International Association of Oil & Gas Producers

SPECIFICATION

IOGP S-754

January 2025

Version 0.1

Supplementary Specification to IEEE Std C57.12.00 for Liquid-Immersed Distribution, Power and Regulating Transformers

JIP33 JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
0.1	January 2025	Issued for Public Review

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2020).

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Introduction

The purpose of the IOGP S-754 specification documents is to define a minimum common set of requirements for the procurement of liquid-immersed distribution, power and regulating transformers in accordance with IEEE Std C57.12.00, published January 2022, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers for application in the petroleum and natural gas industries.

The IOGP S-754 specification documents follow a common structure (as shown below) comprising a specification, also known as a technical requirements specification (TRS), a procurement data sheet (PDS), an information requirements specification (IRS) and a quality requirements specification (QRS). These four specification documents, together with the purchase order, define the overall technical specification for procurement.

JIP33 Specification for Procurement Documents
Supplementary Technical Requirements Specification (TRS)

This specification is to be applied in conjunction with the supporting PDS, IRS and QRS as follows.

IOGP S-754: Supplementary Specification to IEEE Std C57.12.00 for Liquid-Immersed Distribution, Power and Regulating Transformers

This specification defines technical requirements for the supply of the equipment and is written as an overlay to IEEE Std C57.12.00, following the IEEE Std C57.12.00 clause structure. Clauses from IEEE Std C57.12.00 not amended by this specification apply as written. Modifications to IEEE Std C57.12.00 defined in this specification are introduced by a description that includes the type of modification (i.e. *Add*, *Replace* or *Delete*) and the position of the modification within the clause.

NOTE Lists, notes, tables, figures, equations, examples and warnings are not counted as paragraphs.

IOGP S-754D: Procurement Data Sheet for Liquid-Immersed Distribution, Power and Regulating Transformers (IEEE)

The PDS defines application-specific requirements. The PDS is applied during the procurement cycle only and does not replace the equipment data sheet. The PDS may also include fields for supplier-provided information required as part of the purchaser's technical evaluation. Additional purchaser-supplied documents may also be incorporated or referenced in the PDS to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-754L: Information Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers (IEEE)

The IRS defines information requirements for the scope of supply. The IRS includes information content, format, timing and purpose to be provided by the supplier, and may also define specific conditions that invoke the information requirements.

IOGP S-754Q: Quality Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers (IEEE)

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the PDS or in the purchase order.

The specification documents follow the editorial format of IEEE Std C57.12.00 and, where appropriate, the drafting principles and rules of ISO/IEC Directives Part 2.

The PDS and IRS are published as editable documents for the purchaser to specify application-specific requirements. The TRS and QRS are fixed documents.

The order of precedence of documents applicable to the supply of the equipment, with the highest authority listed first, shall be as follows:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser-defined requirements (e.g. PDS, IRS and QRS);

d) this specification;

e) IEEE Std C57.12.00.

1. Overview

1.1 Scope

Replace subclause with

The scope of this specification is to define the procurement requirements for the engineering, design, fabrication, documentation, testing and shipping of the following types of liquid-immersed power and distribution transformers to ANSI standards for oil and gas facilities:

a) Class I and Class II power transformers

b) Pad-mounted transformers rated 10 MVA and below

c) Distribution substation-type transformers rated 10 MVA and below

The scope of this specification includes power and distribution transformers with the following characteristics:

a) Three-phase

b) Two or three winding

c) Liquid-immersed

d) Air-cooled

e) Rated maximum voltage up to 765 kV

f) Rating of 300 kVA through 150 MVA

g) Rated at 50 or 60 Hertz

h) Liquid-filled equipped with a breather and a conservator

i) Sealed-type liquid-filled

j) Pad-mounted

k) For onshore, offshore, marine(ship) and floating facility applications

l) For applications where compliance with CSA standards is needed

The scope of this specification excludes the following types of transformers:

a) Single-phase transformers

b) Instrument transformers

c) Motor-starting transformers

d) Mining transformers

e) Transformers for deep water (submerged) applications

f) Rectifier-type transformers

g) Forced liquid-cooled power transformers

h) Grounding transformers

i) Autotransformers

j) Converter-type drive input transformers

k) Transformers rated below 300 kVA

l) Transformers rated above 150 MVA

m) Pole-mount transformers

n) Inverter transformers

o) Reactors

Add new subclause

1.4 General

1.4.1

Class I and Class II power transformers shall meet the requirements of this specification, excluding Clause 11 and Clause 12, and the requirements of IEEE Std C57.12.10.

1.4.2

Distribution substation-type transformers rated 10 MVA and below shall be provided in accordance with Clause 11.

Add new clause

1.4.3

Pad-mounted transformers rated 10 MVA and below shall be provided in accordance with Clause 12.

2. Normative references

Add to first paragraph

The following documents are referred to in this specification, the PDS (IOGP S-754D) or the IRS (IOGP S-754L) in such a way that some or all of their content constitutes requirements of these specification documents.

Add to clause

10 CFR Part 431, *Part 431—Energy Efficiency Program for Certain Commercial and Industrial Equipment*

46 CFR 111.20, *Title 46 – Shipping, Chapter I - Department of Coast Guard, Subchapter J - Electrical Engineering, Part 111, Subpart 111.20 - Transformer Construction, Installation, and Protection*

ABS MODU, Publication Number 6 Part 4, *Rules for Building and Classing Mobile Offshore Drilling Units - Part 4 Machinery and Systems*

ANSI/NETA ATS-2021, *Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems*

API Recommended Practice 2A-LRFD, *Planning, Designing, and Constructing Fixed Offshore Platforms—Load and Resistance Factor Design*

API Recommended Practice 2A-WSD, *Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*

API Recommended Practice 14F, *Recommended Practice for Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1, and Division 2 Locations*

API Recommended Practice 14FZ, *Recommended Practice for Design, Installation and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations*

ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*

ASTM D1275-06, *Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils*

CAN/CSA-C802.1, *Minimum Efficiency Values For Liquid-Filled Distribution Transformers*

CSA C22.1, *Canadian Electrical Code, Part I Safety Standard for Electrical Installations*

IEEE Std 386, *IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV*

IEEE Std C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)*

IEEE Std C57.12.10-2017, *IEEE Standard Requirements for Liquid-Immersed Power Transformers*

IEEE Std C57.12.34-2022, *IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High-Voltage, 34.5 kV Nominal System Voltage and Below; Low-Voltage, 15 kV Nominal System Voltage and Below*

IEEE Std C57.12.36, *IEEE Standard Requirements for Liquid-Immersed Distribution Substation Transformers*

IEEE Std C57.12.90, *IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE Std C57.19.01-2017, *IEEE Standard for Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings*

IEEE Std C57.32-2015, *IEEE Standard for Requirements, Terminology, and Test Procedures for Neutral Grounding Devices*

IEEE Std C57.32a-2020, *IEEE Standard for Requirements, Terminology, and Test Procedure for Neutral Grounding Devices--Amendment 1: Neutral Grounding Resistors Clause (AM)*

IEEE Std C57.104, *IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers*

IEEE Std C57.106-2015, *IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment*

IEEE Std C57.143-2012, *IEEE Guide for Application for Monitoring Equipment to Liquid-Immersed Transformers and Components*

