



**STANDARD FOR
EXTRUDED INSULATION POWER CABLES
RATED ABOVE 46 THROUGH 345 KV**

Approved by

AMERICAN NATIONAL STANDARDS INSTITUTE

November 27, 2012

Publication # ANSI/ICEA S-108-720-2012

© 2012 by ICEA

INSULATED CABLE ENGINEERS ASSOCIATION, Inc

This is a preview. Click [here](#) to purchase the full publication.

STANDARD FOR
EXTRUDED INSULATION POWER CABLES
RATED ABOVE 46 THROUGH 345 KV

Standard
ICEA S-108-720-2012

Published By
INSULATED CABLE ENGINEERS ASSOCIATION, Inc.
Post Office Box 1568
Carrollton, Georgia 30112, U.S.A.

Approved by Insulated Cable Engineers Association, Inc.: June 6, 2012
Accepted by AEIC: Cable Engineering Committee: March 4, 2010
Approved by ANSI: November 27, 2012

Typographical error corrected in Table 9-3 on 3/6/13

© Copyright 2012 by the Insulated Cable Engineers Association, Inc. 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.

FOREWORD

This Standards Publication for Extruded Insulation Power Cables Rated above 46 to 345 kV (ICEA S-108-720) was developed by the Insulated Cable Engineers Association Inc. (ICEA).

ICEA standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for his particular need. Existence of an ICEA standard does not in any respect preclude the manufacture or use of products not conforming to the standard. The user of this Standards Publication 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 the Insulated Cable Engineers Association, Inc., P. O. Box 1568, Carrollton, Georgia 30112. An official written interpretation will be provided. Suggestions for improvements gained in the use of this Standard will be welcomed by the Association.

The ICEA expresses thanks to the Association of Edison Illuminating Companies, Cable Engineering Committee for providing the basis for some of the material included herein through their participation in the Utility Power Cable Standards Technical Advisory Committee (UPCSTAC), and to the Institute of Electrical and Electronics Engineers, Insulated Conductors Committee, Subcommittee A, Discussion Group A-14 for providing user input to this Standard.

The members of the ICEA working group contributing to the writing of this Standard consisted of the following:

F. Kuchta, Chairman

E. Bartolucci
B. Crawford
L. Hiivala
A. Pack
B. Vaughn

R. Bristol
D. Elder
D. Masakowski
B. Temple
E. Walcott

J. Cancelosi
B. Fleming
K. Nuckles
R. Thrash

TABLE OF CONTENTS

Part 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 Systems on which Cable is to be Used	1
1.3.2 Description of Installation.....	2
1.3.3 Quantities and Description of Cable.....	2
1.4 INFORMATION TO BE SUPPLIED BY MANUFACTURER	2
1.5 DEFINITIONS AND SYMBOLS.....	3
 Part 2 CONDUCTOR	6
2.0 GENERAL	6
2.1 PHYSICAL AND ELECTRICAL PROPERTIES	6
2.1.1 Copper Conductors.....	6
2.1.2 Aluminum Conductors	6
2.1.3 Special Conductors	6
2.1.3.1 Segmental Conductors.....	7
2.2 OPTIONAL WATER BLOCKING COMPONENTS FOR STRANDED CONDUCTORS.....	7
2.3 CONDUCTOR SIZE UNITS	7
2.4 CONDUCTOR DC RESISTANCE	7
2.4.1 Direct Measurement of dc Resistance Per Unit Length.....	8
2.4.2 Calculation of dc Resistance Per Unit Length.....	8
2.5 CONDUCTOR DIAMETER.....	8
 Part 3 CONDUCTOR SHIELD	14
3.1 MATERIAL	14
3.2 EXTRUDED CONDUCTOR SHIELD THICKNESS.....	14
3.3 PROTRUSIONS AND IRREGULARITIES	14
3.4 VOIDS	15
3.5 PHYSICAL REQUIREMENTS	15
3.6 ELECTRICAL REQUIREMENTS	15
3.6.1 Extruded Semiconducting Material.....	15
3.6.2 Extruded Nonconducting Material (For EPR Insulation Only)	15
3.6.3 Semiconducting Tape	15
3.7 CROSSLINKED (THERMOSET) REQUIREMENTS.....	15
 Part 4 INSULATION	16
4.1 MATERIAL	16
4.2 INSULATION THICKNESS	16
4.2.1 Selection of Proper Thickness	17
4.2.2 Insulation Eccentricity	18
4.3 INSULATION REQUIREMENTS	18
4.3.1 Physical and Aging Requirements	18
4.3.2 Electrical Test Requirements.....	19
4.3.2.1 Partial-Discharge for Discharge-Free Designs only	19
4.3.2.2 Voltage Tests.....	20
4.3.2.3 Insulation Resistance Test.....	20
4.3.2.4 Dielectric Constant and Dissipation Factor.....	21
4.3.2.5 Discharge (Corona) Resistance for Discharge-Resistant EPR Designs only	21

