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# INTERNATIONAL STANDARD

**Subsea equipment -**
**Part 2: Power transformers**

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# Subsea equipment - Part 2: Power transformers

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This document is published as an IEC/IEEE Dual Logo standard.

This publication contains attached files in the form of a Microsoft Excel file. This file is intended to be used as a complement and does not form an integral part of the publication.

The text of this International Standard is based on the following IEC documents:

| Draft | Report on voting |
|---|---|
| 18/1978/FDIS | 18/1992A/RVD |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with the rules given in the ISO/IEC Directives, Part 2, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications/.

A list of all parts in the IEC/IEEE 61886 series, published under the general title *Subsea equipment*, can be found on the IEC website.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

# INTRODUCTION

Use of electrical power on the seabed is increasing. Both within the oil and gas and renewable industries, there is an increasing use of electrical power equipment on the seabed. Subsea processing activities like compression and pumping require an increasingly higher amount of electrical power. Power generation, whether onshore or offshore, requires development of equipment both for subsea transmission and distribution.

This document includes requirements related to equipment installed below the sea surface. The objective of this document is to substitute project/client specific specifications.

Use of this document will avoid increased costs and schedule impact (for type testing) and reduce risk for failure. By standardizing tests and implementing continuous improvement on fewer products, this risk will be reduced in the long term.

The SEPS JIP (Subsea Electrical Power Standardization Joint Industry Project) was established in 2010 by seven oil and gas companies, with the aim to develop common operator standards for subsea electrical power equipment and systems and support further development of these into internationally recognized standards. This document proposal is developed by SEPS. The aim for the SEPS JIP is to develop IEC/IEEE dual logo standards; hence both IEC and relevant IEEE standards are referenced where applicable. Relevant equipment manufacturers have contributed with review and comments to the document.

The lack of accessibility (for repair/replacement) defines strict requirements to reliability, beyond what is normally seen in topside applications.

As subsea equipment is in many cases interconnected to topside equipment, specifications for subsea equipment are considered to be within the Scope of IEC Technical Committee 18.

## 1 Scope

This part of IEC/IEEE 61886 is applicable to three-phase and single-phase liquid immersed subsea power transformers (including auto-transformers) with at least one winding with rated voltages in the range 3,6 ≤ $U_m$ ≤ 245 kV and with rated power in the range 50 kVA to 300 MVA. The intention is to specify additional requirements that are not covered by the IEC 60076 series and IEEE Std C57.12™ series.

It is the intention of this document that subsea power transformers be designed and tested either in accordance with the IEC 60076 series (IEC profile) or with the IEEE C57.12 series (IEEE profile).

For subsea transformers where no winding has a rated voltage above or equal to 3,6 kV, this document can be applicable, either as a whole or in part.

The mechanical design principles are also applicable for liquid-immersed reactors.

Where the terms "subsea transformer" or "transformer" are used, this means "transformer assembly". Where required, it is stated whether transformer accessories like penetrators and connectors are included or not.

## 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 60076-1:2011, *Power transformers - Part 1: General*

IEC 60076-2:2011, *Power transformers - Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3:2013, *Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air*
IEC 60076-3:2013/AMD1:2018

IEC 60076-5, *Power transformers - Part 5: Ability to withstand short circuit*

IEC 60076-10, *Power transformers - Part 10: Determination of sound levels*

IEC 60076-14, *Power transformers - Part 14: Liquid-immersed power transformers using high-temperature insulation materials*

IEC 60085, *Electrical insulation - Thermal evaluation and designation*

IEC 60137, *Insulated bushings for alternating voltages above 1000 V*

IEC 60156, *Insulating liquids - Determination of the breakdown voltage at power frequency - Test method*

IEC 60247, *Insulating liquids - Measurement of relative permittivity, dielectric dissipation factor (tan δ) and d.c. resistivity*

IEC 60296:2020, *Fluids for electrotechnical applications - Mineral insulating oils for electrical equipment*

IEC 60422, *Mineral insulating oils in electrical equipment - Supervision and maintenance guidance*

IEC 60475, *Method of sampling insulating liquids*

IEC 60814, *Insulating liquids - Oil impregnated paper and pressboard - Determination of water by automatic coulometric Karl Fischer titration*

IEC 61378-1:2011, *Converter transformers - Part 1: Transformers for industrial applications*

IEC 61619, *Insulating liquids - Contamination by polychlorinated biphenyls (PCBs) - Method of determination by capillary column gas chromatography*

IEC 62021-1, *Insulating liquids - Determination of acidity - Part 1: Automatic potentiometric titration*

IEC 62021-2, *Insulating liquids - Determination of acidity - Part 2: Colourimetric titration*

IEC 62535:2008, *Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil*

IEC 62697-1, *Test methods for quantitative determination of corrosive sulfur compounds in unused and used insulating liquids - Part 1: Test method for quantitative determination of dibenzyldisulfide (DBDS)*