IEEE Std C57.147-2018, *IEEE Guide for Acceptance and Maintenance of Natural Ester Insulating Liquid in Transformers*

IEEE Std C57.150, *IEEE Guide for the Transportation of Transformers and Reactors Rated 10 000 kVA or Higher*

IEEE Std C57.153, *IEEE Guide for Paralleling Regulating Transformers*

ISO 12944-2, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 12944-5, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems*

ISO 12944-9, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures*

NEMA ICS 5, *Industrial Control and Systems: Control-Circuit and Pilot Devices*

ANSI Z535.4, *American National Standard for Product Safety Signs and Labels*

NFPA 70, *National Electrical Code*

UL XPLH, *Underwriters Laboratories (UL) – GuideInfo XPLH - Transformers, Distribution, Liquid-Filled Type, Over 600 Volts*

Replace Clause 3 title with

3. Definitions and abbreviated terms

Add new subclause title to start of clause

3.1 Definitions

Add to subclause

For the purposes of this specification, the following terms and definitions apply.

touch-safe: Protected from inadvertent contact by a finger using covers, recessing of terminals or the size of openings.

NOTE—Touch-safe and similar terms, such as finger safe, are widely used to describe products but are not defined by industry standards. Touch-safe is generally equivalent to IP 2X per ANSI/IEC 60529, but most products are not tested to a particular IP rating.

Add new subclause

3.2 Abbreviated terms

ACO accredited certification organization

AIT auto-ignition temperature

ATC air terminal chamber

BIL basic lightning impulse insulation level

CAS conformity assessment system

CT current transformer

DCS * distributed control system

DETC * de-energized tap changer

DGA dissolved gas analysis

DOT Department of Transportation

HOA hand-off-auto

IRS information requirements specification

NC normally closed

NGR neutral grounding resistor

NO normally open

NRTL nationally recognized testing laboratory

OLTC on-load tap changer

PD partial discharge

PDS procurement data sheet

QRS quality requirements specification

SPR sudden pressure relay

TEFC totally enclosed fan cooled

TRS technical requirements specification

* Cited in IOGP S-754J only.

4. Service conditions

4.3 Unusual service conditions

Add new subclause

4.3.4 Offshore and marine applications

4.3.4.1

For offshore applications, control cabinet enclosures and wired accessory housings shall be made of stainless steel with a minimum protection grade of NEMA 4X.

4.3.4.2

For offshore applications, transformer external hardware shall be 316 stainless steel.

4.3.4.3

For offshore applications, wiring shall be installed in a rigid copper-free aluminum conduit with compatible fittings to individual devices or enclosures.

4.3.4.4

For offshore applications, wiring to individual devices or enclosures that require flexibility shall utilize a corrosion-resistant liquid-tight flexible conduit.

Add new subclause

4.3.5 Hazardous (classified) areas

If transformers are specified for hazardous (classified) areas, the controls, accessories, ground resistors and enclosures shall be NRTL listed or ACO certified for the area classification identified in the transformer data sheets.

Add new subclause

4.4 Design life

4.4.1

Transformers, excluding electronic components, shall have an operating life of at least 25 years when delivering rated output under the specified site conditions.

4.4.2

The electronic components installed on the transformer (e.g., protection, metering and control devices) shall have an operating life of at least 14 years under usual service conditions.

4.4.3

The manufacturer's proposal shall indicate whether the transformer design or any sub-component individually denoted has less than three years of proven operational service.

5. Rating data

5.12 Nameplates

5.12.1 General

Replace first sentence of first paragraph with

A stainless steel nameplate shall be affixed to the transformer.

Add to subclause

The stainless steel nameplate shall be inscribed by means of a durable method (e.g., etching, engraving, stamping).

Add to subclause

The stainless steel nameplate shall be mounted with stainless steel hardware.

Add to subclause

The stainless steel nameplate shall be installed on the transformer tank at eye level.

Add to subclause

The stainless steel nameplate shall be installed in a location at which the nameplate is fully visible and not obscured by radiators or accessories.

5.12.2 Nameplate information

Add to subclause

The percent impedance of the mid-tap voltage ratio at the self-cooled transformer rating shall be shown on the transformer nameplate.

Add to subclause

For transformers utilizing OLTCs, the minimum and maximum percent impedance corresponding to the minimum and maximum voltage ratios shall be shown on the OLTC transformer nameplate.

Add to subclause

The purchase order number or factory shop order number shall be shown on the transformer nameplate.

Add to subclause

If the transformer is NRTL certified, the transformer shall be marked or labeled consistently with the certification.

Add to subclause

The temperature rise design and guarantee based on an altitude above 1006 m (3300 ft), if applicable, shall be shown on the transformer nameplate.

Add to subclause

If the area classification is specified, the transformer nameplate shall display the area classification (i.e., Zone 2, Division 2).

Add new subclause

5.13 Certifications

5.13.1

If seismic requirements are specified, the transformer shall meet the requirements of ASCE/SEI 7.

NOTE—Parameters for seismic design can be found in "Seismic Loads: Guide to the Seismic Load Provisions of ASCE 7-16".

5.13.2

If specified, the complete transformer assembly shall be NRTL certified in accordance with UL XPLH GuideInfo.

NOTE—NRTL certification in accordance with UL XPLH GuideInfo applies only to distribution transformers rated 69 kV and below.

5.13.3

If transformers fabricated to CSA standards are specified, the transformer nameplate shall contain a statement that the transformer is compliant with the applicable CSA standard.

5.13.4

If the transformer is specified for offshore floating or marine applications, the transformer shall be provided in accordance with USCG 46 CFR 111.20 and ABS MODU Rules 4-3-4/9.

NOTE—Additional guidance and information for transformers installed on floating facilities in US territorial waters to USCG and ABS codes can be found in API 14F or API 14FZ.

5.13.5

If the transformer is specified for offshore floating or marine applications, the transformer shall be provided in accordance with the application specific vibration, shock, inclination, and motion criteria detailed in the project drawings or supplementary tab of the PDS.

NOTE—USCG 46 CFR 111.20 and ABS MODU Rules 4-3-4/9 are typically used unless site or application-specific information is provided.

6. Construction

6.1 Bushings

Add new subclause

6.1.1

Bushings rated 1000 V and above shall be provided with a mounting flange.

Add new subclause

6.1.2

Gaskets shall be retained by positive means (i.e., recessed spaces).

Add new subclause

6.1.3

Gaskets shall be made of nitrile rubber (Buna N), fluoroelastomer or other material with equivalent characteristics.

Add new subclause

6.1.4

For sealed transformers, the integrity of the gaskets shall be tested by pressurizing the tanks to at least 69 kPag (10 psig) for a duration of two hours, followed by checking for leaks.

Add new subclause

6.1.5

Bushings shall have tin-plated copper connection pads with a NEMA standard hole pattern.

Add new subclause

6.1.6

The neutral shall be brought out through a full phase current-rated bushing to facilitate a connection to an external neutral or ground.

Add new subclause

6.1.7

Oil-filled and capacitor-type bushings shall be provided for high-voltage bushing applications of 69 kV and above in accordance with IEEE Std C57.19.01.