4.3.3	Voids, Ambers, Gels, Agglomerates and Contaminants as Applicable	21
4.3.3.1	Crosslinked Polyethylene Insulation (XLPE)	21
4.3.3.2	Ethylene Propylene Rubber (EPR)	21
4.3.4	Shrinkback - Crosslinked Polyethylene Insulation (XLPE) Only	21
Part 5 EXTRUDED INSULATION SHIELD	.....	23
5.1 MATERIAL	.....	23
5.2 EXTRUDED INSULATION SHIELD THICKNESS	.....	23
5.3 PROTRUSIONS AND IRREGULARITIES	.....	23
5.4 VOIDS	.....	23
5.5 PHYSICAL REQUIREMENTS	.....	23
5.6 ELECTRICAL REQUIREMENTS	.....	24
5.5.1	Extruded Semiconducting Material.....	24
5.5.2	Semiconducting Tape	24
5.7 CROSSLINKED (THERMOSET) REQUIREMENTS	.....	24
Part 6 METALLIC SHIELDING	.....	25
6.1 GENERAL	.....	25
6.2 SHIELDS	.....	25
6.2.1	Helically Applied Tape Shield	25
6.2.2	Longitudinally Applied And Overlapped Corrugated Tape Shield	25
6.2.3	Wire Shield	25
6.2.4	Flat Strap Shield.....	26
6.3 SHEATHS	.....	26
6.3.1	Lead Sheath.....	26
6.3.2	Smooth Aluminum Sheath	26
6.3.3	Continuously Corrugated Sheath	26
6.4 RADIAL MOISTURE BARRIER	.....	27
6.4.1	Bonded Metallic Foil Laminates	27
6.5 OPTIONAL LONGITUDINAL WATER BLOCKING COMPONENTS	.....	27
Part 7 JACKET	.....	28
7.1 MATERIAL	.....	28
7.1.1	Polyethylene, Black.....	28
7.1.2	Polyvinyl Chloride.....	29
7.2 JACKET APPLICATION AND THICKNESS	.....	30
7.2.1	Thickness of Jacket for Tape, Wire Shield and Metallic Foil Laminate	30
7.2.2	Thickness of Jacket for Sheaths.....	30
7.3 OPTIONAL SEMICONDUCTING COATING	.....	30
7.4 JACKET IRREGULARITY INSPECTION	.....	30
7.4.1	Jackets without Optional Semiconducting Coating	30
7.4.2	Jackets with Optional Semiconducting Coating	30
Part 8 CABLE IDENTIFICATION	.....	33
8.1 CABLE IDENTIFICATION	.....	33
8.1.1	Optional Center Strand Identification	33
8.1.2	Optional Sequential Length Marking	33
Part 9 PRODUCTION TESTS	.....	34
9.1 TESTING	.....	34
9.2 SAMPLING FREQUENCY	.....	34
9.3 CONDUCTOR TEST METHODS	.....	34

