



IEEE Recommended Practice for Testing and Rating of Electrical Submersible Pump Motors

IEEE Industry Applications Society

Developed by the
Petroleum and Chemical Industry Committee

IEEE Std 1017.4™-2023

STANDARDS

IEEE Recommended Practice for Testing and Rating of Electrical Submersible Pump Motors

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Petroleum and Chemical Industry Committee
of the
IEEE Industry Applications Society

Approved 8 August 2023

IEEE SA Standards Board

Abstract: Procedures and test values for testing and rating of electrical submersible pump (ESP) motors as well as installation and handling practices are specified in this document. The specified procedures and test values apply to ESP motor systems rated 3kV through 8kV (phase to phase).

Keywords: electrical submersible pump, electrical submersible pump motor, ESP, IEEE 1017.4™, induction, motor, submersible motor

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Introduction

This introduction is not part of IEEE Std 1017.4-2023, IEEE Recommended Practice for Testing and Rating of Electrical Submersible Polyphase Induction Motors.

This document, IEEE Std 1017.4 Recommended Practice for Testing and Rating of Electrical Submersible Pump Polyphase Induction Motors is part of the IEEE 1017 family of Electric Submersible Pump (ESP) documents. The IEEE 1017 family of documents originally included three Recommended Practices (RPs), including this document, IEEE Std 1017 Recommended Practice for Testing of Electric Submersible Pump Cable (now IEEE Std 1017.1), IEEE Std 1018 Recommended Practice for Specifying Electric Submersible Pump Cable—Ethylene-Propylene Rubber Insulation (now IEEE Std 1017.2), and IEEE Std 1019 IEEE Recommended Practice for Specifying Electric Submersible Pump Cable—Polypropylene Insulation (now IEEE Std 1017.3). These three RPs were the first standards sponsored by the Petroleum and Chemical Industry Committee of the IEEE Industry Applications Society.

Work began on the ESP standards in 1979. At that time, the typical life of ESP cables was significantly less than one year. Less than five vendors manufactured all ESP cable in the world. Each manufacturer used proprietary guidelines, construction, and performance requirements. After five years of work, the initial publication of RP 1017, 1018 and 1019 was completed in 1984. ANSI approval was obtained in 1985.

The original RPs focused on specifications for polypropylene cable (1019™). This was followed by the specifications for a relatively new insulation material EPDM (1018). During this process, it became clear that a document outlining field testing of the cable was required. This grew into IEEE Std 1017. The voltage rating of the cables was limited to 3kV and 5kV. Testing was essentially limited to dc Hi-pot testing and a dc voltage withstand test.

Version 2 (1991) of IEEE Std 1018 and IEEE Std 1019 expanded by the addition of ampacity curves based on the Neher-McGrath method. The Neher-McGrath calculations were modified to make them specifically applicable to the downhole conditions experienced by the cables. No significant changes to the testing requirements contained in IEEE Std 1017 were made.

Version 3 of IEEE Std 1017 (2004) included the addition of general descriptions of new testing procedures, including Time Domain Reflectometers (TDRs), Thumpers, Bridge Type Fault Locators, and dc Burn In. Also included was a major improvement in the interpretation of dc Hi-pot testing results, including methods for predicting failure of the cables without overstressing and destroying the insulation.

By the 2004 version, cable types described in IEEE Std 1018 and IEEE Std 1019 included four types: Round, Round with Lead Sheath, Flat and Flat with Lead Sheath.

Prior to the 2004 version, all values in the ESP cable standards were based on the United States Customary System (USCS, or English Engineering Units). Due to increased globalization of IEEE standards, IEEE Standards Association (SA) had a requirement that all published documents use SI Units exclusively. The market for ESP cable standards deals almost exclusively in USCS units, so the drafts were rejected by the ballot groups. Members of the ballot group threatened to withhold approval of the IEEE RPs and move the work to other Standards Development Organizations. This led the working group to petition the SA Standards Board (SASB) to include dual units, SI and USCS. The SASB approved the dual unit request and made a change to IEEE SA policy to allow dual units in all IEEE standards.

Version 4 (2013) of the RPs primarily involved editorial cleanup and verification of table values. Discussion began on advanced test methods, but these test methods were not included in this version. Discussions also began on inclusion of 8kV rated cables.