IEC/IEEE 61886-1, *Subsea equipment - Part 1: Power connectors, penetrators and jumper assemblies with rated voltage from 3 kV ($U_{max}$ = 3,6 kV) to 30 kV ($U_{max}$ = 36 kV)*

ISO 2178, *Non-magnetic coatings on magnetic substrates - Measurement of coating thickness - Magnetic method*

ISO 2409, *Paints and varnishes - Cross-cut test*

ISO 3452 (all parts), *Non-destructive testing - Penetrant testing*

ISO 9606 (all parts), *Qualification testing of welders - Fusion welding*

ISO 12103-1:2024, *Road vehicles - Test contaminants for filter evaluation - Part 1: Arizona test dust*

ISO 13703-2, *Oil and gas industries including lower carbon energy - Piping systems on offshore platforms and onshore plants - Part 2: Materials*

ISO 15614 (all parts), *Specification and qualification of welding procedures for metallic materials - Welding procedure test*

ISO 17636-1, *Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film*

ISO 17636-2, *Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors*

ISO 17637, *Non-destructive testing of welds - Visual testing of fusion-welded joints*

ISO 17638, *Non-destructive testing of welds - Magnetic particle testing*

ISO 17640, *Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels and assessment*

ISO 17781, *Petroleum, petrochemical and natural gas industries - Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels*

ISO 17782, *Petroleum, petrochemical and natural gas industries - Scheme for conformity assessment of manufacturers of special materials*

ISO 21457, *Petroleum, petrochemical and natural gas industries - Materials selection and corrosion control for oil and gas production systems*

IEEE Std C57.32, *Standard for requirements, terminology, and test procedures for neutral grounding devices*

IEEE Std C57.12.00-2021, *General requirements for liquid-immersed distribution, power and regulating transformers*

IEEE Std C57.12.90-2021, *IEEE standard test code for liquid-immersed distribution, power and regulating transformers*

IEEE Std C57.110-2018, *IEEE recommended practice for establishing liquid immersed and dry-type power and distribution transformer capability when supplying non-sinusoidal load currents*

IEEE Std C57.152, *IEEE guide for diagnostic field testing of fluid-filled power transformers, regulators, and reactors*

IEEE Std C57.154, *IEEE standard for liquid-immersed transformers designed to operate at temperatures above conventional limits using high- temperature insulation systems*

IOGP S-563, *Piping and Valve Components - Material Data Sheets*

API 17F, *Standard for subsea production control systems*

API RP 17N:2023, *Recommended practice on subsea production system reliability, technical risk, and integrity management*

ASME BPVC Section IX:2023, *ASME Boiler and Pressure Vessel Code, Section IX: Welding, Brazing and Fusing Qualifications*

ASME BPVC Section V:2023, *ASME Boiler and Pressure Vessel Code, Section V: Non-destructive Examination*

ASTM D971:20, *Standard test method for interfacial tension of insulating liquids against water by the ring method*

ASTM D974:22, *Standard test method for acid and base number by color-indicator titration*

ASTM D1141-98:2021, *Standard practice for preparation of substitute ocean water*

ASTM D1275-15:2015, *Standard test method for corrosive sulfur in electrical insulating liquids*

ASTM D1298-12b:2017, *Standard test method for density, relative density, or API gravity of crude petroleum and liquid petroleum products by hydrometer method*

ASTM D1524-15:2022, *Standard test method for visual examination of used electrical insulating liquids in the field*

ASTM D1533-20, *Standard test method for water in insulating liquids by Coulometric Karl Fischer titration*

ASTM D1816-12:2019, *Standard test method for dielectric breakdown voltage of insulating liquids using VDE electrodes*

ASTM D3455-11, *Standard test methods for compatibility of construction material with electrical insulating oil of petroleum origin*

ASTM D3487-16e1, *Standard specification for mineral insulating oil used in electrical apparatus*

ASTM D3612-02:2017, *Standard test method for analysis of gases dissolved in electrical insulating oil by gas chromatography*

ASTM D4059-00(2018), *Standard test method for analysis of polychlorinated biphenyls in insulating liquids by gas chromatography*

AWS D1.1/D1.1M:2020, *Structural Welding Code - Steel*

DNV-ST-E273 2.7-3, *Portable offshore units*

DNV-RP-B401, *Cathodic protection design*

DNV-RP-F112, *Duplex stainless steel - Design against hydrogen induced stress cracking*

EN 1011 (all parts), *Welding - Recommendations for welding of metallic materials*

EN 10204, *Metallic products - Types of inspection documents*

EN 13445-5, *Unfired pressure vessels - Part 5: Inspection and testing*

EN 14210, *Surface active agents - Determination of interfacial tension of solutions of surface active agents by the stirrup or ring method*

NORSOK M-501, *Surface preparation and protective coating*

NORSOK M-601:2016, *Welding and inspection of piping*

NORSOK M-630:2020, *Material data sheets and element data sheets for piping*

NORSOK M-650, *Qualification of manufacturers of special materials*

NORSOK M-710:2014, *Qualification of non-metallic materials and manufacturers - Polymers*