International Association of Oil & Gas Producers

SPECIFICATION
IOGP S-754J

August 2025
Version 1.0

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

NOTE This version (S-754J) of the specification document provides the justification statements for each technical requirement, but is otherwise identical in content to S-754.

JIP33
JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
1.0	August 2025	First Edition

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 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 IEEE 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) Liquid-filled sealed-tank

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) Submersible transformers

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The scope of IEEE Std C57.12.00 only includes the general performance and ratings structure for liquid-immersed power and distribution transformers. Large transformers above 150 MVA are very custom and application dependent where smaller transformers below 300 kVA are catalog-type procurement items. IEEE Std C57.12.00 is referenced by the other IEEE Std C57.12 series of standards that individually cover the various transformer types listed in this specification.

Add new subclause

1.4 General

1.4.1

Class I and Class II power transformers shall meet the requirements in Clause 1 through Clause 10 and IEEE Std C57.12.10.

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for Class I and Class II power transformers. IEEE Std C57.12.10 includes these specific requirements.

1.4.2

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for distribution substation-type transformers up to 10 MVA. These transformers are addressed in Clause 11 and IEEE Std C57.12.36.

1.4.3

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for pad-mounted transformers up to 10 MVA. These transformers are addressed in Clause 12 and IEEE Std C57.12.34.

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 Rules for Building and Classing Mobile Offshore Units (MOU Rules) – Part 4 Machinery and Systems, *Rules for Building and Classing Mobile Offshore Units (MOU Rules) – Part 4 Machinery and Systems*

ABS Rules for Building and Classing Mobile Offshore Units (MOU Rules) – Part 6 Equipment and Machinery Certification, *Rules for Building and Classing Mobile Offshore Units (MOU Rules) – Part 6 Equipment and Machinery Certification*

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

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*

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

CAN/CSA C2.1:06, *Single-phase and three-phase liquid-filled distribution transformers*

CAN/CSA C88, *Power transformers and reactors*

CAN/CSA C227.4, *Three-phase, pad-mounted distribution transformers with separable insulated high-voltage connectors*

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 693, *IEEE Recommended Practice for Seismic Design of Substations*

IEEE Std 693a, *IEEE Recommended Practice for Seismic Design of Substations Amendment 1: Alterations of Transformers and Select Appendages, Surge Arresters, Response Spectra, Time Histories, and Their Qualification Methodologies*

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 C57.19.01-2017, *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 C57.106-2015, *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 C57.149, *IEEE Guide for the Application and Interpretation of Frequency Response Analysis for Oil-Immersed 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*

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

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*

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

3.1 Definitions

For the purposes of this document, 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

FRA frequency response analysis

HOA hand-off-auto

IRS information requirements specification

NC normally closed

NGR neutral grounding resistor

NO normally open

NRTL nationally recognized testing laboratory

OCS * outer continental shelf

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 and marine applications, control cabinet enclosures shall be made of 316 stainless steel with a minimum protection grade of NEMA 4X.

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This enclosure requirement minimizes the damage and deterioration of the electrical controls and associated wiring from advanced corrosion due to exposure to offshore and marine environments.

4.3.4.2

For offshore and marine applications, transformer external hardware shall be made of 316 stainless steel.

Justification

IEEE Std C57.12.00 does not have requirements for transformer external hardware. This requirement is designed to mitigate the impact of advanced corrosion on the transformer and the mounting hardware for the accessories and associated wiring, which is a common issue in offshore and marine environments.

4.3.4.3

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. The use of a rigid conduit minimizes mechanical damage and environmental exposure (e.g., offshore and marine salt spray corrosion) for the electrical wiring system due to shipping, installation and maintenance activities.

4.3.4.4

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. The use of a rigid conduit minimizes mechanical damage and environmental exposure (e.g., offshore and marine salt spray corrosion) for the electrical wiring system due to shipping, installation and maintenance activities. In some applications, a degree of flexibility is needed to allow for connection /disconnection of certain transformer accessories.

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.

Justification

In most applications, a transformer that is located in a hazardous (classified) area (Division 2 or Zone 2) does not constitute a source of ignition in a potentially flammable atmosphere. However, transformer accessories, control devices and associated controls can produce sparks and arcs during normal operation and are rated for the area classification specified to minimize the risk of explosion and fire.

Add new subclause

4.4 Design life

4.4.1

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 the specified site conditions.

Justification

This requirement ensures that the electronic components operate for two turnaround cycles that are typically seven years each.

4.4.2

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

Justification

This requirement ensures that materials are proven and have successful operational history or have been identified to the user prior to contract award. This is a standard requirement within operating company specifications, but it is not included in IEEE Std C57.12.00.

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.

Justification

The nameplate for transformer identification contains technical data for electrical protection, ensuring a safe electrical installation. The use of stainless steel material for the nameplate ensures corrosion resistance and ability to withstand the environmental conditions over the life of the transformer.

Add new subclause

5.12.1.1

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

Justification

The nameplate for transformer identification contains technical data for electrical protection, ensuring a safe electrical installation. A durable method of inscription (e.g., etching, engraving, stamping) ensures that the nameplate remains legible for the lifetime of the transformer.

Add new subclause

5.12.1.2

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

Justification

The nameplate for transformer identification contains technical data for electrical protection, ensuring a safe electrical installation. Stainless steel mounting hardware is corrosion resistant and ensures that the nameplate remains attached.

Add new subclause

5.12.1.3

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

NOTE—Eye level is typically considered to be between 1.5 m to 2 m (5 ft to 6 $^{1}/_{2}$ ft) above the base of the transformer.

Justification

The nameplate for transformer identification contains technical data for electrical protection, ensuring a safe electrical installation. This requirement improves readability by ensuring that the nameplate is installed at an average operator's eye level.

Add new subclause

5.12.1.4

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

Justification

The nameplate for transformer identification contains technical data for electrical protection, ensuring a safe electrical installation.

5.12.2 Nameplate information

Add new subclause

5.12.2.1

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

Justification

This nameplate is required for the end user to be able to identify the assembly for installation. It is also needed for maintenance support when contacting the manufacturer for assistance.

Add new subclause

5.12.2.2

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.

Justification

This nameplate is required for the end user to be able to identify the assembly for installation. It is also needed for maintenance support when contacting the manufacturer for assistance.

Add new subclause

5.12.2.3

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

Justification

This nameplate is required for the end user to be able to identify the assembly for installation. It is also needed for maintenance support when contacting the manufacturer for assistance.

Add new subclause

5.12.2.4

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

Justification

This nameplate is required for the end user to be able to identify the assembly for installation. It is also needed for maintenance support when contacting the manufacturer for assistance.

Add new subclause

5.12.2.5

If the transformer is specified for installation at an altitude above 1000 m (3300 ft), the temperature rise design and guaranteed losses shall be shown on the transformer nameplate.

Justification

This nameplate is required for the end user to be able to identify the assembly for installation. It is also needed for maintenance support when contacting the manufacturer for assistance.

Add new subclause

5.12.2.6

If the area classification is specified, the transformer nameplate shall display the area classification information (i.e., Class, Division/Zone, Group and auto-ignition temperature (AIT)).

Justification

This nameplate is required for the end user to be able to identify the assembly for installation. The nameplate is also needed for maintenance support when contacting the manufacturer for assistance.

Add new subclause

5.13 Certifications

5.13.1

If seismic requirements are specified, the transformer shall meet the requirements of IEEE Std 693-2018 and IEEE Std 693a-2024.

Justification

Transformers that are installed in seismically active applications have additional requirements, evaluations and certifications to ensure service continuity.

5.13.2

If NRTL certification is 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.

Justification

The NRTL certification is normally not required. Examples of when a NRTL listing is required include local code authority requirements and insurance requirements. This requirement ensures that when NRTL certification is required that the certification is done in accordance with UL XPLH GuideInfo.

5.13.3

If transformers fabricated to CSA standards are specified, the transformer nameplate shall state that the transformer is compliant with the selected CSA standard.

Justification

For transformers fabricated in accordance with the CSA standards, there are no specific certifications available. Indication on the nameplate is acceptable.

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 Rules for Building and Classing Mobile Offshore Units (MOU Rules) Part 4 and Part 6.

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.

Justification

IEEE Std C57.12.00 does not address the requirements for transformers installed on floating facilities offshore or marine vessels. 46 CFR 111.20 and ABS Rules for Building and Classing Mobile Offshore Units (MOU Rules) Part 4 and Part 6 provide requirements for transformers used in floating marine applications in the outer continental shelf (OCS).

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 Rules for Building and Classing Mobile Offshore Units (MOU Rules) Part 4 and Part 6 are typically used unless site or application-specific information is provided.

Justification

IEEE Std C57.12.00 does not address the requirements for transformers installed on floating facilities offshore or marine vessels. This requirement ensures that additional considerations for these environments are accounted for by the supplier.

6. Construction

6.1 Bushings

Add new subclause

6.1.1

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

Justification

Transformer bushing mounting flanges facilitate replacement and maintenance activities without welding or drilling into the transformer cover or tank.

Add new subclause

6.1.2

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

Justification

The positive means for installation of transformer bushing mounting flanges prevent deformation when the bushing is installed.

Add new subclause

6.1.3

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

Justification

Transformer bushing mounting flange gaskets are a source of leakage or loss of containment if incompatible gasket material is used when exposed to the insulating oil of the transformer.

Add new subclause

6.1.4

For sealed transformers, the bushing gaskets shall withstand an internal tank pressure of at least 69 kPag (10 psig).

Justification

This requirement ensures that transformer bushing gaskets are properly sealed and do not allow for the loss of integrity of the sealed-tank transformer design.