Add new subclause

6.1.8

Oil-filled and capacitor-type bushings utilized in high-voltage applications shall be provided with liquid level indicators.

Add new subclause

6.1.9

Oil-filled and capacitor-type bushings utilized in high-voltage applications shall be provided with power factor test taps.

Add new subclause

6.1.10

Broken delta tertiary winding shall be brought out through two bushings for external connection.

Add new subclause

6.1.11

The primary and secondary bushing BIL shall be greater than or equal to the winding BIL.

Add new subclause

6.1.12

Phase bushings shall be rated for the maximum transformer capacity (i.e. including the forced cooling rating, or provisions for forced cooling, if applicable).

Add new subclause

6.1.13

Bushings not located in air terminal chambers (ATCs) shall be made of porcelain.

Add new subclause

6.1.14

Bushings installed in ATCs in offshore and marine applications shall be made of non-hygroscopic, non-tracking, cycloaliphatic material.

Add new subclause

6.1.15

If specified, heavy contamination creepage distance (i.e., extra creep) bushings shall be provided for outdoor transformers with cover-mounted (i.e., exposed) bushings.

NOTE—Additional information on creepage distance can be found in IEEE Std C57.19.01-2017, Table 1.

6.2 Transformer accessories

Add new subclause

6.2.1 General

6.2.1.1

The transformer vacuum / pressure gauge shall be provided with one set of alarm contacts.

6.2.1.2

The transformer vacuum / pressure gauge shall be provided with an isolation valve.

6.2.1.3

The transformer pressure-relief device shall be of the automatic-resetting type.

6.2.1.4

The transformer liquid temperature indicator shall be provided with one set of alarm contacts (e.g., for remote indication).

6.2.1.5

The pressure-vacuum bleeder device on a sealed-tank transformer shall be provided with a gas sampling valve and a hose spud.

6.2.1.6

If specified, the inert gas purge system for a sealed-tank transformer application shall be supplied with a purge nozzle and shut-off valve.

6.2.1.7

A permanent caution label stating the following shall be affixed adjacent to the de-energized tap changer (DETC): "DO NOT OPERATE WHEN TRANSFORMER IS ENERGIZED".

6.2.1.8

Where the transformer is specified for offshore or marine applications, the pressure-relief device shall be provided with a stainless steel shroud with a corrosion-resistant spout piped to the base of the transformer.

Add new subclause

6.2.2 Transformer accessories location

6.2.2.1

Switches and devices that are operated or tested shall be located at a maximum height of 1.5 m (60 in) above the transformer base.

NOTE—Tap changers and pressure-relief devices are excluded from this requirement.

6.2.2.2

Indicators mounted 1.5 m (60 in) above the transformer base shall be readable by the operator standing at the transformer base level.

6.2.2.3

The view of indicators from ground level shall not be obstructed.

Add new subclause

6.2.3 Alarm and control devices

6.2.3.1

Alarm and control devices shall have single-pole, double-throw contacts (Form C), rated 5A at the specified control voltage.

6.2.3.2

Alarm and control devices shall be identified as shown on the project drawings.

6.2.3.3

Alarm and control devices shall have identification tags as shown on the project drawings.

6.2.3.4

Tags and identification labels for alarm and control devices that are located inside the enclosure shall be of one of the following types:

a) Vinyl or polyester type

b) Adhesive type

c) Thermal transfer printing type

6.2.3.5

Tags for alarm and control devices that are exposed to the environment shall be made of stainless steel.

6.2.3.6

Tags for alarm and control devices that are exposed to the environment shall be mounted with corrosion-resistant screws or rivets.

6.2.3.7

If specified, a transformer fan monitoring system with two normally open (NO) and two normally closed (NC) alarm contacts shall be provided.

6.2.3.8

Alarm and control devices and/or accessories shall be NRTL listed or ACO approved for the area classification in which they are installed.

Add new subclause

6.2.4 Sudden pressure relay (SPR)

6.2.4.1

If a sudden pressure relay (SPR) is specified, the SPR shall be flange mounted.

6.2.4.2

If an SPR is specified, the SPR shall be provided with a globe-type isolation valve.

6.2.4.3

If an SPR is specified, the SPR shall permit testing while the transformer is energized.

6.2.4.4

If an SPR is specified, the SPR shall be provided with a bleeder valve testing facility.

Add new subclause

6.2.5 Neutral grounding resistor (NGR)

6.2.5.1

If specified, a neutral grounding resistor (NGR) shall be provided in accordance with IEEE Std C57.32-2015, Clause 7 and IEE Std C57.32a-2020, Clause 7.

6.2.5.2

If an NGR is specified, the NGR shall be comprised of stainless-steel strap elements that are edge wound around a ceramic core.

6.2.5.3

If an NGR is specified, the resistor elements shall be mounted on a stainless steel frame.

6.2.5.4

If an NGR is specified, the NGR assembly shall have an insulated copper grounding conductor, rated for the voltage class, between the neutral bushing and the resistor.

6.2.5.5

If an NGR is specified, the NGR shall be provided with a corrosion-resistant resistor enclosure.

6.2.5.6

If an NGR is specified, the NGR shall be provided with a resistor enclosure with bolted and removable sides.

6.2.5.7

If an NGR is specified, the resistor enclosure shall be provided with lifting eyes on the top four corners.

6.2.5.8

If specified for offshore applications, the NGR shall be provided with a resistor enclosure made of 316 stainless steel.

Add new subclause

6.2.6 Condition-based monitoring

NOTE—Additional information on transformer continuous monitoring equipment can be found in IEEE Std C57.143.

6.2.6.1 Continuous insulating liquid temperature monitoring

6.2.6.1.1

If a continuous temperature monitoring system for the insulating liquid is specified, the insulating liquid continuous temperature monitoring system shall be provided with at least top oil and ambient temperature measurements.

6.2.6.1.2

If a continuous temperature monitoring system for the insulating liquid is specified, the insulating liquid continuous temperature monitoring system shall provide digital communications functionality.

6.2.6.2 Continuous winding temperature monitoring

6.2.6.2.1

If a continuous temperature monitoring system for the transformer winding is specified, the continuous winding temperature monitoring system shall be provided with at least the ambient temperature and the temperature measurement at the location in the winding that is typically the hottest spot.

6.2.6.2.2

If a continuous temperature monitoring system for the transformer winding is specified, the continuous winding temperature monitoring system shall provide digital communications functionality.

6.2.6.3 Continuous cable termination thermal monitoring

6.2.6.3.1

If a continuous thermal monitoring system for the cable terminations is specified, the continuous cable termination thermal monitoring system shall consist of hotspot detection sensors for cable and bushing connections.

6.2.6.3.2

If a continuous thermal monitoring system for the cable terminations is specified, the continuous cable termination thermal monitoring system shall provide digital communications functionality to transmit temperature data, status and alarming for every monitored point.

6.2.6.4 Dissolved gas-in-oil analysis (DGA) monitoring

6.2.6.4.1

If a dissolved gas-in-oil analysis (DGA) continuous monitoring system is specified, the DGA continuous monitoring system shall provide analysis data and multi-gas monitoring for gases of interest listed in IEEE Std C57.143-2012, Table 4 and specified in the PDS.

