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Steel Armor and Associated Coverings for Impregnated Paper Insulated Cables
(ICEA S-67-401 Fifth Edition)

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ICEA/NEMA Standards Publication Steel Armor and Associated Coverings for Impregnated-paper-insulated Cables

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NEMA—NEMA Standards and Authorized Engineering Information unrevised since their appearance in the 1976 edition were reaffirmed by NEMA.

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FOREWORD

This Standards Publication for *Steel Armor and Associated Coverings for Impregnated-paper-insulated Cables* [ICEA S-67-401 (Fourth Edition; NEMA WC 2-1980 (R 1985))] was developed by the Insulated Cable Engineers Association and approved by the National Electrical Manufacturers Association.

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 ICEA/NEMA standards does not in any respect preclude the manufacture or use of products not conforming to the standards. The user of these standards is cautioned to observe any health or safety regulations and rules relative to the manufacture and use of cable made in conformity with these standards.

Suggestions for improvements gained in the use of this publication will be welcomed. They should be sent to the Insulated Cable Engineers Association, Post Office Box P, South Yarmouth, MA 02664.

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STEEL ARMOR AND ASSOCIATED COVERINGS FOR IMPREGNATED-PAPER-INSULATED CABLES

Part 1
GENERAL

1.1 Scope. This Standards Publication applies to materials, constructions, and requirements for steel armor and associated coverings for impregnated-paper-insulated cables for use in power circuits.

There may be installation, operating, or service conditions which require the use of armor and associated coverings which do not meet the requirements of these standards, e.g., nonmagnetic armor on single-conductor cable for use in alternating-current circuits. (This paragraph has been approved as Authorized Engineering Information.)

1.2 Types of Steel Armor and Conditions of Installation

(a) Flat tape armor
   1. With an outer covering for use on cables for direct burial.
   2. Without an outer covering for use on cables supported by an aerial messenger strand.

(b) Wire armor, with or without an outer covering and with either a fibrous bedding or jacket for use on submarine cables or on cables for direct burial.

Part 2
MATERIALS, CONSTRUCTIONS, AND REQUIREMENTS

2.1 Jute Bedding for Armored Cable

2.1.1 Application. Metal-sheathed cables* to be armored shall be run through hot asphalt or tar compound and then served with a bedding of impregnated-jute yarn or roving, each layer of which shall be run through hot asphalt or tar compound.

*Where corrosion protection or sheath reinforcement is required, the manufacturer should be consulted. (This note has been approved as Authorized Engineering Information.)

2.1.2 Direction of Lay. The direction of lay of the jute bedding shall be opposite to that of the armor directly in contact with it. Adjacent layers of jute shall be applied with opposite directions of lay.

2.1.3 Thickness. The average thickness of the jute bedding under the armor in the finished cable shall be not less than that specified in Table 2-1. The thickness shall be determined by the use of a diameter tape and shall be considered as one-half of the difference in measurement under and over the bedding.

2.2 Plain and Zinc-coated Steel Tape for Flat Tape Armor

This section covers plain and zinc-coated flat steel strip in coils for use as flat armor for electrical cables. The zinc coating shall be applied by either hot-dip or the electrogalvanizing process such that all surfaces of the finished tape width are coated, including edges.

2.2.1 Width of Tape. The nominal width can be less than but shall not be greater than that given in Table 2-2.

For nominal widths of 1.000 inch (25.4 mm) or less, the tolerance in width shall be ±30 mils. For nominal widths greater than 1.000 inch (25.4 mm), the tolerance in width shall be ±45 mils.

2.2.2 Thickness of Tape. The average thickness before the application of any coating shall be not less than that given in Table 2-3.

The tolerance in thickness of an individual tape shall be ±3 mils.

Zinc-coated tape shall not at any place be more than 20 percent thicker than the tape thickness before the application of any coating.

2.2.3 Application, Lay, and Spacing. Two steel tapes shall be applied helically in the same direction over the jute bedding except that they can be applied in opposite directions where the toal area of the conductors is less than 50,000 circular mils (25.4 mm²). The direction of lay of the inner tape shall be opposite to that of the jute bedding. When applied in the same direction as the inner tape, the outer tape shall be approximately centered over the spaces between the convolutions of the inner tape. The maximum space between turns shall not exceed 20 percent of the width of the tape or 0.200 inch (5.08 mm), whichever is greater.

During or prior to application, the tapes shall be flushed with a suitable compound to deter corrosion.