Add new subclause

6.1.5

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

Justification

This requirement ensures the use of standard lugs for the connection of field cables to transformer bushings.

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.

Justification

IEEE Std C57.12.00 allows for the Y connected transformer winding to be connected internally with no external access to the neutral point.

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.

Justification

Bushings used in high-voltage applications have specific dielectric requirements, mechanical properties and characteristics that are not specifically addressed in IEEE Std C57.12.00. Oil-filled and capacitor-type bushings have proven to be more resilient and reliable in high-voltage applications.

Add new subclause

6.1.8

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

Justification

Bushings used in high-voltage applications have specific dielectric requirements, mechanical properties and characteristics that are not specifically addressed in in IEEE Std C57.12.00. Bushing liquid level indicators are used to ensure that sufficient dielectric liquid is present, if not, imminent failure of the bushing is assured.

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.

Justification

Bushings used in high-voltage applications have specific dielectric requirements, mechanical properties and characteristics that are not specifically addressed in in IEEE Std C57.12.00. The power factor test taps allow for the interconnection of test equipment used to evaluate the performance of the high-voltage bushing.

Add new subclause

6.1.10

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

Justification

This requirement ensures external access to the internal tertiary windings of the transformers to facilitate maintenance and troubleshooting activities.

Add new subclause

6.1.11

The primary and secondary bushing basic lightning impulse insulation level (BIL) shall be greater than or equal to the winding BIL.

Justification

This requirement ensures the BIL rating of the bushing is at least equal to the winding BIL. The requirements in IEEE Std C57.12.00 only require an overall BIL rating.

Add new subclause

6.1.12

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

Justification

This requirement ensures that all transformer ratings are available for use by the distribution system. The maximum transformer capacity includes the forced cooling rating, as applicable.

Add new subclause

6.1.13

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

Justification

Bushings exposed to an outdoor environment endure high levels of UV radiation, external contaminates and wet conditions. Porcelain historically has been the material of choice as it has performed well in harsh environments in overhead line service. Specific physical properties and characteristics are not addressed in IEEE Std C57.12.00.

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.

Justification

Bushings installed in ATCs in offshore and marine applications have proved to be problematic in previous installations. Porcelain-type bushings have developed cracks and subsequent dielectric failures from vibration, temperature and humidity. Specific physical properties and characteristics are not addressed in IEEE Std C57.12.00.

Add new subclause

6.1.15

If heavy contamination is 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.

Justification

Transformers with cover-mounted bushings installed in environments that can result in heavy contaminates being deposited on the bushing exterior surface can consider utilizing bushings with extra creepage distances (rated for heavy contamination) which provides sufficient protection against unexpected bushing flashover events.

6.2 Transformer accessories

Add new subclause

6.2.1 General

6.2.1.1

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

Justification

IEEE Std C57.12.10 requires this gauge to be supplied with visual indication only. The alarm contact allows for remote monitoring of a sealed-tank transformer for safety and reliability of operation.

6.2.1.2

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

Justification

IEEE Std C57.12.10 requires this gauge to be supplied with visual indication only. The isolation valve facilitates gauge replacement without the need for depressurizing the tank and exposing the insulating oil to exterior conditions.

6.2.1.3

The transformer pressure-relief device shall be of the automatically-resealing type with latching alarm contacts.

Justification

IEEE Std C57.12.10 requires this device to be supplied but not of the automatic-resealing type. The automatic-resetting feature minimizes the exposure of the insulating oil in the tank to outside contaminants after the high-pressure event has been relieved.

6.2.1.4

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

Justification

IEEE Std C57.12.10 requires this indicator to be supplied with visual indication only. The alarm contacts are used for control of auxiliary devices and provide remote monitoring capability of a transformer for safety and reliability of operation.

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.

Justification

IEEE Std C57.12.10 requires a pressure-vacuum bleeder device for sealed-tank transformers but does require the gas sampling valve. This valve facilitates the monitoring of a sealed-tank transformer for safety and reliability of operation.

6.2.1.6

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

Justification

IEEE Std C57.12.10 identifies this accessory option but does have any specific requirements that pertain to the design of the inert-gas system.

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".

Justification

IEEE Std C57.12.10 identifies this accessory option but does not require a caution label. This requirement guards against inadvertent damage to the transformer if the DETC is operated when the 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.

Justification

IEEE Std C57.12.10 requires this device to be supplied but does not address the location of the discharge from this relief device. This requirement ensures that the discharge from the pressure relief device is not vented into the atmosphere. The routing of the discharge line to the base of the transformer allows for capture and appropriate disposal of any discharge fluids resulting from the operation of the pressure relief device.

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, Buchholz relay, flow relay for OLTC, sudden pressure relay (SPR) and pressure-relief devices are excluded from this requirement.

Justification

IEEE Std C57.12.10 specifies height mounting locations for only a few of the indicating and controlling accessories. This requirement complies with the human factors guidance to allow for operations surveillance, maintenance, troubleshooting and repairs.

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.

Justification

IEEE Std C57.12.10 specifies height mounting locations for only a few of the indicating and controlling accessories. This requirement complies with the human factors guidance to allow for operations surveillance, maintenance, troubleshooting and repairs.

6.2.2.3

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

Justification

IEEE Std C57.12.10 specifies height mounting locations for only a few of the indicating and controlling accessories. This requirement complies with the human factors guidance to allow for operations surveillance, maintenance, troubleshooting and repairs.

Add new subclause

6.2.3 Alarm and control devices

6.2.3.1

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

Justification

IEEE Std C57.12.10 requires indicators to be supplied with visual indication only. The Form C contact allows for remote monitoring of sealed-tank transformers for safety and reliability of operation.

6.2.3.2

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

Justification

IEEE Std C57.12.10 does not address the identification and tagging of auxiliary devices installed on the transformer. This requirement ensures that these devices are properly identified to facilitate troubleshooting and maintenance.

6.2.3.3

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

Justification

IEEE Std C57.12.10 does not address the identification and tagging of auxiliary devices installed on the transformer. This requirement ensures that these devices are properly identified to facilitate troubleshooting and maintenance.

6.2.3.4

Tags for alarm and control devices that are exposed to the environment (e.g., outdoors) shall be made of stainless steel.

Justification

IEEE Std C57.12.10 does not address the identification and tagging of auxiliary devices installed on the transformer. This requirement ensures these devices are properly identified to facilitate troubleshooting and maintenance. Stainless steel material is corrosion and UV-resistant, ensuring longevity of the tags.

6.2.3.5

Tags for alarm and control devices that are exposed to the environment (e.g., outdoors) shall be mounted with corrosion-resistant screws or rivets.

Justification

IEEE Std C57.12.10 does not address the identification and tagging of auxiliary devices installed on the transformer. This requirement ensures these devices are properly identified to facilitate troubleshooting and maintenance. Corrosion-resistant material ensures longevity of the tag fasteners.

6.2.3.6

If a NEMA 7 or explosion-proof enclosure is used, tags for alarm and control devices shall be mounted using a method that does not adversely affect the integrity of the enclosure.

Justification

IEEE Std C57.12.10 does not address the identification and tagging of auxiliary devices installed on the transformer. This requirement ensures that these devices are properly identified to facilitate troubleshooting and maintenance. The use of screws or rivets on a NEMA 7 enclosure as an attachment means can compromise the protection method associated with this type of enclosure.

6.2.3.7

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

Justification

Neither IEEE Std C57.12.00 nor IEEE Std C57.12.10 addresses the installation of a transformer in a hazardous (classified) area. Multiple installation methods to achieve NRTL listing are available (e.g., hermetically sealed contacts and intrinsically safe barriers).

6.2.3.8

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

Justification

IEEE Std C57.12.10 does not have an optional provision for a cooling fan monitoring system. This type of system prevents transformer overtemperature and overloading conditions by providing status of the cooling fans and alarms in the event of fan failures (e.g., control power failure, motor failure).

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.

Justification

IEEE Std C57.12.10 includes some requirements for SPRs. This additional requirement facilitates troubleshooting, maintenance and repair.

6.2.4.2

If an SPR is specified, the SPR shall be provided with a gate or ball type isolation valve.

Justification

IEEE Std C57.12.10 includes some requirements for SPRs. This additional requirement facilitates troubleshooting, maintenance and repair. The SPR is provided with a globe-type isolation valve to ensure tight shutoff.

6.2.4.3

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

Justification

IEEE Std C57.12.10 includes some requirements for SPRs. This additional requirement facilitates troubleshooting, maintenance and repair by allowing online testing of the SPR.

6.2.4.4

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

Justification

IEEE Std C57.12.10 includes some requirements for SPRs. This additional requirement facilitates troubleshooting, maintenance and repair. The SPR is provided with a bleeder valve testing facility to allow functional testing.

Add new subclause

6.2.5 Neutral grounding resistor (NGR)

6.2.5.1

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

Justification

IEEE Std C57.12.00 does not include requirements for an NGR, but requirements can be found in IEEE Std C57.32 and IEEE Std C57.32a. This requirement ensures that the appropriate NGR for the application is provided.

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.

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. This requirement ensures that the appropriate NGR for the application is provided. Stainless steel strap elements are used to provide durability and corrosion resistance.

6.2.5.3

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

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. The stainless steel frame offers corrosion resistance, durability and sufficient support for the NGR.

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.

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. This requirement ensures that the appropriate NGR for the application is provided. This requirement for the grounding conductor ensures sufficient dielectric and withstand strength for the grounding system during fault conditions.

6.2.5.5

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

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. This requirement ensures that the appropriate NGR and enclosure for the application are provided. A corrosion-resistant enclosure ensures longevity of the NGR.