6.2.6.4.2

If a DGA continuous monitoring system is specified, the sampling location for the DGA continuous monitoring system shall include a provision that allows for manual sampling for periodic laboratory analysis.

6.2.6.4.3

If a DGA continuous monitoring system is specified, the sampling location for the DGA continuous monitoring system shall be installed on a dedicated port in the transformer tank.

NOTE—This requirement is not satisfied by adding the DGA sampling location to the combination drain and lower filter valve.

6.2.6.4.4

If a DGA continuous monitoring system is specified, the DGA continuous monitoring system shall provide digital communications functionality to transmit the DGA information.

6.2.6.5 Moisture in oil monitoring

6.2.6.5.1

If a moisture in oil continuous monitoring system and a DGA system are specified, the moisture in oil continuous monitoring system shall be incorporated into the DGA system.

6.2.6.5.2

If a moisture in oil continuous monitoring system is specified, the sampling location for the moisture in oil continuous monitoring system shall be installed on a dedicated port on the transformer tank.

NOTE—This requirement is not satisfied by adding the moisture in oil sampling location to the combination drain and lower filter valve.

6.2.6.5.3

If a moisture in oil continuous monitoring system is specified, the moisture in oil continuous monitoring system shall provide digital communications functionality to transmit the level of moisture detected in the insulating liquid.

6.2.6.6 Continuous partial discharge (PD) monitoring

If a continuous PD monitoring system is specified, the continuous PD monitoring system shall provide digital communications functionality to transmit the level of PD data, status and alarming for monitored points.

6.2.6.7 Conservator membrane monitoring

If a conservator membrane monitoring system is specified, the conservator membrane monitoring system shall provide local and remote indication of a ruptured conservator membrane.

6.2.6.8 Data communications

6.2.6.8.1

If transformer accessories are specified with data communications functionality, the cabling and connection to the devices intended to be monitored shall be compatible with the specified communication protocol or combination of protocols.

6.2.6.8.2

If transformer accessories are specified with data communications functionality, the cabling and connectors for the devices intended to be monitored shall be secured with a mechanical connecting means (e.g., screw-type connectors, RJ45 connectors).

6.2.6.8.3

If transformer accessories are specified with data communications functionality, the cabling to the devices intended to be monitored and controlled shall be rated for 600 V ac.

6.3 Bushing current transformers

Add new subclause

6.3.1 Current transformers (CTs)

6.3.1.1

Current transformers (CTs) shall be supplied in accordance with the one-line diagram or project drawings.

NOTE—For CTs that are used for relaying applications, refer to the guidelines in IEEE Std C37.110.

6.3.1.2

Wiring connections for CTs shall be of the compression type, insulated sleeve, seamless ring-tongue connectors.

6.3.1.3

Wiring for CTs shall be No. 12 AWG stranded copper or larger.

6.3.1.4

One leg of the CT secondary winding circuit shall be grounded to the CT grounding terminal block.

6.3.1.5

CT terminal blocks shall be marked designating the CT phase and tap number.

6.3.1.6

The polarity marking for CT wiring shall be shown at the terminals.

6.3.1.7

Terminal blocks for CT wiring shall have provisions for shorting the individual CT circuits to ground.

6.3.1.8

CT secondary lead shorting-type terminal blocks shall be located in an enclosure installed on the side of the transformer tank.

6.3.1.9

CT secondary leads (i.e., single tap leads, multi-ratio tap leads) shall be installed in a rigid conduit that is supported at intervals in accordance with NFPA 70.

6.3.1.10

Bushing CTs shall have an insulation level equal to the section of the winding that the bushing CTs are associated with.

6.5 Tank pressure requirements

Add new subclause

6.5.3 Tank requirements

6.5.3.1

The transformer tank cover shall have at least one manhole or two handholes.

6.5.3.2

Handholes and manholes on the transformer shall have bolted covers.

6.5.3.3

Handholes and manholes on the transformer shall be provided with gaskets of nitrile rubber (Buna N) rubber, fluoroelastomer or material with equivalent characteristics.

6.5.3.4

The location and size of the manholes or handholes on the transformer shall facilitate the replacement of bushings.

6.5.3.5

The cover of the manhole on the transformer shall have at least two handles for lifting purposes.

6.5.3.6

A permanent warning label stating the following in accordance with ANSI Z535.4 shall be provided on manhole and handhole covers: "WARNING: TANK COULD BE UNDER PRESSURE Do not open unless equipment Is de-energized, locked out, and pressure has been released".

6.5.3.7

Transformers rated 2 MVA and above shall be provided with anchor brackets to accommodate a portable fall arrest post.

6.5.3.8

Tanks, compartments and radiators shall be suitable for vacuum filling at an external pressure of 101.325 kPa (one atmosphere), i.e., full vacuum.

6.6 Liquid insulation system

6.6.2 Insulating liquid preservation

Delete list item c)

6.6.3 Nitrogen inert-gas pressure system

Add new subclause

6.6.3.1

At least two pressure gauges shall be supplied with the nitrogen inert-gas pressure system, one for supply cylinder pressure and one for transformer tank pressure.

Add new subclause

6.6.3.2

A shutoff valve for the nitrogen inert-gas pressure system shall be provided at the transformer inlet.

Add new subclause

6.6.3.3

The nitrogen inert-gas pressure system shall be provided with the fittings and tubing to interconnect the gas cylinders, pressure regulating system and transformer tank.

Add new subclause

6.6.3.4

Nitrogen inert-gas pressure systems shall be provided with a low cylinder pressure alarm contact.

Add new subclause

6.6.3.5

Nitrogen inert-gas pressure systems shall be provided with a high transformer tank pressure alarm contact.

Add new subclause

6.6.3.6

Nitrogen inert-gas pressure systems shall be provided with a low transformer tank pressure alarm contact.

Add new subclause

6.6.3.7 Nitrogen inert-gas pressure system cabinet

6.6.3.7.1

A cabinet to house the nitrogen gas cylinders for the nitrogen inert-gas pressure system shall be provided.

6.6.3.7.2

The cabinet to house the nitrogen gas cylinders for the nitrogen inert-gas pressure system shall have a hinged door with a handle-operated latch.

6.6.3.7.3

The cabinet to house the nitrogen gas cylinders for the nitrogen inert-gas pressure system shall have a door window that allows unobstructed viewing of installed gauges.

6.6.3.7.4

The cabinet to house the nitrogen gas cylinders for the nitrogen inert-gas pressure system shall have a breather and a drain at the bottom of the cabinet.

6.6.3.7.5

The cabinet to house the nitrogen gas cylinders for the nitrogen inert-gas pressure system shall have a means for retaining the cylinders.

Add new clause

6.6.4 Mineral oil

6.6.4.1

If a mineral oil is specified, the mineral oil shall be free of corrosive sulfur and tested in accordance with ASTM D1275-06 Method B.

6.6.4.2

If a mineral oil is specified, the mineral oil shall be new (i.e., not recycled).

6.6.4.3

If a mineral oil is specified, the mineral oil shall be provided with an oxidation inhibitor.

Add new subclause

6.6.5 Sealed Tank

6.6.5.1

For sealed tank transformers, the space in the tank above the oil shall be filled with dry air or nitrogen gas.