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2.2.4 Tensile Strength and Elongation. Plain and zinc-coated steel tape shall have a tensile strength of not less than 40 000 psi (28.1 kgf/mm²) nor more than 70 000 psi (49.2 kgf/mm²). The tensile strength shall be determined on longitudinal specimens consisting of the full width of the tape, when practical, or on a straight specimen taken from the center of the tape. The tape shall have an elongation of not less than 10 percent in 10 inches (254 mm). The elongation shall be the permanent increase in length of a marked section of the tape, originally 10 inches in length, and shall be determined after the specimen has fractured. All tests shall be made prior to the application of the tape to the cable.

2.2.5 Galvanizing Tests for Zinc-coated Steel Tape. The following tests shall be made before the tape is applied to the cable.

2.2.5.1 *Weight of Zinc Coating.* The weight of zinc coating shall be determined in accordance with ASTM A90. The minimum weight of zinc coating shall be 0.35 ounce per square foot (107 grams/meter^2) of exposed surface. The weight of coating specified is the total amount on both surfaces and edges.

2.2.5.2 *Adherence of Zinc Coating.* The zinc coating shall remain adherent when the tape is subjected to a 180-degree bend over a mandrel 1/8 inch (3.18 mm) in diameter. The zinc coating shall be considered as meeting this requirement if it does not flake and if none of it can be removed from the tape by rubbing with the fingers.

Loosening or detachment of superficial, small particles of zinc formed by mechanical polishing of the surface of the zinc-coated tape shall not constitute failure.

2.3 Zinc-coated Low-carbon-steel Wire Armor

2.3.1 Buried Cable

2.3.1.1 *Size of Armor Wires.* The size shall be in accordance with Table 2-4.

2.3.1.2 *Length of Lay of Armor Wires.* The length of lay shall be not less than three nor more than twelve times the pitch diameter of the armor wires.

2.3.2 Submarine Cable

2.3.2.1 *Size of Armor Wires.* The size shall be in accordance with Table 2-5.

If the service requirements are exceptionally severe, larger sizes of armor wire may be required (This sentence has been approved by NEMA as Authorized Engineering Information.)

2.3.2.2 *Length of Lay of Armor Wires.* The length of lay shall be not less than seven nor more than twelve times the pitch diameter of the armor wires.

2.3.3 Requirements for Wire to be Used in Armoring. The tensile strength, elongation, torsion, and galvanizing of the wire shall be determined prior to the application of the wire to the cable and shall be in accordance with the following.

2.3.3.1 *Tensile Strength.* The tensile strength shall be determined in accordance with ASTM E 8 and shall be not less than 50 000 psi (35.2 kgf/mm²) and not more than 70 000 psi (49.2 kgf/mm²).

2.3.3.2 *Elongation.* The elongation shall be determined in accordance with ASTM E 8 and shall be not less than 10 percent in 10 inches (254 mm). The elongation shall be the permanent increase in length of a marked section of the wire, originally 10 inches in length, and shall be determined after the specimen has fractured.

2.3.3.3 *Torsion Test.* The wire shall withstand, without fracture, at least the number of twists specified in Table 2-6. The test shall be made on a sample of wire having an initial length of 6 inches (152 mm) between jaws of a torsion machine havings one head moving horizontally and an effective speed of rotation not exceeding 60 rpm.

2.3.3.4 *Galvanizing Tests.* The following tests shall be made before the wire is applied to the cable.

2.3.3.4.1 Weight of Zinc Coating. The weight of zinc coating shall be determined in accordance with ASTM A 90. The minimum weight of zinc coating shall be in accordance with Table 2-7.

2.3.3.4.2 Adherence of Coating. The zinc coating shall remain adherent when the wire is wrapped at a rate of not more than 15 turns per minute in a closed helix of at least two turns around a cylindrical mandrel having the diameter specified in Table 2-8. The zinc coating shall be considered as meeting this requirement if it does not flake and if none of it can be removed from the wire by rubbing with the fingers.

Loosening or detachment of superficial, small particles of zinc formed by mechanical polishing of the surface of the zinc-coated wire shall not constitute failure.

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2.4 Overall Jute Serving for Armored Cable

2.4.1 Application. When an outer jute serving is required, armored cable shall be run through hot asphalt or tar compound and then served with a layer of sixteen three-ply (16/3) impregnated jute yarn applied with a short close lay, again run through hot asphalt or tar compound, and finished by running through some suitable material which will prevent sticking of adjacent turns of the cable when wound on a reel.