The current version of the IEEE 1017 family of RPs (Version 5) contains the most significant modifications to the RPs in their 40-year history. Version 6 includes greatly expanded content and a complete revamp of the group of RPs. The first major modification was renumbering of the RPs to emphasize the continuity of the standards as a group. IEEE Std 1017 became IEEE Std 1017.1; IEEE Std 1018 became IEEE Std 1017.2; and IEEE Std 1019 became IEEE Std 1017.3. All three RPs were expanded to include 8kV rated cable in addition to the 3kV and 5kV historic rated voltages. Additionally, cable sizes were expanded to include #3/0 AWG and #4/0 AWG.

IEEE Std 1017.1 was expanded to include all testing: factory, acceptance, and field testing. Additionally, advanced test methods including Very Low Frequency Tan-Delta (VLF tan-delta) and Partial Discharge (PD) were included, along with interpretation guidance. Testing for surface feed throughs and downhole connectors was added. New tests for qualification of encapsulating materials for non-lead metallic barrier cables with encapsulating jacket were also added.

IEEE Std 1017.2 and IEEE Std 1017.3 were modified to remove testing (pulled into IEEE Std 1017.1) and were expanded to include non-lead metallic barrier cables (sometimes called tubing encapsulated power cable, TEPC). The insulating and jacket material specifications were expanded to include Reinforced High Modulus materials. Finally, the Neher-McGrath curves were updated to correct an error and to make them more readable and usable.

IEEE Std 1017.4 was added to the family during the most recent revision and includes testing and rating of ESP Polyphase Induction Motors. Currently, the most commonly used electrical submersible motors in ESP systems are three-phase two-pole squirrel cage induction motors. Recently, permanent magnet motors (PMMs) have been commercially introduced into the ESP industry. In its current version, IEEE Std 1017.4 deals only with polyphase induction motors and excludes guidance on PMMs. This is in no way intended to limit or exclude the use of PMMs, or potentially other motor technologies, for ESP applications.

This recommended practice, under the jurisdiction of the Petroleum and Chemical Industry Committee of the IEEE Industry Applications Society, may be used by anyone desiring to do so and is presented as minimum criteria for rating and testing of motors. It is not intended to restrict innovation or to limit development of 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 this recommended practice and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use, for any conflict, or for the infringement of any patent resulting from the use of this recommended practice.

Acknowledgments

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IEEE Recommended Practice for Testing and Rating of Electrical Submersible Pump Motors

1. Overview

1.1 Scope

This document specifies procedures and test values for testing and rating of electrical submersible pump (ESP) motors as well as installation and handling practices. The specified procedures and test values apply to ESP motor systems rated 3kV through 8kV (phase to phase).

1.2 Purpose

The purpose of this recommended practices is as follows:

- Provide guidelines for performing ESP motor tests.
- Provide guidance for rating ESP motors.
- Provide guidelines for the evaluation and interpretation of test results.
- Define terms that have a specific meaning in the recommended practice

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6,7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

⁶The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASTM D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids using Disk Electrodes.

ASTM D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin.

IEEE Std 1™, IEEE Recommended Practice – General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation.^{8,9}

IEEE Std 43™, IEEE Recommended Practice for Testing Insulation Resistance of Electric Machinery.

IEEE Std 112™ IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.

IEEE Std 118™-1978, IEEE Standard Test Code for Resistance Measurement.

IEEE Std 119™-1974, IEEE Recommended Practice for General Principles of Temperature Measurement as Applied to Electrical Apparatus.

IEEE Std 120™, IEEE Master Guide for Electrical Measurements in Power Circuits.

IEEE 522™, IEEE Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines.

ISO 15511, Petroleum and Natural Gas Industries—Drilling and Production Equipment—Part 1: Electric Submersible Pump Systems for Artificial Lift.¹⁰

3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹¹

acceleration (a): A vector quantity that specifies the time rate of change of velocity, both linear and angular. Common units are in/sec² (m/sec²) and radians/sec².

adjustable speed drive (ASD): Surface power electronics equipment used to control the downhole motor speed directly or indirectly.

amplitude: The maximum value of a periodic quantity.

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