6.2.5.6

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

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. This requirement ensures that the appropriate NGR and enclosure for the application is provided with bolted and removable sides for ease of maintenance and replacement of resistor elements. The enclosure requirement ensures safety by protecting personnel from live parts.

6.2.5.7

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

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. This requirement ensures that the appropriate NGR and enclosure for the application are provided with lifting and handling provisions. This requirement ensures safe handling during maintenance and replacement activities.

6.2.5.8

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

Justification

IEEE Std C57.12.00 does not include requirements for an NGR. This requirement ensures that the appropriate NGR and enclosure for the application are provided. A stainless steel enclosure ensures longevity of the NGR.

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.

Justification

Condition-based temperature monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. Overheating can cause transformer failures. Continuous measurement of the top oil temperature is an important factor in maximizing the service life. Top oil temperature, ambient temperature, load (current), fan/pump operations and direct reading winding temperatures (if available) can be combined in algorithms to predict hottest-spot temperature and top oil temperatures for defined conditions of ambient and load and to manage the overall temperature conditions of the transformer.

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.

Justification

Condition-based temperature monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. Overheating can cause transformer failures. Continuous measurement of the top oil temperature is an important factor in maximizing the service life. Top oil temperature, ambient temperature, load (current), fan/pump operations and direct reading winding temperatures (if available) can be combined in algorithms to predict hottest-spot temperature and top oil temperatures for defined conditions of ambient and load and to manage the overall temperature conditions of the transformer.

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.

Justification

Condition-based temperature monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. Overheating can cause transformer failures. Continuous measurement of the top oil temperature is an important factor in maximizing the service life. Top oil temperature, ambient temperature, load (current), fan/pump operations and direct reading winding temperatures (if available) can be combined in algorithms to predict hottest-spot temperature and top oil temperatures for defined conditions of ambient and load and to manage the overall temperature conditions of the transformer.

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 in accordance with IEEE Std C57.143-2012, 5.6.

Justification

Condition-based temperature monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. There is a direct correlation between winding temperature and normally expected service life of a transformer. The hottest spot temperature of the winding is one of a number of limiting factors for the load capability of transformers. Insulation materials lose their mechanical strength with prolonged exposure to excessive heat. This can result in tearing and displacement of the paper and dielectric breakdown that will result in premature failures. These potential hot spot locations are typically identified with thermal modeling software during the transformer design effort.

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.

Justification

Condition-based temperature monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. There is a direct correlation between winding temperature and normally expected service life of a transformer. The hottest spot temperature of the winding is one of a number of limiting factors for the load capability of transformers. Insulation materials lose their mechanical strength with prolonged exposure to excessive heat. This can result in tearing and displacement of the paper and dielectric breakdown that will result in premature failures.

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.

Justification

Condition-based thermal monitoring of cable terminations is not included in IEEE Std C57.12.00. Overheating of cable terminations can cause transformer bushing failures and lead to prolonged outages. Continuous thermal monitoring of the cable terminations inside ATCs increases safety and reliability without opening the ATC doors/covers for visual or thermographic-type inspections to detect abnormal operating temperature conditions, hot spots created by loose wiring terminations within the ATCs.

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.

Justification

Condition-based thermal monitoring of cable terminations is not included in IEEE Std C57.12.00. Overheating of cable terminations can cause transformer bushing failures and lead to prolonged outages. Continuous thermal monitoring of the cable terminations inside ATCs increases safety and reliability without opening the ATC doors/covers for visual or thermographic-type inspections to detect abnormal operating temperature conditions, hot spots created by loose wiring terminations within the ATCs.

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.

Justification

DGA monitoring of the insulating liquid is not included in IEEE Std C57.12.00. Continuous monitoring of the individual gases dissolved in the insulating liquid provides more diagnostic capability, like a continuous stress test under full voltage, temperature and load. This can expand the usefulness of DGA from a periodic maintenance tool to an automated continuous condition assessment. Single-gas or multiple-gas monitors provide early-warning detection of impending fault conditions. Operating experience using continuous DGA monitoring has shown value in detecting all types of faults (e.g., thermal, low-energy discharge, high-energy discharge and partial discharge (PD)) can be identified at an early stage.

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.

Justification

A conventional unscheduled oil sample is often taken for laboratory analysis as a "sanity check" after an alarm condition is reported from the continuous DGA monitoring system. It is important that such a sample be taken from the same sampling location as the continuous monitor (e.g., a port provided in the oil sampling line going to the on-line monitor). Considerable confusion can result by taking such a sample from a drain valve whereas the on-line sampling is from the top oil or an active cooling loop.

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.

Justification

A dedicated port for the continuous DGA monitoring system is used to minimize interference with transformer maintenance activities including testing, draining and refilling the transformer insulating liquid.

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.

Justification

Continuous DGA monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. This capability allows for remote monitoring, data analysis and trending of the transformer insulating liquid health, and allow for early prediction of transformer performance issues.

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.

Justification

Continuous monitoring of moisture in the insulating liquid is not included in IEEE Std C57.12.00. Monitoring the moisture level in the insulating liquid provides a diagnostic capability for evaluating the dielectric strength of the insulation system. Excessive moisture is detrimental for transformer operation. It affects dielectric integrity of liquid/paper system, insulation life and transformer loading capability. Moisture is a major cause of many failures and can lead to PDs, bubble formation, dielectric breakdown, and deterioration of insulating liquid and paper. If a DGA system is also specified, the moisture in oil continuous monitoring system can be incorporated into the DGA unit as an optional feature to optimize the design.

6.2.6.5.2

If a moisture in oil continuous monitoring system that is not part of a DGA 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.

Justification

A dedicated port for the continuous moisture in oil monitoring system is used to minimize interference with transformer maintenance activities including testing, draining and refilling the transformer insulating liquid.

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.

Justification

Continuous moisture in oil monitoring is not included in IEEE Std C57.12.00 and is a general item in IEEE Std C57.12.10. The details for this type of condition-based monitoring are included in IEEE Std C57.143. This capability allows for remote monitoring, data analysis and trending of the transformer insulating liquid health, and allows for early prediction of transformer performance issues.

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.

Justification

Continuous PD monitoring (analytics) has been shown to generate beneficial results when analyzed over a period of time. The ability to collect this data at a central location for analysis purposes is facilitated by communication capability and enables considerable value to be extracted from this investment. Additionally, this system can identify gradual trends in degradation of dielectric performance of the insulation system.

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.

Justification

Monitoring for the rupture of the conservator membrane (diaphragm) for a conservator-type transformer is not included in IEEE Std C57.12.00. Monitoring for the presence of air on the insulating liquid side of the conservator membrane is used to indicate membrane failure. Another method is monitoring for the presence of insulating liquid side on the air side of the conservator membrane. An undetected ruptured membrane inside the transformer conservator can result in excessive moisture in the transformer insulating liquid. This results in a reduction of the dielectric integrity of liquid/paper system, insulation life and transformer loading capability. Moisture is a major cause of many failures and can lead to PDs, bubble formation, dielectric breakdown, and deterioration of insulating liquid and paper.

6.2.6.8 Data communications

6.2.6.8.1

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).

Justification

This requirement prevents unintended separation of the communication network cable connections made in control cabinets and transformer accessory enclosures. In addition, this ensures the integrity of internal signals. These types of systems are utilized to remotely monitor transformers and provide diagnostic, alarms and status that are used in the distributed control system (DCS) and other types of process control and monitoring systems.

6.2.6.8.2

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.

Justification

This 600 V ac rating requirement ensures the integrity of internal signals as these types of systems are utilized to remotely monitor transformer and provide diagnostic, alarms and status that are used in the DCS and other types of process control and monitoring systems. This also eliminates the requirement to segregate and separate different wiring classes.

6.3 Bushing current transformers

Add new subclause

6.3.1

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.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide guidance for CT sizing. This requirement ensures that CTs are installed in accordance with the one-line diagram or project drawings.

Add new subclause

6.3.2

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide guidance for CT wiring. This requirement ensures that wiring connections for CTs are the proper type. Ring-lug type connectors prevent the termination from coming off the terminal point creating an open CT condition which can result in fire or other hazards.

Add new subclause

6.3.3

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide guidance for CT wiring. This requirement standardizes wiring for CTs to accommodate the typical CT circuit burden requirements.

Add new subclause

6.3.4

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide specific details for CT wiring and grounding. This requirement ensures that CTs are properly and consistently grounded (i.e., no intermediate terminal blocks or daisy chains).

Add new subclause

6.3.5

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide guidance for CT marking. This requirement ensures that CTs are properly marked to help in troubleshooting.

Add new subclause

6.3.6

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide specific details for CT identification. This requirement ensures that CTs are installed for proper metering and protective zoning, which requires the polarity marking to be visible.

Add new subclause

6.3.7

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide specific details for the CT type of terminations. This requirement ensures that provisions for shorting the individual CT circuits to ground are included in order to facilitate grounding of the CT circuity for maintenance and other activities (e.g., replacement of relays).

Add new subclause

6.3.8

CT secondary lead shorting-type terminal blocks shall be located in the control cabinet.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide specific details for CT wiring and grounding. This requirement ensures that the CT secondary lead shorting-type terminal blocks are installed in a protected and accessible location for maintenance, preventing inadvertent contact with the grounding system.

Add new subclause

6.3.9

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 or CSA C22.1.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 do not provide specific details for CT wiring and grounding. This requirement ensures that the CT secondary leads are protected in rigid conduit in addition to being supported in accordance with NFPA 70 or the Canadian Electrical Code (CEC).

