac and ± 750 kV dc.
Keywords: conductive clothing, nondestructive evaluation (NDE), nondestructive testing

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

ISBN 1-55937-699-6

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying all patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Introduction

(This introduction is not part of IEEE Std 1067-1996, 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 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 Subcommittee on Engineering in the Safety, Maintenance, and Operation of Lines (ESMOL) 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 the drafting 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 into 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.

At the time this guide was written, the membership of the ESMOL Working Group on Equipment and Tools, 15.07.04, was as follows:

W. T. Croker, *Chair*

W. G. Arthur	M. Eby	R. Melzer
D. A. Blakely	J. Eckman	D. Mitchell
G. K. Brandt	H. Fox	W. Olive
T. Buonincontri	G. Gela	J. L. Price
W. H. Cole	D. A. Gillies	D. Reisinger
E. Davis	E. L. Harris	G. Stinnett
J. F. Doering	E. Jones	J. M. Van Name
J. L. Dushaw	H. J. Kientz*	R. M. Wagner

*Chair of the Conductive Clothing Task Force, 15.07.04.02

The following persons were on the balloting committee:

James G. Applequist	Edward J. Goodwin	Stig L. Nilsson
J. F. Buch	I. S. Grant	R. J. Piwko
Kris Buchholz	E. L. Harris	J. L. Price
Vernon L. Chartier	John G. Kappenman	Edward W. Reid
W. H. Cole	George G. Karady	Farouk A. M. Rizk
W. T. Croker	Nestor Kolcio	B. R. Shperling
G. Gela	Keith E. Lindsey	James R. Stewart
D. A. Gillies	Franklin D. Myers	J. M. Van Name†

†Deceased

When the IEEE Standards Board approved this standard on 21 March 1996, it had the following membership:

Donald C. Loughry, *Chair* **Richard J. Holleman,** *Vice Chair*
Andrew G. Salem, *Secretary*

Gilles A. Baril
Clyde R. Camp
Joseph A. Cannatelli
Stephen L. Diamond
Harold E. Epstein
Donald C. Fleckenstein
Jay Forster*
Donald N. Heirman
Ben C. Johnson
E. G. "Al" Kiener
Joseph L. Koepfinger*
Lawrence V. McCall
L. Bruce McClung
Marco W. Migliaro
Mary Lou Padgett
John W. Pope
Jose R. Ramos
Arthur K. Reilly
Ronald H. Reimer
Gary S. Robinson
Ingo Rüsch
John S. Ryan
Chee Kiow Tan
Leonard L. Tripp
Howard L. Wolfman

*Member Emeritus

Also included are the following nonvoting IEEE Standards Board liaisons:

Satish K. Aggarwal
Alan H. Cookson
Chester C. Taylor

Valerie E. Zelenty
IEEE Standards Project Editor

Nomex is a registered trademark of E. I. Dupont de Nemours and Company.
Velcro is a registered trademark of Velcro Industries B. V.

Contents

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 use, care, maintenance, and electrical testing of conductive clothing, including suits, gloves, socks, and boots, for use 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 enable the in-service use, care, maintenance, and testing of conductive clothing.

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

It is not intended that this guide should replace present proven utility standards, or imply that these recommendations are superior to existing practices and, therefore, should be universally adopted as utility 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.

2. References

This guide should be used in conjunction with the following publications.

ANSI/SIA A92.2-1990, Vehicle Mounted Elevating and Rotating Aerial Devices.[1]

IEC 895 (1987), Specification for Conductive Clothing for Live Working at Nominal Voltage up to 800 kV ac.[2]

3. Use of conductive clothing

3.1 General

Conductive clothing provides an electrical shield around the worker's body that minimizes discomfort due to the electric field. During bare-hand work, it also puts the worker at the same potential as the conductor or device to which the worker is bonded.

A worker may be assigned a particular suit and be made responsible for its care and cleanliness. Training should be provided in the inspection and care of conductive clothing.

3.2 How conductive clothing is worn

Conductive suits shall be the outer garment. (See 3.5 for exception for gloves.)

CAUTION

Do not wear other clothing over conductive suits.
Burning can result in serious injury to the worker.

When dressed in the conductive clothing, it is important that all the different pieces of conductive clothing are well bonded together. Trousers and jackets from different manufacturers may be interchanged so long as they are of the same generic fabric type. If there is discomfort, clothing of the same manufacturer should be used. If discomfort persists, the suit shall 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 should 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 safety hat so that the face is shielded. Otherwise, the face can be subject to discomfort.

3.3 Bonding strap

A bonding strap or "tail" is attached to the suit. It shall 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. When two workers are working from a double bucket, the straps of both suits should be connected to the bucket shields. (See also ANSI/SIA A92.2-1990.)

[1]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[2]IEC publications are available from IEC Sales Department, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/ Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

If, at any time, two “tails” 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 shall always be at the same potential where they can come into contact with each other.

3.4 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 will mitigate electric field effects (annoying spark discharges) to workers working from structures.

3.5 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.

4. Care of conductive clothing

4.1 Care

The integrity of the conductive clothing is essential. It is therefore the responsibility of the worker to exercise extra care while wearing and otherwise handling the clothing. Tears, holes, or other deformities of the material should be repaired according to accepted practice (see 5.1).

The boots, especially the soles, should be kept reasonably 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

Suits, gloves, and socks should be stored in a dustproof breathable container, such as a canvas or vinyl bag or briefcase. The container should be breathable 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. Conductive clothing should not be stored while damp from perspiration or other moisture.

4.3 Cleaning

The conductive suit may be washed by hand or in an automatic washer with a detergent and no other additives (such as chlorine bleach, etc.), and may be dried in an automatic dryer on low heat or air dried.

CAUTION

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

The life of the suit 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.