9.3.1	Method for DC Resistance Determination	34
9.3.2	Cross-Sectional Area Determination	34
9.3.3	Diameter Determination	34
9.4 TEST SAMPLES AND SPECIMENS FOR PHYSICAL AND AGING TESTS		34
9.4.1	General	34
9.4.2	Measurement of Thickness	34
9.4.2.1	Micrometer Measurements	35
9.4.2.2	Optical Measuring Device Measurements	35
9.4.3	Number of Test Specimens	35
9.4.4	Size of Specimens	35
9.4.5	Preparation of Specimens of Insulation and Jacket	36
9.4.6	Specimen for Aging Test	36
9.4.7	Calculation of Area of Test Specimens	36
9.4.8	Unaged Test Procedures	36
9.4.8.1	Test Temperature	36
9.4.8.2	Type of Testing Machine	36
9.4.8.3	Tensile Strength Test	37
9.4.8.4	Elongation Test	37
9.4.9	Aging Tests	37
9.4.9.1	Aging Test Specimens	37
9.4.9.2	Air Oven Test	38
9.4.9.3	Oil Immersion Test for Polyvinyl Chloride Jacket	38
9.4.10	Hot Creep Test	38
9.4.11	Solvent Extraction	38
9.4.12	Wafer Boil Test for Conductor and Insulation Shields	38
9.4.13	Amber, Agglomerate, Gel, Contaminant, Protrusion, Irregularity and Void Test	38
9.4.13.1	Sample Preparation	38
9.4.13.2	Examination	38
9.4.13.3	Resampling for Amber, Agglomerate, Gel, Contaminant, Protrusion, Irregularity and Void Test	39
9.4.13.4	Protrusion and Irregularity Measurement Procedure	39
9.4.14	Physical Tests for Semiconducting Material Intended for Extrusion	40
9.4.14.1	Test Sample	40
9.4.14.2	Test Specimens	40
9.4.14.3	Elongation	40
9.4.15	Retests for Physical and Aging Properties and Thickness	40
9.5 DIMENSIONAL MEASUREMENTS OF THE METALLIC SHIELD		40
9.5.1	Tape Shield	40
9.5.2	Wire Shield	40
9.5.3	Sheath	41
9.5.4	Flat Straps	41
9.6 DIAMETER MEASUREMENT OF INSULATION AND INSULATION SHIELD		41
9.7 TESTS FOR JACKETS		41
9.7.1	Heat Shock (PVC only)	41
9.7.1.1	Preparation of Test Specimen	41
9.7.1.2	Winding of the Test Specimen on Mandrels	41
9.7.1.3	Heating and Examination	42
9.7.2	Heat Distortion	42
9.7.3	Cold Elongation (PVC only)	42
9.7.3.1	Test Temperature	42
9.7.3.2	Type of Testing Machine	42
9.7.3.3	Elongation Test	42
9.8 VOLUME RESISTIVITY		43

