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Electric submersible pump systems for artificial lift

Partie : Systèmes électriques de pompes submersibles pour la remontée artificielle

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

This second edition cancels and replaces the first edition (ISO 15551-1:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

— The relationship between the design verification/validation activities and the functional specification/technical specification has been revised. As this document is intended to be used for the supply of “off the shelf” equipment, it is not possible to tie the design verification/validation activities to the functional specification/technical specification in the vast majority of electrical submersible pump procurement scenarios. In this document, the design verification/validation activities have been tied to a “basis of design” rather than to the functional specification/technical specification.

— Annex E has been augmented to incorporate additional details, guidelines and options for completing functional evaluation of assembled systems.

— A “user’s guide” has been added to this document to provide a simplified view of the practical workflow of the document in response to the industry feedback that the first edition of this document, by its nature, was complex to follow from a workflow perspective.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document has been developed by users/purchasers and suppliers/manufacturers of electric submersible pumps and is intended for use in the petroleum and natural gas industries worldwide. This document provides requirements and information to both parties in the selection, manufacturing, testing, and use of electric submersible pumps as defined in the scope. Further, this document addresses supplier requirements, which set the minimum parameters for claiming conformity with this document.

This document provides grades of requirements for design validation, quality control and functional evaluations allowing the user/purchaser to select each for a specific application. There are three grades of design validation, three grades of quality control and up to three grades of functional evaluation, depending on the component. For each of the design validation, quality and functional evaluation grades, grade 3 is the lowest grade and the higher grades have additional requirements. The user/purchaser can specify requirements supplemental to these grades.

Users of this document are informed that requirements above those outlined in this document can be needed for individual applications. This document is not intended to inhibit a supplier/manufacturer from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. This can be particularly applicable where there is innovative or developing technology.

Petroleum and natural gas industries — Drilling and production equipment — Electric submersible pump systems for artificial lift

1 Scope

This document provides requirements for the design, design verification and validation, manufacturing and data control, performance ratings, functional evaluations, handling and storage of tubing-deployed electrical submersible pump (ESP) systems as defined herein. Additionally, this document provides requirements for assembled ESP system.

This document is applicable to those ESP related components meeting the definition of centrifugal pumps, including gas handling devices, discharge heads, seal chamber sections, intake systems, mechanical gas separators, induction motors (herein motor), shaft couplings, downhole power cables (herein power cables), motor lead extension, and pothead as defined herein. Components supplied under the requirements of this document exclude previously used subcomponents, except where the use of such subcomponents is as defined in this document (Clause 10).

This document includes normative annexes addressing design validation performance rating requirements by component, requirements for determining ratings as an assembled system, functional evaluation: single component and cable reference information.

This document includes informative annexes addressing functional evaluation guidelines for assembled ESP systems, establishing recommended operating range (ROR) of the ESP system, example user/purchaser ESP functional specification form, considerations for the use of 3-phase low and medium voltage adjustable speed drives for ESP applications, analysis after ESP use, downhole monitoring of ESP assembly operation and information on permanent magnet motors for ESP applications.

This document also includes a user guide that offers a high-level process workflow when applying this document.

Equipment not covered by this document includes: wireline and coiled tubing-deployed ESP systems, motor and pump shrouds, electric penetrators and feed-through systems, cable clamps and banding, centralizers, intake screens, passive gas separators, by-pass tools, check and bleeder valves, component adaptors, capillary lines, electric surface control equipment, downhole permanent magnet motors and non-conventionally configured ESP systems such as inverted systems. Repair and redress equipment requirements are not covered in this document.

NOTE The terminology used within this document is “ESP assembly” for a system of products combined into an operational machine, “component” for individual products such as, pumps or seal chamber sections, and “subcomponent” for individual parts or subassemblies that are used in the construction of an individual component.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60228, *Conductors of insulated cables*

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

API RP 11S2, *Electric Submersible Pump Testing*

API RP 11S7, *Recommended Practice of Application and Testing of Electric Submersible Pump Seal Chamber Section*

API RP 11S8, *Practice on Electric Submersible Pump System Vibrations*

ASTM B3, *Standard Specification for Soft or Annealed Copper Wire*

ASTM B8, *Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft*

ASTM B33, *Standard Specification for Tin Coated Soft or Annealed Copper Wire for Electrical Purposes*

ASTM B189, *Standard Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes*

ASTM B193, *Standard Test Method for Resistivity of Electrical Conductor Materials*

ASTM B258, *Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors*

ASTM B496, *Standard Specification for Compact-Round Concentric-Lay-Stranded Copper Conductors*

ASTM D471, *Standard Test Method for Rubber Property — Effect of Liquids*

ASTM E8, *Standard Test Methods for Tension Testing of Metallic Materials*

ANSI/NEMA WC 53/ICEA T-27-581, *Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9000 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
adapter
device used to connect components that are not directly compatible

3.2
adjustable speed drive
device which controls an electric motor's speed by manipulating both the output voltage and the power frequency being supplied to the motor

Note 1 to entry: The term "adjustable speed drive" is interchangeable with other common industry names for this device, such as "variable frequency drive" or "variable speed drive".