6.6 Liquid insulation system

6.6.2 Insulating liquid preservation

Delete list item c)

Justification

IEEE Std C57.12.00 allows for the option of an insulating liquid conservator design without a diaphragm. The use of this type of conservator exposes the insulating liquid to environmental air conditions which allow moisture and airborne contaminants to dissolve into the insulating liquid thereby reducing its dielectric strength and leading to early transformer failures.

6.6.3 Nitrogen inert-gas pressure system

Add new subclause

6.6.3.1

If an inert-gas pressure system is specified, 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.

Justification

IEEE Std C57.12.10 has requirements for the inert-gas pressure system including volumetric and pressure limitations. It does not specify how the system operates. The requirement for these two pressure gauges allows the operator to monitor the transformer tank internal pressure and determine when the nitrogen cylinder should be replaced.

Add new subclause

6.6.3.2

If an inert-gas pressure system is specified, a shutoff valve for the nitrogen inert-gas pressure system shall be provided at the transformer inlet.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system. It does not specify the type of isolation valving. This requirement provides the capability for system isolation and ease of maintenance and troubleshooting.

Add new subclause

6.6.3.3

If an inert-gas pressure system is specified, 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.

Justification

IEEE Std C57.12.10 has requirements for inert-gas pressure system with a reducing valve arrangement. Additional hardware for the complete system is not identified. This requirement ensures that the hardware to connect the system to the transformer is provided.

Add new subclause

6.6.3.4

If an inert-gas pressure system is specified, the nitrogen inert-gas pressure system shall be provided with a low cylinder pressure alarm contact.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement but does not require alarms. This type of alarm alerts the operator if the transformer tank pressure is abnormal and when the nitrogen cylinders need to be replaced.

Add new subclause

6.6.3.5

If an inert-gas pressure system is specified, the nitrogen inert-gas pressure system shall be provided with a high transformer tank pressure alarm contact.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement but does not require alarms. This type of alarm alerts the operator if the transformer tank pressure is abnormal and when the nitrogen cylinders need to be replaced.

Add new subclause

6.6.3.6

If an inert-gas pressure system is specified, the nitrogen inert-gas pressure system shall be provided with a low transformer tank pressure alarm contact.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement but does not require alarms. This type of alarm alerts the operator if the transformer tank pressure is abnormal and when the nitrogen cylinders need to be replaced.

Add new subclause

6.6.3.7 Nitrogen inert-gas pressure system cabinet

6.6.3.7.1

If an inert-gas pressure system is specified, a cabinet to house the nitrogen gas cylinders shall be provided.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement. It does not specify the type of housing and protection for the nitrogen inert-gas pressure system. A cabinet provides environmental and mechanical protection for the nitrogen inert-gas pressure system.

6.6.3.7.2

If an inert-gas pressure system is specified, the cabinet to house the nitrogen gas cylinders shall have a hinged door with a handle-operated latch.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement. It does not specify the type of housing and protection of the inert-gas pressure system. A hinged door with a handle-operated latch facilitates access to the nitrogen inert-gas pressure system for maintenance and adjustment.

6.6.3.7.3

If an inert-gas pressure system is specified, the cabinet to house the nitrogen gas cylinders shall have a door window that allows unobstructed viewing of installed gauges.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement. It does not specify the type of housing and protection of the inert-gas pressure system. A door window allows for viewing of the gauges without opening the door or access panels, thereby minimizing personnel exposure to the inert gas.

6.6.3.7.4

If an inert-gas pressure system is specified, the cabinet to house the nitrogen gas cylinders shall have a breather and a drain at the bottom of the cabinet.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement. A breather and drain at the bottom of the cabinet provides venting. This also provides draining of condensation and water intrusion.

6.6.3.7.5

If an inert-gas pressure system is specified, the cabinet to house the nitrogen gas cylinders shall have a means for retaining the cylinders.

Justification

IEEE Std C57.12.10 has requirements for an inert-gas pressure system with a reducing valve arrangement. A cylinder retaining system provides a means to secure the nitrogen inert-gas system cylinders in place to prevent equipment damage and injury to personnel.

Add new subclause

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.

Justification

IEEE Std C57.12.00 requires mineral insulating oil to meet several ASTM standards. Trace sulfur contaminants in the insulating liquid corrode copper windings and components that are subject to contact with insulating oil.

6.6.4.2

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

Justification

IEEE Std C57.12.00 requires mineral insulating oil to meet several ASTM standards. The use of recycled (used) mineral insulating oil has been linked to numerous premature transformer failures.

6.6.4.3

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

Justification

IEEE Std C57.12.00 requires mineral insulating oil to meet several ASTM standards. The requirement for an inhibitor maintains the preservation of the insulating oil system.

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.

Justification

IEEE Std C57.12.10 has requirements for internal gas pressure but does not specify the type of gas to be used in this type of transformer design. The use of atmospheric air or non-inert gas can introduce moisture into the insulating fluid that can result in a reduction of the dielectric strength.

6.6.5.2

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

Justification

This isolation valve allows nitrogen injection without exposing the tank to atmospheric conditions during maintenance intervals.

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.

Justification

This requirement provides for a separation device (diaphragm, bladder) in the conservator tank with a rubber air cell to isolate the transformer liquid and the air to prevent contamination, oxygen and moisture from coming in contact with the transformer liquid.

6.6.6.2

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

Justification

Experience has shown that the use of conservator transformers in offshore and marine applications is problematic due to extreme weather conditions, corrosion, water ingress and motion concerns.

6.6.6.3

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

Justification

This type of protective relay detects abnormal conditions such as gas accumulation and low liquid level. The double-float Buchholz relay type provides a separate indication of combined gas accumulation / low liquid level which normally is an alarm condition, and liquid surge/loss of liquid which results in a trip condition.

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.

Justification

This requirement provides a means for maintenance and repair activities for conservator-type transformers.

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).

Justification

This requirement provides a separate alarm and trip contacts from the Buchholz relay for remote interconnection to switchgear and remote monitoring systems.

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.

Justification

IEEE Std C57.12.00 requires the grounding of the transformer core but does not address access to this grounding point. This requirement defines a means to access the core ground for testing and maintenance purposes.

Add new subclause

6.7.3

Transformers shall be supplied with stainless steel grounding pads with a NEMA 2-hole pattern.

Justification

IEEE Std C57.12.10 requires grounding pads of various materials. This requirement standardizes the grounding pad materials and provides an assured grounding method.

6.8 Minimum external clearances of transformer live parts

Add to subclause

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

Justification

IEEE Std C57.12.00 includes clearance criteria for energized parts and to ground. This requirement adds clarity that the electrical clearance criteria are different for resistance grounded systems versus solidly grounded systems. If phase-to-ground standard clearances are used on a high resistance grounded system, a bushing flashover to ground can result if the ground fault is not cleared quickly after detection.

Add new subclause

6.9 Windings and core

6.9.1

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

Justification

The use of aluminum leads inside the transformer tank connected to the transformer main bushings has proven to be problematic in the past. Oversize conductors coupled with an increased coefficient of expansion can reduce the dielectric strength of the coil at the bushing interface.

6.9.2

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

Justification

The use of aluminum leads inside the transformer tank connected to the transformer main bushings has proven to be problematic in the past. Oversize conductors coupled with an increased coefficient of expansion can reduce the dielectric strength of the coil at the bushing interface.

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.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements.

6.10.1.2

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. Drip shields prevent moisture from damaging the equipment, especially when installed in outdoor or damp environments. Operators have experienced moisture ingress through the gaskets, hence this requirement.

6.10.1.3

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements.

6.10.1.4

The ATC cable entry plate shall be non-magnetic.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement minimizes the effects of eddy current heating in the ATC.

6.10.1.5

The ATC cable entry plate shall be removable.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement minimizes the effects of eddy current heating in the ATC.

6.10.1.6

The ATC cable entry plate shall be at least 6 mm ($^1/_4$ in) thick.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement minimizes the effects of eddy current heating in the ATC.

6.10.1.7

The ATC cable entry plate shall be bolted and gasketed.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement minimizes the effects of eddy current heating in the ATC. The cable entry plate gasket requirement ensures the integrity of electrical connections in the ATC.

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.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement for cable supports inside the ATC minimizes the stresses imposed on bushings and terminals from the field interconnection cables.

6.10.1.9

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements.

6.10.1.10

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. The gasket material needs to be compatible with transformer oil and prevent water ingress for the life of the transformer.

6.10.1.11

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement is necessary to prevent movement or slippage of the gaskets and prevent water or other contaminate ingress for reliable performance.

6.10.1.12

Components that are installed in the ATC and directly connected to the transformer bushings (e.g., PD sensors, arresters, surge capacitors, voltage dividers) shall not reduce the dielectric withstand of the applicable transformer primary or secondary BIL rating.

Justification

IEEE Std C57.12.00 or IEEE Std C57.12.10 does not have the requirement that any ancillary component that is directly connected to the transformer bushings have a BIL rating that is equal to or greater than the specific transformer winding BIL rating. The use of lower-rated devices can result in a bushing flashover and subsequent transformer damage.

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.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. The danger label alerts the user not to open the cover or door until the power is isolated or the transformer has been de-energized.

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.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. The danger label alerts the user to the danger of the bushings themselves.

6.10.1.15

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. The hinged door provides more expedient access to the components in the ATC and eliminates the need for removal of heavy access covers during maintenance and troubleshooting activities. The padlocking provision supports the LOTO policy of the site.

