

ICEA S-93-639
NEMA WC 74

5-46KV SHIELDED POWER
CABLE FOR USE IN THE
TRANSMISSION AND
DISTRIBUTION OF ELECTRIC
ENERGY



Approved as an American National Standard
ANSI Approval Date: January 4, 2007

**Insulated Cable Engineers Association, Inc. Publication No. ICEA S-93-639
NEMA Standards Publication No. WC 74-2006**

*5-46kV Shielded Power Cable for Use in the Transmission and Distribution
of Electric Energy*

Prepared and Sponsored by:

Insulated Cable Engineers Association, Inc.
P.O. Box 1568
Carrollton, Georgia 30112

www.icea.net

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1752
Rosslyn, Virginia 22209

www.nema.org

© Copyright 2006 by the National Electrical Manufacturers Association and the Insulated Cable Engineers Association, Incorporated. All rights including translation into other languages, reserved under the Universal Copyright Convention, the Berne Convention for the Protection of Literary and Artistic Works, and the International and Pan American Copyright Conventions.

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

The National Electrical Manufacturers Association (NEMA) and the Insulated Cable Engineers Association (ICEA) standards and guideline publications, of which the document contained herein is one, are developed through a voluntary consensus standards development process. This process brings together persons who have an interest in the topic covered by this publication. While NEMA and ICEA administers the process and establishes rules to promote fairness in the development of consensus, they do not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards and guideline publications.

NEMA and ICEA disclaims liability for personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. NEMA and ICEA disclaims and makes no guaranty or warranty, expressed or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. NEMA and ICEA do not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this standard or guide.

In publishing and making this document available, NEMA and ICEA are not undertaking to render professional or other services for or on behalf of any person or entity, nor are NEMA and ICEA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Information and other standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

NEMA and ICEA have no power, nor do they undertake to police or enforce compliance with the contents of this document. NEMA and ICEA do not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health or safety-related information in this document shall not be attributable to NEMA and ICEA and is solely the responsibility of the certifier or maker of the statement.

CONTENTS

	Page
SECTION 1 GENERAL.....	1
1.1 SCOPE	1
1.2 GENERAL INFORMATION	1
1.3 INFORMATION TO BE SUPPLIED BY PURCHASER	1
1.3.1 Characteristics of System on Which Cable is to be Used.....	1
1.3.2 Quantities and Description of Cable	2
SECTION 2 CONDUCTOR.....	3
2.1 PHYSICAL AND ELECTRICAL PROPERTIES	3
2.1.1 Copper Conductors.....	3
2.1.2 Aluminum Conductors.....	3
2.2 OPTIONAL SEALANT FOR STRANDED CONDUCTORS	4
2.3 CONDUCTOR SIZE UNITS	4
2.4 CONDUCTOR DC RESISTANCE PER UNIT LENGTH	4
2.4.1 Direct Measurement of dc Resistance	4
2.4.2 Calculation of dc Resistance Per Unit Length	4
2.5 CONDUCTOR DIAMETER.....	5
SECTION 3 CONDUCTOR SHIELD (STRESS CONTROL LAYER)	11
3.1 MATERIAL.....	11
3.2 PHYSICAL REQUIREMENTS.....	11
3.3 ELECTRICAL REQUIREMENTS	11
3.3.1 Extruded Semiconducting Material	11
3.3.2 Extruded Nonconducting Material (For EPR Insulation Only).....	11
3.3.2.1 Withstand Test	11
3.3.2.2 Electrical Requirements	12
3.3.3 Semiconducting Tape	12
3.4 WAFER BOIL TEST	12
SECTION 4 INSULATION	13
4.1 MATERIAL.....	13
4.2 INSULATION THICKNESS	14
4.2.1 Selection of Proper Thickness	14
4.3 INSULATION REQUIREMENTS	14
SECTION 5 INSULATION SHIELDING	20
5.1 SHIELDING OF INSULATED CABLE	20
5.1.1 Insulation Shield.....	20
5.2 REMOVABILITY OF INSULATION SHIELD	20
5.2.1 Discharge-Free Cable Designs With Extruded Insulation Shields.....	20
5.2.2 Discharge-Resistant Cable Designs With Extruded Insulation Shields	21
SECTION 6 METALLIC SHIELDING (SEE APPENDIX G)	23
6.1 GENERAL	23
6.2 METAL TAPES.....	23
6.2.1 Helically Applied Tape(s)	23
6.2.2 Longitudinally Applied Corrugated Tape.....	23
6.3 COPPER WIRES, STRAPS, SHEATH OR ARMOR	23
6.4 MULTIPLE-CONDUCTOR CABLES	24