6.6.5.2

Sealed tank transformers shall be provided with an isolation valve that allows field connection to a regulated nitrogen source.

Add new subclause

6.6.6 Conservator

6.6.6.1

If a conservator-type transformer is specified, the conservator tank shall be provided with a diaphragm to isolate the transformer liquid and the air.

6.6.6.2

For offshore and marine applications, conservator-type transformers shall not be used.

6.6.6.3

If a conservator-type transformer is specified, the transformer shall be provided with a double-float Buchholz relay.

6.6.6.4

If a conservator-type transformer is specified, the Buchholz relay shall have a provision for taking insulating liquid and gas samples from ground level.

6.6.6.5

If a conservator-type transformer is specified, the Buchholz relay shall be provided with alarm and trip contacts wired to the control cabinet (i.e., gas accumulation, low oil level and oil surge).

6.7 Grounding

6.7.2 Grounding of core

Add new subclause

6.7.2.2

For transformers rated 5000 kVA and above, the core ground shall be brought out to a terminal external to the tank.

Add new clause

6.7.3

Transformers shall be supplied with stainless steel grounding pads.

6.8 Minimum external clearances of transformer live parts

Add to subclause

If a resistance grounded system is specified, phase-to-phase clearances shall be provided between bushings and grounded structures.

Add new subclause

6.9 Windings and core

6.9.1

Conductor joints shall be brazed or welded.

6.9.2

Transformers wound with aluminum windings shall have copper leads brought out for the tap connections.

6.9.3

Transformers wound with aluminum windings shall have the aluminum-to-copper transition made in the insulating liquid using metallurgically bonded transition joints.

Add new subclause

6.10 Cable and bus connections

6.10.1 Air terminal chamber (ATC) for cable connections

6.10.1.1

The ATC for cable connections shall have a front access cover or door.

6.10.1.2

The ATC shall have a drip shield over the horizontal gasketed surfaces.

6.10.1.3

The ATC shall be removable and attached to the transformer tank with a flanged and gasketed connection.

6.10.1.4

The ATC cable entry plate shall be non-magnetic.

6.10.1.5

The ATC cable entry plate shall be removable.

6.10.1.6

The ATC cable entry plate shall be at least 6 mm (1/4 in) thick.

6.10.1.7

The ATC cable entry plate shall be bolted and gasketed.

6.10.1.8

The ATC shall have cable supports spaced at a distance of no more than 300 mm (12 in) from the bottom of the ATC.

6.10.1.9

The ATC shall have a stainless-steel drain at the bottom of the ATC.

6.10.1.10

ATC gaskets shall be nitrile rubber (Buna N), fluoroelastomer or material with equivalent characteristics.

6.10.1.11

Gaskets shall be installed inside a metal groove, channel, or retained by mechanical means.

6.10.1.12

Components installed in the ATC that are directly connected to the transformer bushings, (e.g., partial discharge sensors, arresters, surge capacitors, voltage dividers), shall be rated in accordance with the applicable transformer primary or secondary BIL rating.

6.10.1.13

A permanent danger label stating the following in accordance with ANSI Z535.4, shall be provided on the ATC cover or door: "DANGER xxx VOLTS", where "xxx" is replaced with the applicable voltage level present in the ATC.

6.10.1.14

A permanent danger label stating the following in accordance with ANSI Z535.4 shall be provided near the bushings inside the ATC: "DANGER xxx VOLTS", where "xxx" is replaced with the applicable voltage level present in the ATC.

6.10.1.15

If an ATC door is specified, the door shall be provided with hinges and padlocking provisions.

6.10.1.16

If an ATC door is specified, the door shall open at least 180 degrees.

6.10.1.17

If an ATC cover is specified, the cover shall be bolted and gasketed.

6.10.1.18

If an ATC cover is specified, the cover shall have at least two handles for lifting.

6.10.1.19

The ATC shall be provided with a grounding bar that accommodates cable shields, cable armor, surge arresters, surge capacitors and auxiliary circuits.

6.10.1.20

If a full-height ATC is specified, the ATC shall be provided with lifting provisions.

6.10.1.21

If an ATC is specified with thermal scanning inspection windows, these windows shall be installed at locations where hot spots at the power cable connections to the bushings are detectable by external thermal scanning.

6.10.1.22

If an ATC is specified with thermal scanning inspection windows, these windows shall be NRTL or ACO approved.

Add new subclause

6.10.2 Throat connection for bus bar

6.10.2.1

The throat connection shall be welded to the tank wall.

6.10.2.2

The throat connection shall be furnished with a predrilled flange.

6.10.2.3

Flexible connectors with the same ampacity as the bushings shall be provided for bus bar and bus duct connections.

6.10.2.4

The throat flange gasketed joint shall be provided with a drip shield.

6.10.2.5

Gaskets shall be installed inside a metal groove or channel, or retained by mechanical means.

6.10.2.6

Throat connection gaskets shall be nitrile rubber (Buna N), fluoroelastomer or material with equivalent characteristics.

Add new subclause

6.11 Space heaters

6.11.1

Space heaters less than or equal to 2 kW shall operate at 120 V ac.

6.11.2

Space heaters 2 kW and above shall operate at 208 V ac.

6.11.3

Space heaters shall be wired to an accessible terminal block provided for connection to a single external power source.

6.11.4

Enclosure space heaters shall be guarded (e.g., fitted with an expanded metal cage around the heater).

6.11.5

Enclosure space heaters shall be sized to provide a 5 K rise over the upper ambient air temperature limit of the site.

6.11.6

Space heaters shall be installed on standoff insulators.

6.11.7

If the transformer is installed in a Class I, Division 2 classified location, the space heater element surface temperature shall not exceed 80%of the auto-ignition temperature (AIT) of the explosive atmosphere.

6.11.8

Caution labels shall be provided on doors or panels of enclosures and ATCs that contain externally powered space heaters.

6.11.9

Caution labels stating the following in accordance with ANSI Z535.4 shall be provided on space heaters: "CAUTION: SPACE HEATERS MAY BE ENERGIZED".

6.11.10

If enclosure space heater automatic control is specified, a thermostatic-type control unit shall be provided.

6.11.11

If an enclosure space heater ammeter is specified, the ammeter for the space heater circuit shall have an appropriately sized scale so that failure of a single space heater element results in a discernible change in ammeter reading.

6.11.12

If the enclosure space heater ammeter is specified, the normal operating ampacity of the enclosure space heater circuit shall be inscribed on the ammeter nameplate.

Add new subclause

6.12 Surge arresters

6.12.1

If surge arresters are specified, the arresters shall be provided in accordance with IEEE Std C62.11.

6.12.2

If lightning or surge arresters are specified, the arresters shall be located to minimize the circuit distance between the surge arresters and the terminal bushings.

6.12.3

If lightning or surge arresters are specified for an ATC application, the arresters shall be installed inside the ATC.

6.12.4

If lightning or surge arresters are specified, the insulating bushings of the surge arresters shall be of the same insulation class and BIL level as the transformer phase bushings.

6.12.5

If arresters are specified, the circuit distance between the surge arresters and the ground terminals shall be minimized.

6.12.6

If lightning or surge arresters are specified, for the cover-mounted (exposed) bushings rated above 52 kV, the arresters shall be provided with discharge counters.