6.10.1.16

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. The minimum opening requirement for the ATC door allows for unobstructed component repair and replacement during troubleshooting and maintenance activities.

6.10.1.17

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements.

6.10.1.18

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. The handles facilitate the safe removal and installation of access covers during maintenance and troubleshooting activities.

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.

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. An appropriate grounding means in the ATC allows for grounding the shielded power cables and other devices installed inside the ATC.

6.10.1.20

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements.

6.10.1.21

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

Justification

The thermal scanning inspection windows allow for safe inspection of potential hotspots without personnel being exposed to energized parts associated with the ATC.

6.10.1.22

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

Justification

The thermal scanning inspection windows allow for safe inspection of potential hotspots without personnel being exposed to energized parts associated with the ATC.

6.10.2 Throat connection for bus bar

6.10.2.1

The throat connection shall be welded or stud bolted with gaskets to the tank wall.

Justification

IEEE Std C57.12.10 provides the location of the throat connection on the transformer but does not include design or construction requirements. Through bolting into the side wall of the transformer can lead to insulating oil leaks and introduce additional reliability issues.

6.10.2.2

The throat connection shall be furnished with a predrilled flange.

Justification

IEEE Std C57.12.10 provides the location of the throat connection on the transformer but does not include design or construction requirements. Drilling holes in the field can delay energization and introduces additional reliability issues related to water ingress into the ATC.

6.10.2.3

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

Justification

IEEE Std C57.12.10 provides the location of the throat connection on the transformer but does not include design or construction requirements. Flexible connectors are used because bus bars directly connected to the bushing stud or pad can result in premature bushing failures due to thermal expansion/contraction from thermal cycling and inherent stresses due to misalignment of conductors during field installation.

6.10.2.4

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

Justification

IEEE Std C57.12.10 provides the location of the throat connection on the transformer but does not include design or construction requirements. A gasketed flange-type throat connection alone does not provide sufficient protection to prevent water ingress. A drip shield is used to accommodate the relaxation of the gasketed joint due to thermal cycling.

6.10.2.5

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement prevents movement or slippage of the gaskets and water or other contaminate ingress for reliable performance.

6.10.2.6

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

Justification

IEEE Std C57.12.00 and IEEE Std C57.12.10 provide the location of the ATC on the transformer but do not include design or construction requirements. This requirement ensures that the gasket material is compatible with transformer oil and prevents water ingress for the lifetime of the transformer.

Add new subclause

6.11 Space heaters

6.11.1

Space heaters 2 kW and below shall operate at 120 V ac and provide the full rated power output.

Justification

Low voltage reduces the risk associated with shock and arc flash. Space heater circuits requiring higher power operate at higher voltage to minimize the effect of voltage drop and to provide sufficient heat.

6.11.2

Space heaters above 2 kW shall operate at 208 V ac or above and provide the full rated power output.

Justification

Low voltage reduces the risk associated with shock and arc flash. Space heater circuits requiring higher power operate at higher voltage to minimize the effect of voltage drop and to provide sufficient heat.

6.11.3

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

Justification

This requirement provides a safe and easily identifiable means of accessing and maintaining the space heater circuit supplied from an external source.

6.11.4

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

Justification

This requirement provides protection to prevent burns due to incidental contact with the space heater.

6.11.5

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

Justification

Space heaters minimize condensation and ensure the accumulation of significant amounts of moisture that can result in an arc-flash event or failure of components installed inside transformer enclosures or ATCs.

6.11.6

Space heaters shall be installed on standoff insulators.

Justification

Standoffs prevent direct contact with the enclosure surface to prevent hot spots on the outside of the ATC or enclosure that can result in failure or degradation of the coating system (e.g., burned paint).

6.11.7

If the transformer is installed in a hazardous (classified) location, the space heater element surface temperature shall not exceed 80% of the AIT of the explosive atmosphere.

Justification

A space heater located in a hazardous (classified) area, operating at a surface temperature of higher than 80% of the AIT of the gas or vapor involved, represents a source of ignition risk that may result in a fire at the transformer location if there is a release of flammable material in the area.

6.11.8

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

Justification

The caution label alerts the user to the possibility of the space heater energized terminals within the enclosure.

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".

Justification

The caution label alerts the user of the possibility of the space heater energized terminals within the enclosure.

6.11.10

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

Justification

Thermostat control of section space heaters can be used to control cycling of the space heaters on and off to increase power usage efficiency in certain applications. This additional function allows for testing of the enclosure space heaters.

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.

Justification

The use of an ammeter demonstrates that there is current in the space heater circuit. The common failure mode results in open circuiting the space heater element.

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 identification tag.

Justification

The use of an ammeter with the normal expected current indication demonstrates that the space heater circuit is operating normally.

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.

Justification

IEEE Std C57.12.00 does not provide guidance for transformer surge arrester applications. Surge arresters help mitigate electrostatic discharges, switching surges, and direct or indirect lightning surges).

6.12.2

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

Justification

IEEE Std C57.12.00 does not provide guidance for transformer surge arrester applications. Increased distances between the surge arrester and the line terminal can result in the transformer being exposed to transient over-voltages due to arrester misoperation.

6.12.3

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

Justification

IEEE Std C57.12.00 does not provide guidance for transformer surge arrester applications.

6.12.4

If 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.

Justification

IEEE Std C57.12.00 does not provide guidance for transformer surge arrester applications.

6.12.5

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

Justification

IEEE Std C57.12.00 does not provide guidance for transformer surge arrester applications. This requirement ensures that the ground path for the arrester is sufficiently sized such that it does not result in arrester failure or flashover during arrester activation.

6.12.6

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

Justification

IEEE Std C57.12.00 does not provide guidance for transformer surge arrester applications. High-voltage transformer windings with cover-mounted bushings connected to overhead transmission or distribution lines are more susceptible to damage from transients. Counters provide necessary information on the number of transient events, which can be used to assist in evaluating the remaining life of the transformer.

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.

Justification

IEEE Std C57.12.00 does not have any requirements for control wiring for transformer auxiliary circuits. This 600 V ac rating requirement ensures the integrity of internal signals as these types of systems are utilized to remotely operate and monitor transformer functions. The SIS and XHHW types provide the needed flexibility and durability for this outdoor application. This also eliminates the requirement to segregate and separate different wiring classes.

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.

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits.

6.13.1.3

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement ensures the integrity of internal signals as these types of systems are utilized to remotely operate and monitor transformer functions.

6.13.1.4

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement clearly identifies any grounding circuit required to minimize shock hazards on the transformer.

6.13.1.5

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

Justification

The minimum internal wiring size for alarm and control signals varies between operators. However, to help drive standardization, the workgroup agreed on behalf of the operating companies to standardize on No.16 AWG for alarm and control signals. These types of signals are normally utilized to remotely operate the equipment and provide diagnostic, alarms and status which are used in the DCS and other types of process control systems.

6.13.1.6

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

Justification

Double-ended 360° slip-on or heat-shrink wire markers drive standardization, increase quality control and improve safety and maintainability. Adhesive-type markers are well-known for coming off, causing delays in maintenance, troubleshooting, repair and operating tasks, and leading to rework. This requirement facilitates the tracing of circuits and troubleshooting.

6.13.1.7

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

Justification

Double-ended 360° slip-on or heat-shrink wire markers drive standardization, increase quality control and improve safety and maintainability. Adhesive-type markers are well-known for coming off, causing delays in maintenance, troubleshooting, repair and operating tasks, and leading to rework.

6.13.1.8

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

Justification

Double-ended 360° slip-on or heat-shrink wire markers drive standardization, increase quality control and improve safety and maintainability. Alternatively, printed wire designations appearing on the wire at intervals can have the wire marker further back into the wiring bundle and not visible at the location where the circuit is being diagnosed. This requirement facilitates the tracing of circuits and troubleshooting.

6.13.1.9

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement promotes standardization and reduces the probability of inadvertent disconnection due to vibration or maintenance and troubleshooting activities.

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.

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement promotes standardization and provides an alternate method of control wiring termination for devices utilizing European-style type terminals.

6.13.1.11

Wiring into devices and enclosures shall be bottom entry, except where bottom entry is not feasible (e.g., due to lack of space), in which case side-entry is an acceptable alternative.

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. Cable entry into the top of devices or enclosures can allow water ingress, resulting in accelerated corrosion and component failure.

6.13.1.12

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. The use of rigid conduit minimizes mechanical damage and environmental exposure for the electrical wiring system due to shipping, installation and maintenance activities. Compatible fittings ensure adequate corrosion resistance, water ingress prevention and electrical grounding continuity.

6.13.1.13

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. The use of rigid conduit minimizes mechanical damage to the electrical wiring system due to shipping, installation and maintenance activities. In some applications, a degree of flexibility is needed to allow for connection /disconnection of certain transformer accessories. The length of flexible conduit is minimized to only the amount sufficient to service the equipment and does not compromise the rigidity of the wiring support system.

6.13.1.14

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. The use of rigid conduit minimizes mechanical damage to the electrical wiring system due to shipping, installation and maintenance activities. In some applications, a degree of flexibility is needed to allow for connection /disconnection of certain transformer accessories. This requirement ensures that the length of flexible conduit is minimized to only the amount sufficient to service the equipment and does not compromise the rigidity of the wiring support system.

6.13.1.15

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

Justification

IEEE Std C57.12.10 does have a requirement for a control cabinet but does not address the wiring type or the devices to be interconnected to the control cabinet.

6.13.1.16

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

Justification

Spare contacts wired to terminal blocks allow for expansion / additional control capabilities.

6.13.2 Auxiliary wiring terminals

6.13.2.1

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

Justification

The use of two-part terminals or connectors does not provide adequate troubleshooting facilities for maintenance activities.