9.8.1	Conductor Shield.....	43
9.8.2	Insulation Shield and Semiconducting Extruded Jacket Coating	43
9.8.3	Test Equipment.....	44
9.8.4	Test Procedure.....	44
9.9	SHRINKBACK TEST PROCEDURE.....	44
9.9.1	Sample Preparation	44
9.9.2	Test Procedure.....	44
9.9.3	Pass/Fail Criteria and Procedure.....	44
9.10	RETESTS ON SAMPLES.....	44
9.11	AC VOLTAGE TEST	45
9.11.1	General.....	45
9.11.2	AC Voltage Test.....	45
9.12	PARTIAL-DISCHARGE TEST PROCEDURE	45
9.13	METHOD FOR DETERMINING DIELECTRIC CONSTANT AND DIELECTRIC STRENGTH OF EXTRUDED NONCONDUCTING POLYMERIC STRESS CONTROL LAYERS.....	45
9.14	WATER CONTENT.....	46
9.14.1	Water Under the Jacket.....	46
9.14.2	Water in the Conductor.....	46
9.14.3	Water Expulsion Procedure.....	46
9.14.4	Presence of Water Test.....	46
9.15	ADHESION TESTS FOR METALLIC FOIL LAMINATES	46
9.15.1	Visual Inspection	46
9.15.2	Adhesion Strength of Metallic Foil Laminate.....	47
9.15.3	Adhesion Strength of Overlap of Metallic Foil Laminate	47
9.16	PRODUCTION TEST SAMPLING PLANS.....	49
Part 10	QUALIFICATION TESTS	52
10.0	GENERAL	52
10.1	CABLE QUALIFICATION TESTS	52
10.1.1	Cable Design Qualification	52
10.1.2	Cable Bending Procedure.....	55
10.1.2.1	Bending Diameter.....	55
10.1.3	Thermal Cycling Procedure	55
10.1.3.1	Thermal Cycles.....	55
10.1.3.2	Voltage During Thermal Cycles	56
10.1.4	Hot Impulse Test Procedure	56
10.1.5	AC Voltage Withstand Test Procedure	56
10.1.6	Partial Discharge Test Procedure (For Discharge-Free Designs Only).....	56
10.1.7	Measurement of Dissipation Factor.....	56
10.1.8	Dissection and Analysis of Test Specimens	57
10.2	JACKET MATERIAL QUALIFICATION TESTS	57
10.2.1	Polyethylene Jackets	57
10.2.1.1	Environmental Stress Cracking Test	57
10.2.1.1.1	Test Specimen.....	57
10.2.1.1.2	Test Procedure	57
10.2.1.2	Absorption Coefficient Test.....	57
10.2.2	Semiconducting Extruded Jacket Coatings	58
10.2.2.1	Brittleness Temperature	58
10.2.3	Polyvinyl Chloride.....	58
10.2.3.1	Sunlight Resistance.....	58
10.2.3.1.1	Test Samples	58
10.2.3.1.2	Test Procedure	58

10.3 OTHER QUALIFICATION TESTS	58
10.3.1 Insulation Resistance	58
10.3.2 Accelerated Water Absorption Tests	58
10.3.3 Resistance Stability Test	59
10.3.4 Brittleness Temperature for Semiconducting Shields	59
10.3.5 Discharge Resistance Test for Discharge-Resistant EPR Designs only	59
10.3.5.1 Test Specimens	59
10.3.5.2 Test Environment	59
10.3.5.3 Test Electrodes	60
10.3.6 Dielectric Constant and Voltage Withstand for Nonconducting Conductor Shield	60
Part 11 APPENDICES	61
APPENDIX A NEMA, ICEA, IEEE, ASTM AND ANSI STANDARDS (Normative)	61
A1 NEMA PUBLICATIONS	61
A2 ICEA PUBLICATIONS	61
A3 IEEE AND ANSI STANDARDS	61
A4 ASTM STANDARDS	61
APPENDIX B EMERGENCY OVERLOADS (Normative)	64
APPENDIX C PROCEDURE FOR DETERMINING THICKNESS REQUIREMENTS OF THE INSULATION SHIELD, LEAD SHEATH AND JACKET (Normative)	67
APPENDIX D CABLE COMPONENT FUNCTION (Informative).....	69
D1 CONDUCTOR.....	69
D1.1 Function	69
D1.2 Material	69
D2 CONDUCTOR SHIELD	69
D2.1 Function	69
D2.1.1 Nonconducting	69
D2.1.2 Semiconducting	69
D2.2 Voltage Stress	69
D3 INSULATION.....	70
D4 INSULATION SHIELD	70
D4.1 Semiconducting Shield.....	71
D4.2 Metallic Shield.....	71
D5 JACKET.....	71
APPENDIX E HANDLING AND INSTALLATION PARAMETERS (Informative).....	73
E1 INSTALLATION TEMPERATURES	73
E2 RECOMMENDED MINIMUM BENDING RADIUS	73
E3 DRUM DIAMETERS OF REELS	73
E4 MAXIMUM TENSION AND SIDEWALL BEARING PRESSURES	73
E5 ELECTRICAL TESTS AFTER INSTALLATION	74
E5.1 Insulation.....	74
E5.2 Jacket.....	74
APPENDIX F TRADITIONAL INSULATION WALL THICKNESS (Informative).....	75
APPENDIX G ADDITIONAL SHIELD WIRE AND CONDUCTOR INFORMATION (Informative).....	76
APPENDIX H ETHYLENE ALKENE COPOLYMER (EAM) (Informative)	79
APPENDIX I SPECIFICATION FOR ALLOY LEAD SHEATHS (Informative).....	80
I1 PURPOSE	80
I2 MATERIAL	80
I3 REQUIREMENTS	80
APPENDIX J GUIDELINE FOR DEGASSING (Informative)	81
APPENDIX K STRESS CALCULATION FOR EPR CABLES WITH A NONCONDUCTING CONDUCTOR SHIELD (Informative)	83