2.4.2 Direction of Lay. The direction of lay of the overall jute serving shall be opposite to that of the armor in contact with it.

2.5 Thermoplastic Covering for Armored Cable

2.5.1 Application. When a thermoplastic covering is required, it shall be extruded over the armor and shall fit tightly thereto. It shall be either black or colored polyvinyl chloride meeting the requirements of ICEA S-19-81/NEMA WC 3, 4.13.5, or black polyethylene meeting the requirements of 4.13.6, except that in each case the covering shall meet the cold bend test described in ICEA S-19-81/NEMA WC 3, 4.14.15.4.

2.5.2 Thickness. The average thickness of the thermoplastic covering shall be not less than that specified in Table 2-9. The minimum thickness shall be not less than 70 percent of the value given in the table. The minimum and maximum thickness shall be determined directly on a ring of covering removed from the cable with a micrometer, a steel scale with pocket glass, or a micrometer microscope. The average of these determinations shall be taken as the average thickness.

2.5.3 Alternating-current Spark Test. The thermoplastic covering shall withstand the alternating-current spark test voltage given in Table 2-9. The voltage shall be applied between an electrode at the outside surface of the covering and the armor for not less than 0.15 second.

Table 2-1
Thickness of Jute Bedding for Armored Cable

Calculated Diameter of Cable Under Jute Bedding		Thickness of Jute Bedding			
		Flat Tape Armored Cable		Round Wire Armored Cable	
inches	mm	mils	mm	mils	mm
0 - 0.450	0 - 11.43	30	0.76	45	1.14
0.451 - 0.750	11.46 - 19.05	45	1.14	45	1.14
0.751 - 1.000	19.08 - 25.40	45	1.14	65	1.65
1.001 - 2.500	25.43 - 63.50	65	1.65	80	2.03
2.501 and larger	63.53 and larger	65	1.65	95	2.41

Table 2-2
Width of Plain and Zinc-coated Steel Tape for Flat Tape Armor

Calculated Diameter of Cable Under Jute Bedding		Nominal Width of Tape	
inches	mm	inches	mm
0 - 0.450	0 - 11.43	0.750	19.0
0.451 - 1.000	11.46 - 25.40	1.000	25.4
1.001 - 1.400	25.43 - 35.56	1.250	31.8
1.401 - 2.000	35.59 - 50.80	1.500	38.1
2.001 - 3.500	50.83 - 88.90	2.000	50.8
3.501 and larger	88.93 and larger	3.000	76.2

Table 2-3
Thickness of Plain and Zinc-coated Steel Tape for Flat Tape Armor

Calculated Diameter of Cable Under Jute Bedding		Average Thickness of Tape	
inches	mm	mils	mm
0 - 1.000	0 - 25.40	20	0.51
1.001 and larger	25.43 and larger	30	0.76

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Table 2-4
Size of Armor Wire for Buried Cable

Calculated Diameter of Cable Under Jute Bedding		Size of Armor Wires		
			Diameter	
inches	mm	BWG	inches	mm
0 - 0.750	0 - 19.05	14	0.083 ± 0.003	2.11
0.751 - 1.000	19.08 - 25.40	12	0.109 ± 0.004	2.77
1.001 - 1.700	25.43 - 43.18	10	0.134 ± 0.004	3.40
1.701 - 2.500	43.21 - 63.50	8	0.165 ± 0.004	4.19
2.501 and larger	63.53 and larger	6*	0.203 ± 0.005*	5.16*

*Where greater strength is desired than is obtainable with a 6 BWG wire or where the required number of wires exceeds the capacity of the armoring machine, a 4 BWG (0.238 inch ± 0.005) (6.05 mm) wire may be used. (This note has been approved be NEMA as Authorized Engineering Information.)

Table 2-5
Size of Armor Wire for Submarine Cable

Calculated Diameter of Cable Under Jute Bedding		Size of Armor Wires		
			Diameter	
inches	mm	BWG	inches	mm
0 - 0.750	0 - 19.05	12	0.109 ± 0.004	2.77
0.751 - 1.000	19.08 - 25.40	10	0.134 ± 0.004	3.40
1.001 - 1.700	25.43 - 43.18	8	0.165 ± 0.004	4.19
1.701 - 2.500	43.21 - 63.50	6	0.203 ± 0.005	5.16
2.501 and larger	63.53 and larger	4	0.238 ± 0.005	6.05

