

DEP SPECIFICATION

LIQUID-IMMERSED TRANSFORMERS FOR NORTH AMERICAN APPLICATION

DEP 33.65.40.32-Gen.

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DESIGN AND ENGINEERING PRACTICE



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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design and manufacture of liquid-immersed transformers for use in North American applications. This DEP is limited to transformers that are:

- three-phase;
- two or three winding;
- liquid-immersed; and,
- air-cooled, with:
- a rating of 500 kVA and above
- up to and including voltages of 765 kV nominal for high voltage winding.

NOTE: For transformers rated above 230 kV, consider contracting a consultant to assist in specifying unique design considerations for extra high voltage that may not be addressed in this DEP.

Part III covers requirements for power transformers for US facilities, and is written in the form of amendments and supplements to IEEE Standard C57.12.00-2006.

Part IV covers requirements for Pad-Mounted transformers for US facilities.

Part V of this DEP covers requirements for all liquid-immersed transformers for Canadian facilities.

Part VI covers documentation requirements applicable for all transformers.

Part VII covers supplemental non-technical requirements applicable for all transformers.

Part VIII lists references associated with this DEP.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied for other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regard to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Electrical Technical Authority of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Electrical Technical Authority may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal (or Electrical Technical Authority) may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor. The Manufacturer/Supplier may also be referred to as the vendor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal. The Principal may also be referred to as the owner or user.

The word **shall** indicates a mandatory requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Electrical terms used in this DEP are in accordance with IEEE Std C57.12.80:2002. Additional terms are defined as follows:

Electrical Technical Authority	The discipline engineer appointed by the Principal and is responsible for all technical decisions associated with the work. The Electrical Technical Authority is responsible for technical integrity
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Tap changer for de energized operation	A device for changing the voltage ratio of the transformer only after the transformer has been isolated from the high voltage and low voltage sources.
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1.3.3 Abbreviations

DEP Design and Engineering Practice

NRTL Nationally Recognized Testing Laboratory

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (Part VIII).

1.5 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.6 DATASHEETS

Data sheet DEP 33.65.40.94-Gen shall be used to specify transformers for US application.

Data sheet DEP 33.65.40.95-Gen shall be used to specify transformers for Canadian application.

The applicable data sheet sections shall be completed and returned by the Manufacturer as part of the quotation.

PART II GENERAL REQUIREMENTS

1.1 TRANSFORMERS FOR US FACILITIES

Transformers for US facilities shall comply with Part III of this DEP, except for pad-mounted transformers (see Part II, 1.2)

Part III is written in the form of amendments and supplements to IEEE Standard C57.12.00:2006. Wherever reference is made to IEEE C57.12.00, it shall be understood to mean IEEE Standard C57.12.00:2006, as amended/supplemented by this DEP.

For ease of reference, the section and clause numbering of IEEE C57.12.00 is used in Part III of this DEP.

Clauses of IEEE C57.12.00 that are not amended by this DEP shall remain applicable as written.

1.2 PAD-MOUNTED TRANSFORMERS FOR US FACILITIES

Pad mounted transformers for US facilities shall comply with Part IV of this DEP.

1.3 TRANSFORMERS FOR CANADIAN FACILITIES

Transformers for Canadian facilities shall comply with Part V of this DEP.

1.4 DOCUMENTATION REQUIREMENTS

Documentation for all transformers shall comply with Part VI of this DEP.

1.5 NON-TECHNICAL REQUIREMENTS

All transformers shall comply with supplemental, non-technical requirements in Part VII of this DEP.

1.6 STATEMENT OF COMPLIANCE

The Manufacturer of the transformer(s) and its ancillary equipment shall confirm that the equipment fully complies with the quotation and the whole system is properly designed, constructed and suitable for the specified duty.

All performance values established in the pre-ordering meeting or quotation (whichever is the later) shall be regarded as maximum or minimum values as applicable.

These values shall also be guaranteed by the Manufacturer under the most arduous conditions specified in this DEP and the requisition.

Tolerances shall be in accordance with this DEP and the relevant reference publications. All the equipment forming part of the order shall be tested individually and in combination at the Manufacturer's works to prove their capability and compliance with the specifications and the performance data.

The Manufacturer shall comply with regulatory requirements applicable to the equipment for the location in which it will be installed.

Whenever equipment proposed by the Manufacturer cannot fully meet the requirements of this DEP, such exceptions shall be clearly stated in Manufacturer's proposal with cross-references to the specific sections and subsections to which exceptions are taken. No exceptions are allowed unless approved by the Electrical Technical Authority in writing.

If no exceptions are taken to these specifications or drawings, a specific statement to that effect shall be included.

If any one of the components or the whole system does not comply with the specifications and any agreed amendments, the Manufacturer shall rectify and re-test the transformer(s) within a mutually agreed time.

1.7 LIFETIME AND RELIABILITY

The equipment (including auxiliaries) covered by this standard shall be suitable for the specified operating conditions. Equipment shall be designed and constructed for a minimum service life and uninterrupted continuous operation as specified. It is recognized that this is a design criterion and that uninterrupted operation for this period of time involves factors beyond the Manufacturer's control.

1.8 PRE-ORDERING MEETING

If deemed necessary by one of the parties involved, a pre-ordering meeting shall be arranged to define clearly the overall scope of supply, individual responsibilities and test methods.