6.13.2.2

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

Justification

This requirement protects electrical personnel from incidental contact and shock exposure during electrical troubleshooting or maintenance activities.

6.13.2.3

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

Justification

A system of unique wire numbering that matches the schematic drawings is critical for troubleshooting and commissioning activities. Wire marking mismatches and errors are well known for causing delays in maintenance, troubleshooting, repair and operating tasks, and leading to rework.

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.

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This enclosure requirement minimizes mechanical damage and environmental exposure for the electrical wiring system due to shipping, installation, operation and maintenance activities.

6.13.3.2

Control cabinets shall have a hinged door with padlock provisions.

Justification

IEEE Std C57.12.00 does not have requirements for the control cabinet details. This requirement provides LOTO capability for safe inspection and maintenance activities.

6.13.3.3

For transformers installed in hazardous (classified) locations, control cabinet enclosures, internal devices (except those installed in explosion-proof enclosures) and wired accessories shall be NRTL or ACO approved for Class I Division 2 or Zone 2 areas.

Justification

IEEE Std C57.12.00 does not have requirements for hazardous area classification, therefore NRTL or ACO approved equipment is required for installation in these areas.

6.13.3.4

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement minimizes mechanical damage and air flow restrictions for the function of the radiators.

6.13.3.5

Control cabinets shall be provided with a drain.

Justification

IEEE Std C57.12.00 does not have requirements for control cabinets. This requirement minimizes the impact of water ingress and environmental damage to the electrical wiring system due to operation and maintenance activities.

6.13.3.6

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement improves safety and maintainability during electrical troubleshooting or maintenance activities.

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.

Justification

This requirement minimizes the electric shock risk to personnel if electrical continuity (i.e., bonding) across the metallic door to the control cabinet ground facility is solely dependent on the rotating metal-to-metal contact surface made by the hinge itself.

6.13.3.8

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement improves safety and maintainability during electrical troubleshooting or maintenance activities.

6.13.3.9

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement improves safety and reliability during electrical troubleshooting or maintenance activities.

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.

Justification

IEEE Std C57.12.00 does not have requirements for control cabinet details. This requirement improves safety and operability during electrical troubleshooting or maintenance activities.

6.13.3.11

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

Justification

IEEE Std C57.12.00 does not have requirements for control cabinet details. This requirement improves safety and operability during electrical troubleshooting or maintenance activities. A maximum height requirement provides consideration for human factors engineering practices and eliminates the need for working at heights, thus reducing the risk of injury.

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.

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement improves safety and reliability during electrical troubleshooting or maintenance activities.

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.

Justification

This requirement provides a standardized interface device specification and quality level by referring to a widely used industry standard, NEMA ICS 5, to provide safe and reliable unit controls.

6.13.3.14

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

Justification

IEEE Std C57.12.00 does not have requirements for control wiring for transformer auxiliary circuits. This requirement improves safety and maintainability during electrical troubleshooting or maintenance activities.

6.13.3.15

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

Justification

Labeling and tagging requirements are not included in IEEE Std C57.12.00. This requirement has been added to be in line with operating company minimum requirements, promote standardization and ensure that each component is individually labeled.

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.

Justification

IEEE Std C57.12.00 does not have fabrication requirements for pancake radiator fins. This requirement ensures the integrity of the pancake-style radiator fins. Based on previous operating experience, oil leaks from this type of cooling fins on radiators are one of the most common leak points.

6.14.1.2

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

Justification

IEEE Std C57.12.00 does not have fabrication requirements for radiators. This requirement ensures the integrity of the radiator fins. Based on previous operating experience, oil leaks from cooling fins on radiators are one of the most common leak points. The use of removable radiators allows for maintenance and repair activities without the need to drain all the insulating fluid from the transformer tank.

6.14.1.3

If removable radiators are specified, flanged shut-off valves and flanges shall be made of 316 stainless steel.

Justification

IEEE Std C57.12.00 does not have fabrication requirements for radiators. This requirement ensures the integrity of the radiator fins. Based on previous operating experience, oil leaks from cooling fins on radiators are one of the most common leak points. The use of removable radiators allows for maintenance and repair activities without the need to drain all the insulating fluid from the transformer tank.

6.14.1.4

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

Justification

IEEE Std C57.12.00 does not have fabrication requirements for radiators. This requirement ensures the integrity of the radiator fins. Based on previous operating experience, oil leaks from cooling fins on radiators are one of the most common leak points. Replacement of removable radiators typically requires the weight of the insulating fluid to be removed prior to handling and shipping of individual radiators.

6.14.1.5

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

Justification

IEEE Std C57.12.00 does not have fabrication requirements for radiators. This requirement provides details for replacement of individual radiators. Based on previous operating experience, oil leaks from cooling fins on radiators are one of the most common leak points.

6.14.1.6

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

NOTE—Only cooling fans can be installed on radiators.

Justification

IEEE Std C57.12.00 does not have fabrication requirements for radiators. This requirement ensures the integrity of the radiator fins. Installing accessories and junction boxes on the radiators can negatively impact the cooling performance and hamper maintenance and repair activities.

6.14.2 Cooling fans

6.14.2.1

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. This requirement provides guidance on when the cooling fans are to be controlled on the temperature of the winding or the temperature of the insulating liquid. Experience has shown that the thermal lag associated with the temperature increase in larger volumes of insulating fluid significantly delays the response from temperature protective devices. For larger transformer sizes, relying on winding temperature is more accurate and responsive.

6.14.2.2

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. This requirement provides guidance on when the cooling fans are to be controlled on the temperature of the winding or the temperature of the insulating liquid. Experience has shown that the thermal lag associated with the temperature increase in larger volumes of insulating fluid significantly delays the response from temperature protective devices. For larger transformer sizes, relying on winding temperature is more accurate and responsive.

6.14.2.3

Radiator fans shall not be clamped directly to radiator coils or fins.

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. Cooling fans installed on the radiator fins can result in premature oil leaks and damage to the radiator assembly due to fan vibration, the additional weight installed in a cantilever fashion on the radiator cooling fin or pipe, and the dissimilar metal corrosion that occurs due to the damage to the cooling fin coating system from the mechanical clamps.

6.14.2.4

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. The operation of the fans is normally controlled by the temperature of the transformer winding or insulating oil. Experience has shown that other modes of operation are needed (i.e., off mode, which allows for maintenance and repair activities, and manual mode, which allows for operator direct control of the fans to accommodate temperature device failures or replacements, or anticipated high ambient conditions coinciding with higher load conditions).

6.14.2.5

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. This requirement ensures that personnel guards are provided for rotating parts to protect personnel from injury when performing repair or maintenance activities on the transformer.

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.

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. The control system for the cooling fans maintains the temperature of the transformer during periods of high loading. This requirement provides a method for the control system to interface with the DCS or monitoring system of the site.

6.14.2.7

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. The cooling fans are normally not energized and only operate during periods of high loading on the transformer. This requirement ensures that the motor assemblies withstand the anticipated weather conditions and ensures the functionality of the cooling system when needed.

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.

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. The cooling fans are sized to provide adequate cooling of the radiators to prevent over-temperature conditions. A common problem associated with replacement or repair of this type of fans is that the reverse direction produces significantly less air flow over the radiator fins. The direction indicator ensures adequate cooling and reliable transformer operation.

6.14.2.9

If forced air-cooling fans are provided for offshore, marine and hazardous (classified) area transformer applications, fan blades shall be non-sparking and made of corrosion-resistant material.

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. This requirement minimizes the risk of ignition of flammable vapors on an offshore facility. The selection of incompatible materials for the fan blades in a corrosive atmosphere leads to premature fan failure and low volumes of cooling air.

6.14.2.10

If forced air-cooling fans are provided for offshore and marine transformer applications, the fan guard material shall be made of corrosion-resistant material.

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fans. Metal is more susceptible to corrosion in an offshore environment. This requirement ensures the fan guard will not corrode and prolongs the life of the fan.

6.14.3 Cooling fan provisions

6.14.3.1

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fan provisions. This requirement provides guidance on when the cooling fans are to be controlled on the temperature of the winding or the temperature of the insulating liquid. Experience has shown that the thermal lag associated with the temperature increase in larger volumes of insulating fluid significantly delays the response from temperature protective devices. For larger transformer sizes, relying on winding temperature is more accurate and responsive.

6.14.3.2

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fan provisions. This requirement provides guidance on when the cooling fans are to be controlled on the temperature of the winding or the temperature of the insulating liquid. Experience has shown that the thermal lag associated with the temperature increase in larger volumes of insulating fluid significantly delays the response from temperature protective devices. For larger transformer sizes, relying on winding temperature is more accurate and responsive.

6.14.3.3

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

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

Justification

IEEE Std C57.12.00 does not have requirements for forced air-cooling fan provisions. Cooling fans installed on the radiator fins can result in premature oil leaks and damage to the radiator assembly due to fan vibration and the additional weight installed in a cantilever fashion on the radiator pipe support and gasket connection to the transformer tank.

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.

Justification

IEEE Std C57.12.00 does not have requirements for provisions for future forced air-cooling fans. The cooling fans are either controlled by the insulating liquid temperature or the winding temperature. The control system is used to maintain the temperature of the transformer during periods of high loading.

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.

Justification

IEEE Std C57.12.00 does not have requirements for provisions for future forced air-cooling fans. This requirement provides terminal blocks for the control system for future fan power feed and to interface with the DCS or monitoring system of the site.

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).

