

IEEE Recommended Practice for Specifying Electric Submersible Pump Cable— Polypropylene Insulation

Sponsor

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Abstract: Minimum requirements for the construction, manufacturing, purchasing, and application of electric submersible pump (ESP) cable are presented. The cable is round or flat, with ethylene-propylene rubber insulation, nitrile jacket, and armor. The recommendations apply to cables rated for voltages not exceeding 3 kV or 5 kV and for ambient temperatures not exceeding 205 °F or below 14 °F. Conductors, insulation, assembly, jacket, armor, requirements for testing by the manufacturer, and cable ampacity ratings are covered.

Keywords: cable construction, assembly, testing, ampacity ratings.

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Foreword

(This foreword is not a part of IEEE 1019-1991, IEEE Recommended Practice for Specifying Electric Submersible Pump Cable—Polypropylene Insulation.)

This recommended practice, under the jurisdiction of the IEEE Industry Applications Society, Petroleum and Chemical Industry Committee, presents minimum requirements for the construction, manufacturing, purchasing, and application of electric submersible pump cable. The configuration of the cable is either round or flat, with polypropylene insulation, nitrile jacket, and armor.

Anyone desiring to use this recommended practice may do so. It is presented as minimum criteria for construction of this class of submersible cable. It is not intended to restrict innovation or to limit development or improvements in cable design. Every effort has been made to assure the accuracy and reliability of the data contained herein. However, the committee makes no representation, warranty, or guarantee in connection with the publication of these specifications. Furthermore, the committee hereby expressly disclaims any liability or responsibility for loss or damage resulting this standard's use and for violation of any federal, state, or municipal regulation with which it may conflict, or for the infringement of any patent resulting from its use.

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IEEE Recommended Practice for Specifying Electric Submersible Pump Cable—Polypropylene Insulation

1. Scope

This recommended practice establishes requirements for three-conductor round and flat-type oil well cable used in supplying three-phase ac electric power to submersible pump motors. The major cable components are: copper conductors, polypropylene insulation, nitrile jackets, and galvanized armor. Cables meeting requirements of the recommended practice should be rated for voltages not exceeding 3 kV or 5 kV and for conductor operating temperatures not exceeding 205 °F. Use of cable above rated temperature can cause premature deterioration of the insulation and jacketing. The cables defined herein are not recommended for installation below a temperature of 14 °F. Voltage ratings are nominal phase-to-phase ratings.

Cable purchased under the recommendation of this document, unless otherwise specified herein, should meet the requirements of ASTM B3-1990 [4]¹, ASTM A90-1981 [5], ASTM B8-1990 [6], ASTM B33-1991 [7], ASTM B189-1990 [8], ASTM D412-1987 [9], ASTM B496-1992 [10], ICEA S-19-81 [11], and ICEA S-61-402 [12], where applicable.

This recommended practice recognizes the common practice of continuing to operate the pump's electrical system after a phase has faulted to ground and that some power distribution systems are even designed with one corner of the delta system grounded. The purpose of this recommended practice is not to condone or disapprove such practice, but the user should be aware that such operation produces a higher than normal phase-to-ground voltage across the insulation/jacket dielectric of the two ungrounded conductors. Due to the disruption of the normally balanced three-phase field, such operation produces stresses through the insulation/jacket dielectric that shortens cable life. ICEA S-61-402-1973 [12] recommends a 173% insulation level for grounded-phase operation, but this is often impractical for downhole oil well cable; therefore, this specifying standard recommends insulation thicknesses based on a normal three-phase energized delta or wye system, with no phase grounded.

¹Numbers in brackets correspond to those of the references listed in Section 2.

2. References

- [1] ANSI/NFPA 70-1990, National Electrical Code.²
- [2] API RP 11R, Recommended Practice for Electric Submersible Pump Installations, May 30, 1986, 2nd Edition.³
- [3] API RP 11U, Recommended Practice for Sizing and Selection of Electric Submersible Pump Installations, May 30, 1986, 2nd Edition.
- [4] ASTM B3-1990, Standard Specification for Soft or Annealed Copper Wire.⁴
- [5] ASTM A90-1981 (1991), Standard Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
- [6] ASTM B8-1990, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- [7] ASTM B33-1991, Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.
- [8] ASTM B189-1990, Standard Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes.
- [9] ASTM D412-1987, Standard Test Methods for Rubber Properties in Tension.
- [10] ASTM B496-1992, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
- [11] ICEA S-19-81, Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 3-1986).⁵
- [12] ICEA S-61-402, 3rd Edition, Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. (NEMA WC 5-1985.)
- [13] IEEE Standard 1017-1991, IEEE Recommended Practice for Field Testing Electric Submersible Pump Cable.⁶

3. Conductors

3.1 Material. Conductors should be annealed, coated, or uncoated copper in accordance with ASTM B3-1990 [4] for uncoated conductors; in accordance with ASTM B33-1991 [7] for tin-coated conductors; or in accordance with ASTM B189-1990 [8] for lead or lead-alloy coated conductors.

²NFPA documents are available from Publications Sales, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

³API Publications are available from the Publications Section, American Petroleum Institute, 1200 L Street NW, Washington, DC 20005, USA.

⁴ASTM Publications are available from the Customer Service Department, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.

⁵ICEA publications are available from ICEA, P.O. Box 411, South Yarmouth, MA 02664, USA.

⁶IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lanes, P.O. Box 1331, Piscataway, NJ 08855-1331 USA.

3.2 Construction. Conductors should be solid or concentric-stranded as shown in Table 1. Concentric-stranded conductors should conform to ASTM B8-1990 [6] and interstices should be filled for gas blockage. Compact round conductors, if used, should conform to ASTM B496-1992 [10] with diameters approximately 92% of corresponding noncompact conductors.

Table 1
Physical Characteristics

AWG Size	No. of Strands	Area (cmil)	Nominal Weight (lb/1000 ft)	Maximum Ω /1000 ft at 77 °F			
				Diameter (mil)		Bare Copper	Coated Copper
				1 strand	7 strand		
6	1	26 240	79.4	162		0.419	0.431
4	1 or 7	41 740	126.0	205	232	0.263	0.271
2	1 or 7	66 360	206.0	258	292	0.169	0.175
1	1 or 7	83 690	260.0	289	328	0.134	0.139

3.3 Conductivity. Conductors should have a direct current resistance at 77 °F not to exceed the values listed in Table 1.

4. Insulation

4.1 Material. Insulation should be a thermoplastic polypropylene meeting the properties shown in Table 2 when tested in accordance with ICEA S-61-402, 3rd Edition [12], Section 6, except that pull rate should be 2 in/min. The polypropylene should be copper stabilized.

Table 2
Polypropylene Properties

Physical Requirements—Unaged	
Tensile strength, minimum, psi	3000
Elongation at rupture, minimum, percent	250
Physical Requirements—Aged in Air Oven at 121 °C (250 °F) for 72 h	
Tensile strength, minimum, percent of unaged value	75
Elongation, minimum, percent retention	75

4.2 Construction. The insulation should be extruded on the conductor. For 3 kV rated cable, average wall thickness should be 75 mil or more, with a minimum wall thickness of 68 mil at any point. For 5 kV rated cable, average wall thickness should be 90 mil or more, with a minimum wall thickness of 81 mil at any point.