Add new subclause

6.13 Auxiliary enclosures, devices, and wiring

6.13.1 Wiring

6.13.1.1

Control, alarm and low-voltage power wiring shall be 600 V type SIS or 600 V type XHHW.

6.13.1.2

Accessory and auxiliary wiring shall be installed in accordance with NFPA 70 (NEC) for applications in the United States and CSA 22.1 Part 1 (CEC) for Canadian applications.

6.13.1.3

Control, alarm and low-voltage power wiring shall be continuous with no splices.

6.13.1.4

The grounding conductor insulation color for grounding circuits shall be green or green with a yellow stripe.

6.13.1.5

The minimum wire size control and alarm signals shall be No. 16 AWG.

6.13.1.6

Wire terminations shall be marked with heat shrink-type wire markers or permanently marked at both ends accordance with the transformer wiring diagrams.

6.13.1.7

Adhesive-type wire markers, labels and wire holders shall not be used for internal wire marking.

6.13.1.8

Internal wire termination markers shall be visible at the termination point without disassembling the cable bundle.

6.13.1.9

Control wiring terminated on screw-type terminals shall use insulated, compression, locking fork tongue-type lugs.

6.13.1.10

Control wiring terminated on clamp-type terminals that cannot accept fork tongue-type lugs shall use insulated crimp-type ferrules or pin lugs.

6.13.1.11

Wiring into devices and enclosures shall be bottom-entry.

NOTE—Side-entry is an acceptable alternative where bottom entry is not feasible (e.g. due to lack of space).

6.13.1.12

Wiring shall be installed in rigid galvanized steel conduit with compatible fittings to individual devices or enclosures.

6.13.1.13

Wiring to individual devices or enclosures that require flexibility shall utilize liquid-tight flexible conduit.

6.13.1.14

The length of flexible conduit shall not exceed 457 mm (18 in).

6.13.1.15

Control, signal, and alarm wiring from devices and accessories on the transformer, shall be connected to terminal blocks inside the control cabinet installed on the side of the transformer.

6.13.1.16

Unused contacts from accessory devices shall be wired to terminal blocks in the control cabinet.

6.13.2 Auxiliary wiring terminals

6.13.2.1

The terminal blocks shall be of solid one-piece or din rail mount type.

6.13.2.2

Exposed energized terminals of auxiliary devices (e.g., control relays, terminal blocks, fuse holders) shall be provided touch safe or covered by an insulating barrier.

6.13.2.3

Internal wire terminations shall have a unique number assigned per the approved schematic and wiring diagrams.

6.13.3 Control cabinet or instrument enclosures

6.13.3.1

Control cabinet enclosures and wired accessory housings shall have a minimum protection grade of NEMA 3R.

6.13.3.2

Control cabinets shall have a hinged door with padlock provisions.

6.13.3.3

For transformers installed in hazardous (classified) locations, control cabinet enclosures, internal devices, and wired accessories shall be NRTL or ACO approved for a Class I Division 2 or Zone 2 area.

6.13.3.4

Control cabinets or accessories shall not be mounted on radiators or on the high or low-voltage ATCs.

6.13.3.5

Control cabinets shall be provided with a drain.

6.13.3.6

Control cabinet enclosures shall have separate numbered terminal blocks segregated by power, control, and alarm wiring.

6.13.3.7

Hinged doors on metallic control cabinets equipped with powered devices shall be bonded across the hinge with a flexible copper conductor connected between the hinged door and the metallic enclosure.

6.13.3.8

Control cabinet components and cable entrance hubs shall be bonded to the ground bar by an insulated, copper grounding conductor.

6.13.3.9

Control cabinet enclosures shall be provided with a plated copper grounding bar.

6.13.3.10

The bottom of control cabinets shall be no less than 600 mm (2 ft) above the bottom of the transformer base.

6.13.3.11

When the control cabinet is mounted on the transformer, the top of the cabinet shall not exceed a height of 1700 mm (66 in) above the transformer base.

6.13.3.12

A copy of the wiring diagram or schematic shall be attached inside the enclosure in a weather protective cover located inside the control cabinet.

6.13.3.13

Control relay output contacts and auxiliary (interposing) control-circuit device contacts shall have a contact ampacity performance rating for the intended switching application in accordance with NEMA ICS 5.

6.13.3.14

Components in the control cabinet enclosure shall be identified as detailed in the schematic and wiring diagrams.

6.13.3.15

Components within the control cabinet (e.g., terminals, relays, switches, fuse blocks) shall be identified with individual permanent device labels.

Add new subclause

6.14 Cooling equipment

6.14.1 Radiators

6.14.1.1

If pancake-type radiators are provided, the seams shall be continuously welded.

6.14.1.2

If removable radiators are specified, the radiators shall be provided with 316 stainless-steel flanged shut-off valves and flanges.

6.14.1.3

If removable radiators are specified, the radiators shall be provided with a means to drain the insulating fluid from each radiator.

6.14.1.4

If removable radiators are specified, the radiators shall be provided with lifting eyes to facilitate the handling and removal of the radiator.

6.14.1.5

Equipment, devices, instruments, accessories, junction boxes and hardware shall not be installed on the radiators.

NOTE—Only cooling fans can be installed on radiators.

6.14.2 Cooling fans

6.14.2.1

If forced air-cooling fans on transformers rated below 5000 kVA are provided, the fan operation shall be controlled by the temperature of the insulating liquid.

6.14.2.2

If forced air-cooling fans on transformers rated 5000 kVA and above are provided, the fan operation shall be controlled by the temperature of the transformer windings.

6.14.2.3

If forced air-cooling fans are provided, they shall be installed on structural supports.

NOTE—Clamping of fans to radiator coils or fins is not an acceptable support.

6.14.2.4

If forced air-cooling fans are provided, their operation shall be controlled with a three-position selector switch that allows for the selection of "automatic", "off" and "manual".

6.14.2.5

If forced air-cooling fans are provided, they shall be provided with personnel protection guards.

6.14.2.6

If forced air-cooling fans are provided, the control system for the fans shall be provided with two normally open (NO) auxiliary contacts from the contactor wired to terminal blocks for remote indication of fan operation.

6.14.2.7

If forced air-cooling fans are provided, the fan motor enclosures shall be totally enclosed fan cooled (TEFC).

6.14.2.8

If forced air-cooling fans are provided, the intended direction of rotation of the cooling fan shall be indicated on the fan enclosure.

6.14.2.9

If forced air-cooling fans are provided for an offshore transformer application, fan blades shall be non-sparking and of corrosion-resistant material.

6.14.2.10

If forced air-cooling fans are provided for an offshore transformer application, the fan guard material shall be of corrosion-resistant material.

6.14.3 Cooling fan provisions

Add new subclause

6.14.3.1

If provisions for future forced air-cooling fans are specified on transformers rated below 5000 kVA, the fan operation shall be controlled by the temperature of the insulating liquid.

Add new subclause

6.14.3.2

If provisions for future forced air-cooling fans are specified for transformers rated 5000 kVA and above, the fan operation shall be controlled by the temperature of the transformer windings.

Add new subclause

6.14.3.3

If provisions for future forced air-cooling fans are specified, the fans shall be provided with the structural supports for installation.