Justification

IEEE Std C57.12.00 does not have requirements for provisions for future forced air-cooling fans. This requirement ensures that the transformer can provide the increased output as designated on the transformer nameplate for the fan cooled rating within the defined temperature limits after the fans are outfitted on the transformer radiators without any additional modifications.

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 IEEE Std C57.12.10-2017, 4.5.2 and Clause 6.

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The majority of the requirements for an OLTC are included in IEEE Std C57.12.10.

6.15.1.2

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

Justification

Individual tap changer mechanisms are prone to off-tap synchronization problems and can cause out of phase switching surges.

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.

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. This requirement ensures the ratings compatibility and continuity throughout the transformer design.

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.

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The co-mingling of the insulating oil between the OLTC oil vessel and the main transformer tank can lead to premature oil contamination, which leads to early transformer dielectric failure. This requirement applies to non-vacuum type OTLCs where the switching is performed under oil, risking cross-contamination of the main tank.

6.15.1.5

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. IEEE Std C57.12.10 only requires provisions to be made for a future dehydrating breather device in the OLTC oil vessel. This requirement applies to non-vacuum type OTLCs where moisture can accumulate in the oil, resulting in damage to the arcing contacts.

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.

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. IEEE Std C57.12.10 only requires provisions to be made for monitoring the insulating oil in the OLTC vessel for sudden flow conditions. This requirement applies to non-vacuum OLTCs where the switching is done under oil, and carbonization of the oil happens under switching.

6.15.1.7

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. This requirement is identified as an option in IEEE Std C57.12.10.

6.15.1.8

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. This requirement ensures sufficient life and performance that is complementary to the transformer. Vacuum-type OLTCs provide significantly more switching operations than non-vacuum type OLTCs. If a non-vacuum type OLTC is specified, the number of switching operations is significantly less.

6.15.1.9

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. This requirement ensures sufficient life and performance that is complementary to the transformer.

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.

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The use of two different types of insulating liquids for non-vacuum OLTCs is problematic during transformer maintenance activities requiring several insulation liquids onsite and can lead to mixing two incompatible materials.

6.15.1.11

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. To maintain the reliability and performance of the complete transformer system, the requirements for the OLTC auxiliary equipment and enclosures are the same as similar equipment for the main transformer tank.

6.15.1.12

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The use of a remote-control panel allows the operation of the OLTC in an indoor location without exposure to overhead energized conductors or at the local control panel installed on the side of the transformer tank. The local-control panel provides a means of indicating fault indication on the remote control panel utilizing the hardwired Form C contacts provided for remote annunciation. This is typically a common fault indication sent back to the DCS or local alarm panel for annunciation.

6.15.2 Motor and drive mechanism

6.15.2.1

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The requirements for the motor-drive mechanism are located in IEEE Std C57.12.10-2017, 6.3. Padlockable isolation for the separate power feed to the OLTC ensures that the operation of the OLTC complies with the local electrical safety rules.

6.15.2.2

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The requirements for the motor and drive mechanism can be found in IEEE Std C57.12.10-2017, 6.3. This requirement ensures that the transformer can remain in service after a tap change has not transitioned correctly.

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.

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The operation of several transformers with OLTCs in parallel is a complex control scheme that requires a sophisticated control system. IEEE Std C57.12.10-2017, 6.5.3.3.2 provides further considerations for parallel operation.

6.15.3.2

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

Justification

IEEE Std C57.12.00 contains minimal requirements for an OLTC. The use of a remote-control panel allows the operation of the OLTC in an indoor location. A NEMA 1 enclosure provides protection to the components within.

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.

Justification

IEEE Std C57.12.00 does not contain requirements for lifting and handling facilities for transformers and refers to IEEE Std C57.12.10 for these requirements.

6.16.2

Transformers shall be provided with structural steel members on the bottom of the transformer tank.

Justification

The bottom of the transformer is elevated above the foundation with sufficient clearance to minimize transformer tank corrosion. Carbon or stainless steel is chosen to prolong the life of the transformer base.

6.16.3

Provisions for lifting the complete transformer shall include a minimum of four lifting eyes located on the top of the transformer tank.

Justification

IEEE Std C57.12.00 does not contain requirements for lifting and handling facilities for transformers and refers to IEEE Std C57.12.10 for these requirements. The use of lifting hooks does not meet this requirement.

6.16.4

The lifting eye pin hole 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.

Justification

This requirement for the minimum lifting eye pin hole size is larger than the size referenced in IEEE Std C57.12.10 in order to accommodate the typical shackle size that is available at most operating company facilities, 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.

Justification

IEEE Std C57.12.00 does not include specific requirements for transformer base securement. Installations of large liquid-filled transformers use a means of securement to prevent movement (e.g., vibration) that can damage the electrical connections to the primary or secondary windings, which can result in equipment damage or electrical outages.

6.16.6

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

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

Justification

IEEE Std C57.12.00 does not include specific requirements for operation in dynamic motion conditions and lifting provisions necessary for offshore-floating and marine-ship applications. This requirement identifies the dynamic load factors and allowable stresses experienced in these type applications.

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.

Justification

IEEE Std C57.12.00 only provides guidance on coating systems with regards to temperature rise. This requirement provides the needed coating (paint) system for the transformer installed in onshore corrosive environments to deliver the expected life without significant corrosion damage.

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.

Justification

IEEE Std C57.12.00 only provides guidance on coating systems with regards to temperature rise. This requirement provides the needed coating (paint) system for the transformer installed in offshore or marine corrosive environments to deliver the expected life without significant corrosion damage due to exposure to extreme moisture and salt air environments.

6.17.3

The transformer base metal in contact with the surface of the foundation (e.g., concrete pad) shall be coated with an asphalt-based paint or mastic, except if the transformer base metal is fabricated from stainless steel.

Justification

IEEE Std C57.12.00 does not include specific requirements for transformer base securement. This requirement prevents premature failure of the base structure due to corrosion by ensuring that installations of large liquid-filled transformers have an adequate coating between the foundation and the transformer base.

Add new subclause

6.18 General

6.18.1

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

Justification

IEEE Std C57.12.00 does not have requirements for transformer external hardware. The use of 316 stainless steel in both bolts and nuts leads to galling and to the inability to loosen the nut and bolt after installation. The use of silicone bronze or similar material for the nuts allows removal of transformer external hardware and prevents galling.

6.18.2

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

Justification

IEEE Std C57.12.10 requires a manhole or handhole of minimal dimensions but does not specify a minimum quantity. This requirement states the minimum quantity of manholes/handholes in order to access the winding for testing and inspection activities.

6.18.3

Handholes and manholes on the transformer tank shall have bolted covers.

Justification

IEEE Std C57.12.10 requires a manhole or handhole of minimal dimensions but does not specify how they are affixed to the transformer tank cover.

6.18.4

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

Justification

IEEE Std C57.12.10 requires a manhole or handhole of minimal dimensions but does not specify the gasket materials. Experience has shown that other oil-resistant materials do not provide sufficient life when exposed to UV and all weather conditions.

6.18.5

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

Justification

IEEE Std C57.12.10 requires a manhole or handhole of minimum dimensions but does not specify the location. IEEE Std C57.12.10 also does not state that manholes and handholes allow for replacement of bushings.

6.18.6

Manhole covers on the transformer shall have at least two handles for lifting purposes.

Justification

IEEE Std C57.12.10 requires a manhole or handhole of minimal dimensions but does not specify details for the manhole cover construction.

6.18.7

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".

Justification

IEEE Std C57.12.10 requires a manhole or handhole of minimal dimensions but does not require labels on the covers that warn of possible high pressure behind the cover. This is typical for sealed-type transformers but it can also apply to other transformers that have liquid preservation systems under pressure.

6.18.8

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

Justification

Transformers of this size and larger typically require personnel to perform work activities at height to access bushings or top cover plates, conservator apparatus or accessories for diagnostic, maintenance or repair activities.

6.18.9

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

Justification

IEEE Std C57.12.00 does not include requirements for vacuum filling, and IEEE Std C57.12.10 presently includes vacuum filling requirements for the tank only. This requirement ensures that the liquid can be evacuated from the transformer, compartments and radiators in the field.

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.

Justification

Insulating oil analysis is a reliable and economical method of detecting transformer faults that can present an unacceptable possibility of damage or near-term failure. This requirement ensures that the insulating oil used in the transformer during testing does not show signs of an incipient or intermittent fault within the transformer.

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.

Justification

Insulating oil analysis is a reliable and economical method of detecting transformer faults that can present an unacceptable possibility of damage or near-term failure. This requirement ensures that the insulating oil used in the transformer during testing does not show signs of an incipient or intermittent fault within the transformer.

Add new subclause

8.2.1.3

Resistance measurement tests of the transformer windings shall be performed in accordance with IEEE Std C57.12.90.

Justification

Table 17 requires the resistance measurement tests of the transformer windings to be performed on transformers above 2.5 MVA. This requirement ensures that the winding resistance is determined on all transformers. The information from the resistance measurement tests of the transformer windings is critically important to support the maintenance and repair activities, and it is the baseline for trending the transformer performance and integrity to ensure the asset life.

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.

Justification

This requirement ensures that the transformer is successfully tested and shipped without defects.

Add new subclause

8.2.1.5

The winding insulation resistance test of transformer windings shall be performed in accordance with IEEE Std C57.12.90.

Justification

Table 17 requires the winding insulation test of windings to be performed on large power transformers only. This requirement ensures that the winding insulation resistance test is performed on all transformers. The information from the winding test is critically important to support the maintenance and repair activities and is the baseline for trending the transformer performance and integrity to ensure the asset life.

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.