SECTION 7 COVERINGS	25
7.1 JACKETS	25
7.1.1 Crosslinked and Thermoplastic Jackets - General	25
7.1.2 Neoprene, Heavy-Duty Black (CR-HD).....	25
7.1.3 Neoprene, General Purpose (CR-GP).....	25
7.1.4 Polyvinyl Chloride.....	25
7.1.5 Low and Linear Low Density Polyethylene (LDPE & LLDPE)	25
7.1.6 Medium Density Polyethylene, Black (MDPE).....	25
7.1.7 High Density Polyethylene (HDPE).....	25
7.1.8 Nitrile-butadiene/Polyvinyl-chloride, Heavy-Duty (NBR/PVC-HD).....	26
7.1.9 Nitrile-butadiene/Polyvinyl-chloride, General – Purpose Duty (NBR/PVC-GP).....	26
7.1.10 Chlorosulfonated Polyethylene, Heavy Duty (CSPE-HD).....	26
7.1.11 Chlorinated Polyethylene, Thermoplastic (CPE-TP).....	26
7.1.12 Chlorinated Polyethylene, Crosslinked, Heavy Duty (CPE-XL-HD)	26
7.1.13 Polypropylene (PP).....	26
7.1.14 Thermoplastic Elastomer (TPE).....	26
7.1.15 Low Smoke Halogen Free Jackets (LSHF)	26
7.1.16 Repairs	27
7.1.17 Test for Suitability for Exposure to Sunlight.....	27
7.1.18 Optional Tray Cable Flame Test Requirement	27
7.1.19 Separator Under Jacket	27
7.1.20 Jacket Thickness.....	30
7.1.21 Jacket Irregularity Inspection	30
7.2 METALLIC AND ASSOCIATED COVERINGS	31
7.2.1 General	31
7.3 DIVISION I	32
7.3.1 Metallic Sheaths.....	32
7.3.2 Flat Steel Tape Armor	34
7.3.3 Interlocked Metal Tape Armor.....	36
7.3.4 Continuously Corrugated Metal Armor.....	37
7.3.5 Galvanized Steel Wire Armor For Submarine Cables	38
7.3.6 Bedding Over Cable Cores To Be Metallic Armored	41
7.3.7 Outer Servings	42
7.3.8 Crosslinked Jackets Over Metallic Sheaths and Armors	42
7.3.9 Thermoplastic Jackets Over Metallic Sheaths or Armors	43
7.4 DIVISION II.....	44
7.4.1 Borehole Cable (Suspended at One End Only).....	44
7.4.2 Dredge Cable	45
7.4.3 Shaft Cable	46
7.4.4 Vertical Riser Cable	46
7.5 DIVISION III.....	47
7.5.1 Buried Land Cables.....	47
SECTION 8 ASSEMBLY, FILLERS, AND CABLE IDENTIFICATION	48
8.1 ASSEMBLY OF MULTIPLE-CONDUCTOR CABLES	48
8.2 FILLERS	49
8.3 CONDUCTOR IDENTIFICATION	49
8.4 CABLE IDENTIFICATION	49
SECTION 9 PRODUCTION TESTS AND TEST METHODS	51
9.1 GENERAL	51
9.1.1 Testing and Test Frequency	51
9.1.2 Test Methods	51
9.1.3 Number of Test Specimens from Samples	53
9.2 THICKNESS MEASUREMENTS	53

9.2.1	Beddings and Servings	53
9.2.2	Other Components	53
9.3	SAMPLES AND SPECIMENS FOR PHYSICAL AND AGING TESTS	53
9.3.1	General	53
9.3.2	Sampling	53
9.3.3	Size of Test Specimens	54
9.3.4	Specimens with Bonded Layers	54
9.3.5	Specimen Surface Irregularities	54
9.3.6	Specimens for the Aging Tests	55
9.3.7	Calculation of Area of Test Specimens	55
9.4	AGING TESTS	56
9.4.1	Air Oven Aging Test	56
9.4.2	Oil Immersion Test	56
9.5	HEAT SHOCK TEST	56
9.6	COLD-BEND TEST	57
9.7	TIGHTNESS OF POLYETHYLENE JACKET TO SHEATH TEST	57
9.8	ELECTRICAL TESTS ON COMPLETED CABLES	57
9.8.1	Voltage Tests	57
9.8.2	Partial-Discharge Test Procedure	58
9.9	ADHESION (INSULATION SHIELD REMOVABILITY TEST)	58
9.10	HOT CREEP TEST	58
9.11	SOLVENT EXTRACTION	58
9.12	WAFER BOIL TEST FOR EXTRUDED THERMOSET SHIELDS	58
9.12.1	Insulation Shield Hot Creep Properties	58
9.13	WATER CONTENT	58
9.13.1	Water Under the Jacket	59
9.13.2	Water in the Conductor	59
9.13.3	Water Expulsion Procedure	59
9.13.4	Presence of Water Test	59
9.14	VOLUME RESISTIVITY	59
9.15	RETESTS	59
9.15.1	Physical and Aging Properties and Thickness	59
9.15.2	Other Tests	60
SECTION 10 QUALIFICATION TESTS		61
10.1	ACCELERATED WATER ABSORPTION TEST, ELECTRICAL METHOD AT 60HZ	61
10.2	Insulation Resistance Test	61
10.3	DRY ELECTRICAL TEST FOR CLASS III INSULATIONS ONLY	62
10.3.1	Test Samples	62
10.3.2	Test Procedure	62
10.3.3	Electrical Measurements	62
10.4	TEST FOR DISCHARGE RESISTANT INSULATION (EPR CLASS IV INSULATION ONLY)	62
10.5	Brittleness Test for Semiconducting Shields	63
10.6	TRAY CABLE FLAME TEST	63
10.7	SUNLIGHT RESISTANCE TEST	63
10.8	Dielectric Constant and Dissipation Factor	63
10.9	Halogen Content of Non-Metallic Elements	64
10.10	Smoke generation test	64
10.11	Acid gas equivalent test	64
10.12	ENVIRONMENTAL STRESS CRACKING TEST	64
10.13	ABSORPTION COEFFICIENT	64
10.14	Dielectric constant and voltage withstand for nonconducting stress control layers	64
SECTION 11 CONSTRUCTIONS OF SPECIFIC TYPES		65
11.1	Preassembled Aerial Cable	65
11.1.1	Scope	65