LIST OF TABLES

Table 2-1	Weight Increment Factors	8
Table 2-2	Nominal Direct Current Resistance in Ohms Per 1000 Feet at 25 °C	
	of Concentric Lay Stranded and Segmental Conductor	9
Table 2-2 (Metric)	Nominal Direct Current Resistance in Milliohms Per Meter at 25 °C	
	of Concentric Lay Stranded and Segmental Conductor	10
Table 2-3	Nominal Diameters for Round Copper and Aluminum Conductors	11
Table 2-3 (Metric)	Nominal Diameters for Round Copper and Aluminum Conductors	12
Table 2-4	Nominal Diameters for Segmental Copper and Aluminum Conductors	13
Table 2-5	Factors for Determining Nominal Resistance of Stranded Conductors	
	Per 1000 Feet at 25 °C	13
Table 3-1	Extruded Conductor Shield Thickness.....	14
Table 4-1	Conductor Maximum Temperatures	16
Table 4-2	Conductor Sizes, Maximum Insulation Eccentricity, Insulation Maximum Stress and Test Voltages.....	18
Table 4-3	Insulation Physical Requirements.....	19
Table 4-4	Partial-Discharge Requirements.....	19
Table 4-5	Test Voltages for Partial-Discharge Measurements	20
Table 4-6	Impulse Values	20
Table 4-7	Dielectric Constant and Dissipation Factor	21
Table 4-8	Shrinkback Test Requirements	22
Table 5-1	Insulation Shield Thickness	23
Table 6-1	Lead Sheath Thickness.....	26
Table 7-1	Polyethylene, Black	28
Table 7-2	Polyvinyl Chloride.....	29
Table 7-3	Semiconducting Extruded Coating	31
Table 7-4	Jacket Thickness and Test Voltage for Tape, Wire Shield or Metallic Foil Laminated Cables.....	31
Table 7-5	Jacket Thickness and Test Voltage for All Sheath Cables	32
Table 9-1	Test Specimens for Physical and Aging Tests	35
Table 9-2	Bending Requirements for Heat Shock Test	42
Table 9-3	Summary of Production Tests and Sampling Frequency Requirements	49
Table 9-4	Plan E	51
Table 9-5	Plan F	51
Table 10-1	Generic Grouping of Cable Components	53
Table 10-2	Accelerated Water Absorption Properties	59
Table D-1	Jacket Functions	72
Table E-1	Recommended Minimum Bending Radius	73
Table F-1	Traditional Insulation Thickness from AEIC CS7-93, Test Voltages and Conductor Sizes	75
Table G-1	Solid Copper Shield Wires	76
Table G-2	Concentric Stranded Class B Aluminum and Copper Conductors	77
Table G-3	Concentric Stranded Class C and D Aluminum and Copper Conductors	78
Table I-1	Chemical Requirements for Alloy Lead Sheaths	80