Justification

The insulation power factor and capacitance test in Table 17 requires the test to be performed as detailed in IEEE Std C57.12.90. However, this document does not contain the acceptance criteria for this test. The referenced NETA standard contains the industry accepted values for this test. The information provided from this test is critically important to support the maintenance and repair activities, and is the baseline for trending the performance and integrity of the transformer to ensure the asset life.

Add new subclause

8.2.1.7

If a frequency response analysis (FRA) test is specified, the test shall be performed in accordance with IEEE Std C57.149 with the transformer fully assembled with insulating liquid.

Justification

The FRA test can be conducted in various configurations of the transformer to be tested. The IEEE Std C57.149 guide allows for this analysis to be conducted in several arrangements (e.g., fully or partially assembled, with or without insulating liquid). The information provided from this test is critically important to support the maintenance and repair activities, and is the baseline for trending the transformer performance and integrity to ensure the asset life.

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

Justification

The temperature rise design tests are defined in IEEE Std C57.12.90.

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.

Justification

This requirement ensures that electrical losses of smaller transformers are minimized and meet the efficiency guidelines in the applicable countries in which they are installed.

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.

Justification

Shipping transformers of this size are normally shipped with insulating liquid to minimize the assembly and commissioning effort at the field location. It is also done to preserve the dielectric integrity of the liquid insulation system.

10.1.2

Transformers rated below 20 MVA shall be shipped with the radiators attached to the transformer tank, except for conservator-type transformers.

Justification

Shipping transformers of this size are typically shipped with the insulating liquid and radiators installed to minimize the assembly and commissioning effort at the field location. It is also done to preserve the dielectric integrity of the liquid insulation system.

10.1.3

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

Justification

Shipping transformers of this size are typically shipped with insulating liquid and pressurized to minimize the assembly and commissioning effort at the field location. It is also done to preserve the dielectric integrity of the liquid insulation system.

10.1.4

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

Justification

A common cause of transformer shipping damage is inadequately protected exposed bushings on the top cover of the transformer. Replacement of these primary bushings in the field is a cumbersome activity that causes significant delays in startup and commissioning.

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.

Justification

Large transformers are typically shipped without the weight of the insulating liquid. A dry gas of sufficient quality such as nitrogen or air is used to preserve the dielectric integrity of the core and coil in the tank during the transportation period.

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.

Justification

This requirement preserves the dielectric integrity of the liquid insulation system and provides a visual indication that the transformer has not been compromised during shipping.

10.1.7

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

Justification

IEEE Std C57.12.00 does not have requirements for shipping of transformers. This requirement provides information for minimizing the risk of damage and delays in the shipping of large transformers with respect to the transformer design, shipment preparation, transportation, heavy-hauling and arrival inspections.

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.

Justification

This requirement ensures that components and accessories shipping separate from the main transformer tank are sufficiently marked, easily identified, and documented in the assembly drawings and instructions provided with the transformer so as not to create delays during transformer assembly and installation 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.

Justification

Transformer accessories and components that are shipped separately from the main transformer tank are sufficiently packaged with acceptable weatherproof materials to minimize damage from handling and damage due to moisture ingress.

10.1.10

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

Justification

Transformer component enclosures, whether shipped separately or on the main tank, are exposed to weather and shipping conditions, and can be subjected to damage from handling and moisture ingress.

Add new subclause

10.2 Insulating Oil Shipped Separately

10.2.1

Insulating oil shipped separately shall be delivered to the job site in Department of Transportation (DOT) approved containers or tanker trucks.

Justification

Shipping the transformer insulating liquid separately in DOT approved facilities meets the logistic requirements for transportation of combustible materials and minimizes contaminates to preserve the dielectric integrity of the liquid insulation.

10.2.2

If tanker trucks are used for shipping insulating oil, the tanker truck shall be used only for this service or provided with a wash certificate for the delivery.

Justification

Shipping the transformer insulating liquid separately to the transformer installation site using tanker trucks meets the logistic requirements for transportation of combustible materials and minimizes contaminates to preserve the dielectric integrity of the liquid insulation. Multipurpose tanker trucks with a wash certificate provide evidence that the interior of the tanker truck has been thoroughly cleaned and sanitized to eliminate contamination from previous cargoes that can degrade the dielectric strength of the insulating oil.

Add new clause

11. Distribution substation-type transformers

11.1

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all the manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for distribution substation-type transformers up to 10 MVA. IEEE Std C57.12.36 includes these specific requirements.

11.2

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all the manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for distribution substation-type transformers up to 10 MVA. The IEEE Std C57.12.36 includes some of these specific additional requirements. Table 20 includes additional requirements not covered in IEEE Std C57.12.00 and IEEE Std C57.12.36.

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	5.12.1.1, 5.12.1.2 and 5.12.1.4
Nameplate information	5.12.2.3, 5.12.2.4 and 5.12.2.6
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	6.1.14
Creepage	6.1.15
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 6.2.3.7
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 through 6.3.9
Nitrogen inert-gas pressure system	6.6.3
Mineral oil	6.6.4
Sealed-tank	6.6.5
Conservator	6.6.6
Stainless steel grounding pads	6.7.3
Phase-to-phase clearances	6.8
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 6.14.2.10
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
Connection of transformers for shipment	10.1.1 through 10.1.6

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for distribution substation-type transformers rated 10 MVA and below. IEEE Std C57.12.36 includes some of these specific additional requirements. Table 20 includes additional requirements not covered in IEEE Std C57.12.00 and IEEE Std C57.12.36.

Add new clause

12. Pad-mounted transformers

12.1

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for pad-mounted transformers up to 10 MVA. IEEE Std C57.12.34 includes these specific requirements.

12.2

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.

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for pad-mounted transformers up to 10 MVA. IEEE Std C57.12.34 includes these specific requirements. However, IEEE Std C57.12.34-2022, Annex A is labeled "informative", so this requirement ensures that suppliers instead treat the requirements as normative.

12.3

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

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for pad-mounted transformers up to 10 MVA. IEEE Std C57.12.34 includes these specific requirements. Table 21 includes additional requirements not covered in IEEE Std C57.12.00 and IEEE Std C57.12.34.

12.4

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.

Justification

The scope of IEEE Std C57.12.34 does not address short circuit requirements for pad-mounted transformers up to 10 MVA. IEEE Std C57.12.34 only has recommended impedance values that were designed to meet IEEE Std C57.12.00-2021, 7.1.4.1 and 7.1.4.2, which defines the maximum per-unit short-circuit withstand capability. The end user considers other requirements such as voltage regulation, system impedance or available fault current when using the recommended impedance values.

12.5

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

Justification

When dead-front bushings are used in a pad-mount transformer, the parking stand is used to minimize damage and contamination for the removable portion of the dead-front bushing assembly (i.e., elbow connector).

12.6

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

Justification

This requirement ensures that transformer maintenance activities can be conducted without exposing personnel to open exposed energized components. This requirement reduces the risk of injuries due to shock or arc flash during maintenance activities.

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	4.3.5
Proven operational service	4.4.2
Nameplates (general)	5.12.1.1 and 5.12.1.2
Nameplate information	5.12.2.3
NRTL logo, area classification	5.12.2.4 and 5.12.2.6
Certifications	5.13.1 through 5.13.3
Neutral connection to external neutral or ground	6.1.6
Pressure-relief device	6.2.1.3
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
Connection of transformers for shipment	10.1.6

Justification

IEEE Std C57.12.00 is the primary industry standard used by all manufacturers that produce liquid-immersed power and distribution transformers for the North American market. The current scope of IEEE Std C57.12.00 does not address all the requirements for pad-mounted transformers rated 10 MVA and below. IEEE Std C57.12.34 includes these specific requirements. Table 21 includes additional requirements not covered in IEEE Std C57.12.00 and IEEE Std C57.12.34.

12.7

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.

Justification

A visual dial type liquid level indicator offers a higher level of reliability compared to sight glass level indicators, which are more susceptible to damage. Such damage could lead to environmental spills and contamination that would compromise the dielectric performance of the insulating liquid.

12.8

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

Justification

This requirement ensures that transformer monitoring and maintenance activities can be conducted without exposing personnel to energized components. This requirement reduces the risk of injuries due to shock or arc flash during maintenance activities.

12.9

For pad-mounted transformers, a visual-dial-type liquid temperature indicator shall be provided in accordance with IEEE Std C57.12.34-2022, A.6.2.

Justification

A visual dial type of indicator offers a higher level of reliability compared to temperature label indicators, which are more susceptible to deterioration and failure. This type of indicator is equipped with two separate dial indicators, one for actual temperature and the other for illustrating the maximum temperature.

12.10

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

Justification

This requirement ensures the use of standard lugs for the connection of field cables to low-voltage pad-mounted transformer bushings.

12.11

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

Justification

Where dead-front bushings are used in a pad-mounted transformer, the arresters need to be dead-front type so as not to expose personnel to energized parts during maintenance or switching operations.

12.12

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.

Justification

IEEE Std C57.12.34 requires pad-mounted transformers to be tested as specified in IEEE Std C57.12.00. The testing requirements are given in Table 17 of that standard but there is no column identified for pad-mounted transformers. This requirement clarifies which tests are needed for pad-mounted transformers.

12.13

The nameplate shall be located on the exterior of the transformer in a location at which the nameplate is fully visible outside of the LV compartment and not obscured by accessories.

Justification

This requirement ensures that transformer nameplate information is available for operations and maintenance activities without exposing personnel to energized components. This requirement reduces the risk of injuries due to shock or arc flash during maintenance activities. This requirement overrides the requirement in IEEE Std C57.12.34-2022, 8.8.1.

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).

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