11.1.2	Conductors	65
11.1.3	Insulation	65
11.1.4	Cable Types	65
11.1.5	Jacket	66
11.1.6	Identification	66
11.1.7	Assembly	66
11.1.8	Messenger	66
11.1.9	Design Criteria	66
11.1.10	Tests	67
SECTION 12 APPENDICES		69
Appendix A	INDUSTRY STANDARD REFERENCES (Normative)	69
Appendix B	EMERGENCY OVERLOADS (Normative)	72
Appendix C	PROCEDURE FOR DETERMINING DIMENSIONAL REQUIREMENTS OF JACKETS AND ASSOCIATED COVERINGS (Normative)	73
Appendix D	OPTIONAL FACTORY DC TEST (Informative)	76
Appendix E	REPRESENTATIVE TENSILE STRENGTH and ELONGATION OF NONMAGNETIC METALS (Informative)	77
Appendix F	VOLTAGE TESTS AFTER INSTALLATION (Informative)	78
Appendix G	SHIELDING (Informative)	79
Appendix H	ADDITIONAL CONDUCTOR INFORMATION (Informative)	81
Appendix I	RECOMMENDED BENDING RADII FOR CABLES (Informative)	84
Appendix J	ETHYLENE ALKENE COPOLYMER (EAM) (Informative)	87

Foreword

This Standards Publication for 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy was developed by the Insulated Cable Engineers Association (ICEA) and approved by the National Electrical Manufacturers Association (NEMA).

ICEA/NEMA Standards are adopted in the public interest and are designed to eliminate misunderstanding between the manufacturer and the user and to assist the user in selecting and obtaining the proper product for his particular need. Existence of an ICEA/NEMA Standard does not in any respect preclude the manufacture or use of products not conforming to the standard. The user of this Standard is cautioned to observe any health or safety regulations and rules relative to the manufacture and use of cable made in conformity with this Standard.

Requests for interpretation of this Standard must be submitted in writing to:

Insulated Cable Engineers Association
P.O. Box 1568
Carrollton, GA 30112, USA

An official written interpretation will be provided once approved by ICEA and NEMA. Suggestions for improvements gained in the use of this Standard will be welcomed by the Association.

< This page is intentionally left blank. >

Section 1 GENERAL

1.1 SCOPE

These standards apply to materials, constructions, and testing of 5000 volt to 46,000 volt shielded crosslinked polyethylene, and ethylene propylene rubber insulated wires and cables which are used for the transmission and distribution of electrical energy for normal conditions of installation and service, either indoors, outdoors, aerial, underground, or submarine.

1.2 GENERAL INFORMATION

These standards cover the requirements for conductors, the insulations and protective coverings and general constructional and dimensional details common to most standard shielded types of wires and cables. Constructions of specific types are covered in Section 11 or in other ICEA documents. Where a conflict exists between the requirements of Section 11, or other ICEA documents, and those of Sections 1 to 9 inclusive, the requirements of specific types shall apply. See Appendix A for complete titles and dates of ICEA publications and ASTM Standards to which reference is made in this publication. See Section 9 for test procedures not elsewhere referenced. Recommended minimum bending radii are given in Appendix I.

In classifying crosslinked insulations and jackets in these standards, the term "rubber" when used alone without further description shall mean synthetic rubber.

Insulation thicknesses are designated in terms of cable insulation levels (see 4.2).

In classifying jackets and sheaths in these standards, the term "jacket" refers to a continuous nonmetallic covering and "sheath" to a continuous metallic covering.

U.S. customary units, except for temperature, are specified throughout this standard. Approximate International System of Units (SI) equivalents are included for information only.

Requirements of a referenced ASTM standard shall be determined in accordance with the procedure or method designated in the referenced ASTM standard unless otherwise specified in this standard.

1.3 INFORMATION TO BE SUPPLIED BY PURCHASER

When requesting design proposals from cable manufacturers, the prospective purchaser should furnish the following information:

1.3.1 Characteristics of System on Which Cable is to be Used

1. Current - alternating or direct.
2. Frequency - hertz.
3. Normal operating voltage between phases or, in direct current, between conductors.
4. Number of phases and conductors.
5. Cable insulation level (see 4.2).
6. Minimum temperature at which cable will be installed.
7. Description of installation.
 - a. In buildings.
 - b. In underground ducts.