5. Patching and repair of conductive clothing

Snags and rips can be sewed with flame-retardant thread (e.g., Nomex® or equivalent). 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.

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

Socks and gloves are not repairable.

6. Inspection before use

6.1 General

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 Velcro® may be used to eliminate the need for metal fasteners.

6.2 Suits

The suit should be inspected to make sure that it is not damaged, and that the tail connection is secure.

6.3 Boots and leg straps

The straps between the boots to the calf should be inspected for breaks that would disrupt electrical continuity. They should be replaced if they are judged inadequate (see 3.2). The soles of the boots should be checked for dirt or contaminants. The soles should be kept clean.

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

6.4 Socks

Socks should be inspected for damage.

6.5 Gloves

Gloves should be inspected for damage.

6.6 Continuity check

Conductive clothing and boots may be tested for continuity using an ohmmeter.

7. Nondestructive testing

7.1 General

Conductive suits, as the name implies, must be conductive. If an ohmmeter is connected between any two extremities of the material on a suited person, it should register continuity. (The degree of continuity, or specifically, the ohmic value that must not be exceeded, is currently under review.)

The test procedure in this clause may be followed in order to ensure that resistance values can be uniformly measured and reported. Such standardized test results may lead to a specified resistance limit in this guide at the next revision.

The purpose of this testing is to obtain data on resistance values of jackets and trousers.

Other nondestructive test methods, such as screening efficiency tests, are available, but are beyond the scope of this document. See IEC 895 (1987).

7.2 Apparatus

The following apparatus is needed for the test:

a) An ac or dc power supply that can be regulated to give an injection current of 1–5 mA [see IEC 895 (1987)]
b) One milliammeter
c) One voltmeter
d) Ohmmeter, if required (see the note in 7.5.1)
e) Two electrodes (see 7.4)
f) Optional: self-contained, commercially available 5 mA constant-current ohmmeter

7.3 Preparation of specimens

Resistance values for the jacket and trousers should be measured separately to avoid the variable resistance introduced when tying the two garments together or mixing garments from different manufacturers. Where a total suit resistance reading is desired, see the third paragraph below.

The apparel should be laid unstretched on a flat insulating surface. Weights should not be placed on top of the fabric.

Electrodes should be placed approximately 50 mm (2 in) back from the extremity of the material. Each electrode should contact the top and bottom layer of cloth. The electrodes should be placed to measure the resistance from arm to arm, leg to leg, each bonding strap to the suit, and the top of the hood to both the lapel and the back. If a total suit reading is desired, test from the right arm cuff to the left leg cuff via the ties.

Moisture content of the fabric and/or high relative humidity can affect the resistance values obtained by the test.

7.4 Electrodes

Suggested electrodes may be made from clothespins of the type used for clamping rubber insulating blankets around insulators and crossarms. The inside surfaces of the clamp may be lined with bright stainless steel foil that has adhesive on one side. See figure 1.

The tips of these electrodes (jaws in contact with the material) shall be used to make contact with the cloth.

Figure 1—Suggested electrodes for taking resistance measurements

7.5 Test procedures

7.5.1 Procedures for power-supply voltmeter-milliammeter tests

a) Connect the electrodes to the power supply having a milliammeter in the output circuit.

b) Connect a voltmeter across the electrodes.

c) Adjust the power source for a preferred current injection of 5 mA. If the suit resistance is too high to permit 5 mA at 30 V ac or 60 V dc, a current as low as 1 mA may be used.

NOTE—Suit resistance varies with current. The preferred injection current is 5 mA. Values less than 5 mA should be denoted on the data sheet. If the resistance of the suit is extremely high, and precludes the use of the injection current method, then measuring resistance values using an ohmmeter is permissible, and the values should be recorded. The injection current method is preferred over the ohmmeter method since the former gives more reproducible results.

d) A minimum of two consecutive current readings and resulting voltage readings should be made for each test.

7.5.2 Procedures for 5 mA constant-current ohmmeter resistance tests

a) Clamp each electrode to its designated test spot on the fabric.

b) Turn on the input power to the constant-current ohmmeter. Take a resistance reading as soon as a stable reading is reached. This allows the internal capacitors in the meter to charge up.

c) An alternate procedure is to turn on the input power to the constant-current ohmmeter prior to connecting the electrodes to the fabric. After 15 s, connect the electrodes to the fabric and record the readings.

7.6 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 will 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) Voltage
d) Injection current
e) Resistance calculation or ohmmeter reading
f) Name and model of ohmmeter, if used
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 test data should be 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.

7.7 Frequency of tests

The manufacturer shall perform an initial resistance test on all jackets and trousers produced (see the note in 7.6). Initial acceptance tests may also be performed by the user.

In-service tests should be performed by the user on an annual basis, as a minimum.

Test No. _____

Date _____

TEST REPORT ON CONDUCTIVE SUIT

Suit manufacturer_____

Identification number _____

Resistance value supplied by manufacturer_____

Condition of suit [ ] New [ ] Worn [ ] Soiled [ ] Torn

Number of washings _____

Location of measurement	Voltage ac [ ] dc [ ]		Injection I		*Resistance	
	1st	2nd	1st	2nd	1st	2nd
Jacket cuff, arm to arm						
Trouser cuff, leg to leg						
Top of hood to lapel						
Left bond to suit attach point						
Right bond to suit attach point						
Right arm cuff to left arm cuff via the ties						
Top of hood to center of back						

*If an ohmmeter is used, give the name and model.

NOTES

1—Any discomfort from annoying transient discharge? [ ] Yes [ ] No
If yes, were undergarments worn? [ ] Yes [ ] No

2—Operating voltage _____

3—Other comments _____

_____

_____

Signature _____

Company _____

Figure 2—Suggested test form