NOTE—Clamping of fans to radiator coils or fins is not an acceptable support.

Add new subclause

6.14.3.4

If provisions for future forced air-cooling fans are specified, the control cabinet shall be provided with the relays, motor starters, hand-off-auto (HOA) controls and interconnect wiring for fan operation.

Add new subclause

6.14.3.5

If provisions for future forced air-cooling fans are specified, the control cabinet shall be provided with terminal blocks to facilitate field wiring and power supply interconnection.

Add new subclause

6.14.3.6

If provisions for future forced air-cooling fans are specified, the transformer shall be provided with the increased capacity associated with the higher kVA fan cooled rating (i.e., current carrying parts, bushings, CTs, tap changing components, and interconnections to the core and coil).

Add new subclause

6.15 On-load tap changer (OLTC)

6.15.1 General

6.15.1.1

If an on-load tap changer (OLTC) is specified, the OLTC shall be in accordance with Clause 6 and IEEE Std C57.12.10-2017, 4.5.2.

6.15.1.2

If an OLTC is specified, the OLTC shall be a polyphase unit with a single drive mechanism.

6.15.1.3

If an OLTC is specified, the OLTC shall have an insulation level and short-circuit rating no less than that of the winding connected to the tap changer.

6.15.1.4

If a non-vacuum-type OLTC is specified, the OLTC oil vessel shall be connected to a separate conservator or segregated section of the main conservator of the transformer.

6.15.1.5

If a non-vacuum-type OLTC is specified, the OLTC oil vessel shall be provided with a dehydrating breather.

6.15.1.6

If a non-vacuum-type OLTC is specified, the OLTC oil vessel shall be provided with a protective device monitoring sudden-flow conditions.

6.15.1.7

If an OLTC is specified, the OLTC shall deliver rated kVA output on all tap positions.

6.15.1.8

If a vacuum OLTC is specified, the OLTC shall be rated for at least 500 000 operations.

6.15.1.9

If a non-vacuum-type OLTC is specified, the OLTC shall be rated for at least 100 000 operations.

6.15.1.10

If a non-vacuum-type OLTC is specified, the OLTC and the main transformer tank shall have the same insulating liquid type.

6.15.1.11

If an OLTC is specified, the enclosures, auxiliary devices and wiring shall be in accordance with 6.13.

6.15.1.12

If an OLTC is specified, the local control panel shall be provided with common fault indication with two sets of voltage-free Form C contacts.

6.15.2 Motor and drive mechanism

6.15.2.1

If the OLTC is specified, the motor-drive mechanism shall be provided with a padlockable incoming power supply switch or circuit breaker.

6.15.2.2

If an OLTC is specified, the OLTC equipment, even when stalled in a non-operating position, shall permit the transformer to deliver its full-rated output.

6.15.3 Remote control

6.15.3.1

If an OLTC with parallel operation functionality is specified, the OLTC shall be provided with parallel operation functionality in accordance with IEEE Std C57.153.

6.15.3.2

If an OLTC with a remote-control panel is specified, the control cabinet shall be NEMA 1 gasketed.

Add new subclause

6.16 Lifting and handling facilities

6.16.1

Lifting, moving and jacking facilities shall be provided in accordance with IEEE Std C57.12.10-2017, 5.3.

6.16.2

The bottom of the transformer tank shall be installed on steel structural members.

6.16.3

Provisions for lifting the complete transformer shall include lifting eyes at the top corners of the transformer tank.

6.16.4

The lifting eye pinhole for the lifting eyes shall be a diameter of at least 31.75 mm (1 1/4 in) in order to accept a nominal 25 mm (1 in) shackle with a pin diameter of 27 mm (1 1/16 in), even if the transformer weight allows a smaller shackle.

6.16.5

The transformer base shall have a means to be secured onto a concrete base or steel structure.

6.16.6

If the transformer is specified for offshore or marine applications, the transformer shall be designed in accordance with API 2A-WSD and API 2A-LRFD.

NOTE—Additional motion criteria (e.g., static/dynamic tilt, period, lateral/vertical acceleration) can be provided in the supplemental tab of the PDS or the project documents.

Add new subclause

6.17 Coatings

6.17.1

If the transformer is specified for onshore applications with unusual environment conditions, the transformer shall be provided with a C5 coating (paint) system in accordance with ISO 12944-5.

6.17.2

If the transformer is specified for offshore or marine applications, the transformer shall be provided with a CX coating (paint) system in accordance with ISO 12944-9.

6.17.3

If the transformer base metal is in contact with the foundation surface, the transformer base metal shall be coated with an asphalt-based paint or mastic.

Add new subclause

6.18 General

If transformer external hardware made of 316 stainless steel is removeable (e.g., radiators), the bolting material shall prevent galling (e.g., 316 stainless steel bolts with silicon-bronze nuts).

8. Testing and calculations

8.2 Routine, design, and other tests for transformers

8.2.1 Routine tests

Add new subclause

8.2.1.1

If mineral oil is specified for the insulating liquid, an insulating oil analysis shall be performed in accordance with the tests and methods listed in IEEE Std C57.106-2015, Table 2.

Add new subclause

8.2.1.2

If natural ester oil is specified for the insulating liquid, an insulating oil analysis shall be performed in accordance with the tests and methods listed in IEEE Std C57.147-2018, Table 3.

Add new subclause

8.2.1.3

The resistance measurement tests of the transformer windings shall be performed in accordance with IEEE Std C57.12.00.

Add new subclause

8.2.1.4

If the transformer does not successfully pass the factory tests or the specified additional tests, the complete test program shall be repeated after the corrective actions have been implemented prior to shipment.

Add new subclause

8.2.1.5

The winding insulation resistance test of the transformer windings shall be performed in accordance with IEEE Std C57.12.00.

Add new subclause

8.2.1.6

The measured power factor from the insulation power factor and capacitance test defined in IEEE Std C57.12.90 shall not exceed the values listed in ANSI/NETA ATS-2021, Table 100.3.

8.5 Determination of thermal duplicate temperature-rise data

Add to subclause

If a temperature test is specified and a thermal duplicate test is provided, it shall demonstrate the following thermal characteristics as a minimum:

a) Equal or less than the radiating area

b) Equal or greater load loss

c) Equal or greater no-load loss

9. Tolerances

9.3 Tolerances for losses

Add to subclause

Transformers rated 2500 kVA and below shall meet the efficiencies defined by 10 CFR Part 431 for applications in the United States or CAN/CSA-C802.1 for applications in Canada.

10. Connection of transformers for shipment

Add new subclause

10.1 Shipping and packaging

10.1.1

Transformers rated below 40 MVA shall be shipped filled with insulating liquid, except for conservator-type transformers.

10.1.2

Transformers rated below 40 MVA shall be shipped with the radiators attached to the transformer tank, except conservator-type.

10.1.3

Sealed tank transformers rated below 50 MVA shall be shipped under positive nitrogen pressure in the main transformer tank.

10.1.4

Exposed bushings (i.e., cover or side mounted) shall be protected from damage during shipping.

10.1.5

If the transformer is shipped without insulating liquid, the transformer shall be under a dry gas positive pressure (e.g., nitrogen, air) with a dew point of −40°C or lower.