3.3
ampacity
maximum current that can pass through a power cable without exceeding its temperature limit for a specific operating environment

3.4
ampacity coefficient
temperature rise of the power cable divided by the square of the amperage for a specific operating environment

3.5
armor
outer covering to the power cable that can provide protection from mechanical damage and provides mechanical constraint against swelling or expansion of underlying materials on exposure to well fluids

3.6
assembled ESP system
assembly of ESP downhole equipment which includes some or all components as identified in this document

Note 1 to entry: See also *ESP assembly* (3.52).

3.7
auxiliary equipment
equipment or components that are outside the scope of this document and are typically selected and/or installed by the user/purchaser

EXAMPLES Cable protectors, motor shrouds, by-pass tools and electrical penetrators.

3.8
axial stage type
type of stage with inlet and exit flow path essentially parallel to the shaft axis

3.9
bag/bladder/bellows
flexible subcomponent of a seal chamber section that functions as a positive barrier that isolates the wellbore production fluid from the motor fluid

3.10
bag/bladder/bellows chamber
chamber which houses the bag/bladder/bellows

3.11
barrier
subcomponent of an ESP power cable that can be applied over the insulated conductors and provides fluid protection, hoop strength or both

3.12
best efficiency point
BEP
pump performance values at the flow rate where the pump efficiency is highest

3.13
bleeder valve
valve placed above a check valve for the purpose of reducing pressure or draining the fluid from within the production tubing

3.14
braid
supplementary layer of material used to provide mechanical performance characteristics to the power cable system such as hoop strength for gas decompression

3.15
bubble point
pressure at which gas begins to break out of under-saturated oil/fluid and form a free gas phase

3.16
by-pass tool
device that is installed into the wellbore along with the ESP assembly that divides the tubing system to permit the installation of additional tubing string parallel to the ESP

3.17
cable band
metal band which is used to secure ESP power cable to production tubing

3.18
cable clamp
device, usually of rigid material, for strengthening or supporting power cable to production tubing

3.19
capillary line
independent tubing string commonly used for hydraulic control of safety valves and sliding sleeves or for chemical injection

Note 1 to entry: This device is also commonly referred to as a chemical injection line or control line.

3.20
casing
pipe extending from the surface and intended to line the walls of a drilled well

3.21
casing size
nominal casing outside diameter (od), mass (weight), inside diameter (id), and/or drift diameter as specified in ISO 11960

3.22
centralizers
device used to keep the ESP assembly or other downhole equipment in the centre of the tubing, casing or wellbore

3.23
centrifugal pump
component of an ESP system that uses rotating impeller(s) to impart kinetic energy (velocity) by centrifugal force to a fluid and stationary diffusers to convert the kinetic energy to potential energy (pressure)

3.24
chamber
subcomponent of the seal chamber section

3.25
check valve
device that allows one-directional flow of fluid when a differential pressure exists

3.26
coefficient of determination
statistic used to determine the strength of a fit between a mathematical model and a set of observed data values

3.27
coiled tubing
pipe typically supplied and installed in one continuous length and wound onto a reel or spool

3.28
coiled tubing deployed ESP
ESP system which is deployed into the wellbore using coiled tubing rather than by other deployment means such as jointed tubing or wireline

3.29
common hardware
hardware that does not require traceability and is included as part of an ESP component

EXAMPLES Bolts, washers, screws, and snap rings.

3.30
compact stranded cable
electrical conductor configuration in which a multiple-strand conductor has been compacted to reduce its circumference while maintaining conductor area

3.31
component
individual part of an assembly

EXAMPLES Pumps (including gas handling devices), discharge heads, seal chamber sections, intake systems, mechanical gas separators, induction motors (herein motor), shaft couplings, downhole cables (herein power cables), motor lead extensions, and potheads.

3.32
compression pump construction
configuration where the impeller is fixed to the shaft to prevent axial movement

3.33
conductor
subcomponent of the power cable that functions to conduct electrical power

3.34
conductor shield
layer adjacent to the conductor to distribute voltage stress evenly over the surface of the conductor

3.35
configuration
component designation that identifies the end connection designs for attaching additional components in series

EXAMPLES Upper tandem, lower tandem, middle/centre tandem, and single tandem.

3.36
contraction capacity
volume that a chamber or set of parallel chambers can draw in due to temperature and pressure cycles without allowing wellbore fluid ingress through the chamber or causing damage

3.37
coupling
device which connects the shafts of ESP components

3.38
deployment method
method used to deploy the ESP downhole equipment to its setting location

3.39
design basis
documented set of conditions, needs, and requirements taken into account by the supplier/manufacturer in designing a facility or product.

Note 1 to entry: For the purposes of this document, the “design basis” is developed by the supplier/manufacturer and is used for designing and establishing the performance ratings of the product.

3.40
design validation
process of proving a design by testing to demonstrate conformity of the product to design requirements and performance ratings.

3.41
design verification
process of examining the premise of a given design by calculation, comparison or investigation, to substantiate conformity with specified requirements