Table 2-6
Number of Twists

Size of Armor Wire, BWG	Minimum Number of Twists
14 - 12	14
10 - 8	10
6 - 4	7

Table 2-7
Minimum Weight of Zinc Coating

Size of Coated Wire			Minimum Weight of Zinc Coating	
	Diameter		Oz/sq Ft of Exposed Wire Surface	Grams/meter² of Exposed Wire Surface
BWG	inches	mm		
14	0.083	2.11	0.60	189
12	0.109	2.77	0.80	244
10	0.134	3.40	0.80	244
8	0.165	4.19	0.90	275
6	0.203	5.16	1.00	305
4	0.238	6.05	1.00	305

Table 2-8
Mandrel Diameter

Wire Size, BWG	Mandrel Diameter
14 - 12	2 times wire diameter
10 - 4	3 times wire diameter

Table 2-9
Thermoplastic Coverings

Calculated Diameter of Cable Under Thermoplastic Covering		Average Thickness of Covering		AC Spark Test Voltage, kV
inches	mm	mils	mm	rms
0 - 0.750	0 - 19.05	50	1.27	4.5
0.751 - 1.500	19.08 - 38.10	65	1.65	6.0
1.501 - 2.250	38.13 - 57.15	80	2.03	7.0
2.251 - 3.000	57.18 - 76.20	95	2.41	8.5
3.001 and larger	76.23 and larger	110	2.79	10.0

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Part 3

ELECTRICAL TESTS ON ARMORED CABLE

3.1 Tests to be Made at the Factory. Cables intended to be armored shall be tested prior to the application of the armor and shall meet the requirements of the applicable standards.

3.1.1 After the armor is applied, an alternating-current voltage test shall be made at 80 percent of the value at which the unarmored cable was tested.

3.1.2 If the charging current required for alternating-current voltage tests on long lengths of submarine cable is in excess of the capacity of the factory test equipment, the voltage test before and after armoring shall be made with direct current.

The dc/ac voltage ratio shall be 2.4 provided the temperature of the cable does not exceed 25 °C (77 °F). If the temperature exceeds 25 °C (77 °F), the dc/ac voltage ratio shall be reduced by 0.013 for each degree in excess of 25 °C (77 °F).

3.1.3 Ionization tests shall be made only prior to the application of the armor. If any length of submarine cable is such that the test equipment is not adequate for measuring the power factor at the high test voltage specified for the ionization test, the power factor shall be measured on the full length of cable at the low test voltage specified and, also, at the highest test voltage possible with the available test equipment. As an alternative, the ionization test shall be made on a sample of the cable at the specified low and high test voltages and, in addition, the power factor shall be measured on the full length of cable at the specified low test voltage.

3.2 Tests after Installation. If voltage tests are made after installation, they shall be made immediately. The test voltage shall be not more than 60 percent of the test voltage determined in accordance with 3.1.1 when applied for 4 consecutive hours or not more than 80 percent when applied for 15 consecutive minutes. This test shall be made with either an ac or dc test voltage. The dc/ac voltage ratio shall be 2.4 provided the temperature of the cable does not exceed 25 °C (77 °F). If the temperature exceeds 25 °C (77 °F), the dc/ac voltage ratio shall be reduced by 0.013 for each degree in excess of 25 °C (77 °F).

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Part 4

APPENDICES

These appendices have been approved by NEMA as Authorized Engineering Information.

Appendix A

INSTALLATION INFORMATION

A.1 Bending Radius. The recommended minimum bending radius for the permanent installation of armored cables is twelve times the overall diameter of the completed cable.

A.2 End Seals and Pulling Eyes. End seals and pulling eyes used on metal-sheathed cables should be protected during installation or resealed after installation to prevent the entrance of moisture from leaks which may be caused by the stresses and damage incident to installation. The sealed ends of the cable should be trained to the upper part of the manhole to keep them out of any water which may be present.

Appendix B

ASTM STANDARDS

Throughout this publication, references to ASTM publications refer to the following editions of publications of the American Society for Testing and Materials. Copies of these publications are available directly from the Society at 1916 Race Street, Philadelphia, PA 19103.

Publication No. and Year	Title
A 90-81	*Test Method for Weight of Coating on Zinc-coated (Galvanized) Iron or Steel Articles*
E8-84	*Methods of Tension Testing of Metallic Materials*

Appendix C

ICEA/NEMA STANDARDS
ICEA S-19-81/NEMA WC 3-1980

Rubber-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Copies of this publication are available directly from NEMA at 2101 L Street, N.W., Washington, D.C. 20037.

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