10.1.6

Transformers shall be provided with a tag attached to a pressure-vacuum gauge indicating the pressure of the nitrogen blanket and the temperature of insulating liquid at the time of shipment.

10.1.7

Transformers rated 10 MVA and above shall be shipped in accordance with IEEE Std C57.150.

10.1.8

Transformers and transformer accessories shall be marked with identification compatible with the assembly drawings to facilitate assembly and erection at the site.

10.1.9

Transformer components that are shipped separately from the transformer (e.g., radiators, bushings, accessories, ATCs) shall be shipped in weather-tight packaging, acceptable for outdoor storage.

10.1.10

Insulating oil shipped separately shall be delivered to the job site in Department of Transportation (DOT) approved containers or tanker trucks that are used only for this service.

10.1.11

If specified, transformer components, inclusive of components that are shipped separately from the transformer (e.g., radiators, bushings, accessories, ATCs) shall be shipped with desiccant bags inside the component enclosures.

Add new clause

11. Distribution substation-type transformers

11.1 General

11.1.1

Distribution substation-type transformers rated 10 MVA and below shall be provided in accordance with IEEE Std C57.12.36.

11.1.2

Distribution substation-type transformers rated 10 MVA and below shall be provided in accordance with Table 20.

Add new Table 20

Table 20 —Additional requirements applicable to distribution substation-type transformers

Topic	IOGP S-754 references
General	1.4.2
Other unusual service conditions - hazardous areas	4.3.3 r)
Offshore and marine applications	4.3.4
Proven operational service	4.4.3
Nameplates (general)	5.12.1 excluding third sentence of third paragraph
Nameplate information	5.12.2 third, fourth and sixth sentences of second paragraph
Certifications	5.13
Bushing connection pad hole patterns	6.1.5
Bushing neutral to ground connection	6.1.6
Phase bushing rating	6.1.12
Bushing material for offshore	6.1.15
Creepage	6.1.16
Vacuum / pressure gauge alarm contacts	6.2.1.1
Pressure-relief device automatic-resetting type	6.2.1.3
Liquid temperature indicator alarm contacts	6.2.1.4
Tap-changer label	6.2.1.7
Alarm and control devices	6.2.3.1 through 6.2.3.5 and 6.2.3.7 through 6.2.3.8
NGRs	6.2.5
Continuous cable termination thermal monitoring	6.2.6.3
DGA monitoring	6.2.6.4
Moisture monitoring	6.2.6.5
CTs	6.3.1
Nitrogen inert-gas pressure system	6.6.3
Mineral oil	6.6.4
Sealed tank	6.6.5
Stainless steel grounding pads	6.7.4
Phase-to-phase clearances	6.8.1
Windings and core	6.9
ATC for cable connections	6.10.1
Throat connection for bus bar	6.10.2
Space heaters	6.11
Surge arresters	6.12.1 through 6.12.5

Table 20 *(continued)*

Topic	IOGP S-754 references
Auxiliary enclosures, devices and wiring - Wiring	6.13.1.1 through 6.13.1.3, 6.13.1.6, 6.13.1.7, and 6.13.1.11 through 6.13.1.14
Auxiliary enclosures, devices and wiring - Auxiliary wiring terminals	6.13.2
Auxiliary enclosures, devices and wiring - Control cabinet or instrument enclosures	6.13.3
Radiators	6.14.1
Cooling fans	6.14.2.1 through 6.14.2.6 and 6.14.2.8 through 6.14.2.1.10
Cooling fan provisions	6.14.3
Lifting and handling facilities	6.16.1 and 6.16.4 through 6.16.6
Coatings	6.17
Routine tests	8.2.1.1 through 8.2.1.5
Efficiencies	9.3.1
Connection of transformers for shipment	10.1.1 through 10.1.6

Add new clause

12. Pad-mounted transformers

12.1 General

12.1.1

Pad-mounted transformers rated 10 MVA and below shall be provided in accordance with IEEE Std C57.12.34.

12.1.2

For pad-mounted transformers rated 10 MVA and below, the recommendations given in IEEE Std C57.12.34-2022, Annex A shall be considered normative requirements.

12.1.3

Pad-mounted transformers rated 10 MVA and below shall be provided in accordance with Table 21.

Add new Table 21

Table 21 —Additional requirements applicable to pad-mounted type transformers

Topic	IOGP S-754 references
General	1.4.3
Other unusual service conditions - hazardous areas	4.3.3 r)
Proven operational service	4.4.3
Nameplates (general)	5.12.1 excluding third sentence of third paragraph
Nameplate information	5.12.2 first, second and third sentences of second paragraph
NRTL logo, area classification	5.12.2 fourth sentence of second paragraph
Certifications	5.13.1 through 5.13.2
Neutral connection to external neutral or ground	6.1.6
Liquid temperature indicator alarm contacts	6.2.1.4
Tap-changer label	6.2.1.7
Alarm and control device NRTL certification	6.2.3.7
DGA monitoring	6.2.6.4
Moisture monitoring	6.2.6.5
Mineral oil	6.6.4
Sealed tank	6.6.5.1
ATC danger label	6.10.1.13
Surge arresters	6.12.1 through 6.12.4
Routine tests	8.2.1.1 through 8.2.1.2
Efficiencies	9.3.1
Connection of transformers for shipment	10.1.6

12.1.4

Pad-mounted transformers shall be provided with a short-circuit withstand capability greater than or equal to that of the available fault current (symmetrical) of the power system specified in the PDS.

12.1.5

Parking stands shall be provided for dead-front bushings on pad-mounted transformers.

12.1.6

Bushings rated 2.5 kV and above on a pad-mounted transformer shall be provided in accordance with IEEE Std 386.

12.1.7

For pad-mounted transformers, a visual-dial-type liquid level indicator shall be provided in accordance with IEEE Std C57.12.34-2022, A.5.2.

12.1.8

Indicating devices provided for determining the status of the pad-mounted transformer shall be viewable without exposing personnel to energized components.

12.1.9

For pad-mounted transformers, a visual-dial-type liquid temperature indicator shall be provided in accordance with IEEE Std C57.12.34, A.6.2.

12.1.10

Bushings rated below 2.5 kV shall have tin-plated copper connection pads with a NEMA standard hole pattern.

12.1.11

If surge or lightning arresters are specified for pad-mounted transformers with dead-front bushings, dead-front type arresters shall be provided.

12.1.12

Tests for pad-mounted transformers shall be performed in accordance with the "Distribution transformers" column in Table 17, except as described in IEEE Std C57.12.34-2022, 7.2 and 7.3.

Annex D

(informative)

Bibliography

Add to start of Bibliography

The following documents are informatively cited in the text of this specification, IEEE Std. C57.12.00, the PDS (IOGP S-754D) or the IRS (IOGP S-754L).

Add to Bibliography

[B51] ANSI/IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

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[B53] API Specification Q2, *Specification for Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries*

[B54] ASTM D1535, *Standard Practice for Specifying Color by the Munsell System*

[B55] IEEE Std C37.110, *IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes*

[B56] ISO 9001, *Quality management systems — Requirements*

[B57] ISO 10005, *Quality management — Guidelines for quality plans*

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[B59] Seismic Loads, *Guide to the Seismic Load Provisions of ASCE 7-16*

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