PART III REQUIREMENTS FOR LIQUID-IMMERSED POWER TRANSFORMERS FOR US APPLICATIONS (AMENDMENTS/SUPPLEMENTS TO IEEE C57.12.00)**4 SERVICE CONDITIONS****4.3 UNUSUAL SERVICE CONDITIONS**

Add new clauses:

4.3.4 Captive Transformers

If specified, the transformer will be used as a captive transformer for a large motor. The transformer design shall be suitable for across-the-line starting of the motor and shall be able to withstand the mechanical and thermal duty imposed by the magnitude of the motor starting currents and the permissible number of starts and intervals between starts. Heavy-duty bracing and heavy-duty no-load tap changer shall be provided as necessary for captive transformer service. As an option, Manufacturer/Supplier shall quote bolted links in lieu of no-load tap changer.

4.3.5 Non-Linear Loads

Transformers specified to supply non-linear loads, such as adjustable speed drives shall meet the requirements of IEEE C57.18.10. Transformers which have more than 20% of their base rating as nonlinear loads shall have the rating determined in accordance with IEEE C57.110.

5. RATING DATA**5.4 RATED KILOVOLTAMPERES****5.4.2 Preferred continuous kilovoltampere ratings**

Replace this clause with:

The continuous self-cooled (ONAN) kVA ratings of single-phase and three-phase distribution and power transformers shall be based on an average winding rise by resistance of 55°C, in accordance with 5.11.1.1, and are listed in Table 3 of IEEE C57.12.00.

In addition to the self-cooled (ONAN) 55°C temperature rise kVA rating, transformers shall have an additional self-cooled 65°C temperature rise kVA rating at least 112% of the 55°C kVA rating.

If specified, transformers shall have additional cooling stage ratings as indicated below:

- For transformers rated 500–2499 kVA, the forced air-cooled (ONAF) rating, shall be 115% of the self-cooled rating.
- For transformers rated 2500–11999 kVA, the forced air-cooled (ONAF) rating, shall be 125% of the self-cooled rating.
- For transformers rated 12000 kVA and above, the 1st cooling stage rating, shall be 133% of the self-cooled rating. The 2nd cooling stage rating shall be 166% of the self-cooled rating

Add new clause:

5.4.3 Design life

Transformers shall be designed to operate continuously at rated kVA under site conditions listed on the Data Sheet. Transformers shall have a design lifetime of at least 25 years, when delivering rated output under the site conditions specified, and maintained according to the Manufacturer's recommendation.

Add new clause:

5.4.4 NRTL

If specified, transformers shall be NRTL listed and be labelled in accordance with UL Guideline XPLH. Definitions and guidance on NRTLS (US), which are listing and certifying agencies, are provided in Electrical Design DEP 33.64.20.10-Gen.

NOTE: NRTL listing is normally not required. Examples of when a NRTL listing is required include local code authority requirements and insurance requirements.

5.8 IMPEDANCE

Replace this clause with:

The impedance shall be referred to a temperature equal to the sum of the rated average winding temperature rise by resistance, plus 20°C. Unless otherwise specified, standard percent impedance voltages at self-cooled (ONAN) kVA rating at 55°C rise shall be in accordance with Table 3 of IEEE C57.12.10.

5.10 INSULATION LEVELS

Add to this clause:

Unless otherwise specified, basic impulse insulation level (BIL) levels shall be the highest option listed in Table 4. The neutral ends of windings shall have the same insulation levels as the line ends. The neutral bushing shall be identical to the line end bushings.

5.11 TEMPERATURE RISE AND LOADING CONDITIONS

5.11.1 Limits of observable temperature rise

5.11.1.1 Winding temperature rises

Replace 1st sentence in clause with:

Unless otherwise specified, the average winding temperature rise above ambient temperature shall not exceed 55° C at rated kVA when tested in accordance with IEEE Std. C57.12.90 using the combination of connections and taps that give the highest average winding temperature rise.

5.11.1.4 Liquid temperature rise

Replace this clause with:

The temperature rise of the insulating liquid at base rating and measured near the top of the tank shall not exceed the average winding temperature rise above ambient.

5.12 NAMEPLATE

5.12.1 General

Add to this clause:

Transformers shall have a stainless steel nameplate mounted with stainless steel or silicon bronze hardware to the tank at approximately eye level.

5.12.2 Nameplate information

Replace this clause with:

Unless otherwise specified, the minimum information shown on the nameplate shall be that specified in Table 7 and its associated notes, and shall be in accordance with the following categories:

- a) Nameplate A shall be used on transformers rated below 500 kVA with a high-voltage basic impulse insulation level (BIL) less than 150 kV.

b) Nameplate B shall be used on transformers rated below 500 kVA, which are not covered above.

c) Nameplate C shall be used on transformers rated 500 kVA and above.

In addition, PCB content shall be labeled on the nameplate based on test results as specified in Sec 8.2.7.4

6. CONSTRUCTION

6.1 BUSHINGS

Add to this clause:

Additional bushing features include:

- a) Bushings and terminal enclosures shall be in accordance with the data sheet.
- b) Bushings shall have bolted construction.
- c) Gaskets shall be retained by positive means, such as recessed spaces, to avoid deformation when bushing is installed. Cork gaskets shall not be used. Provide Nitrile (Buna N) or equivalent material gaskets. Alternatively, provide Viton or equivalent material gaskets.
- d) For sealed transformers, integrity of gaskets shall be tested by pressurizing the tanks to a minimum of 10 psig for 2 hours, and checking for leaks.

NOTE: For conservator type transformers, consult with the Manufacturer for the appropriate pressure test value.

- e) Unless otherwise specified, bushings shall have tin-plated copper NEMA standard four-hole pads.
- f) Neutral shall be brought out through a bushing.
- g) To minimize spare parts, neutral bushings shall be identical to phase bushings.
- h) Unless otherwise specified, neutral bushing shall be located along with the phase bushings.

6.2 TRANSFORMER ACCESSORIES

Replace this clause with:

Specific information on accessories is contained below.

Add new clause:

6.2.1 General

Transformers shall have the following accessories and accessory features:

- a) Standard IEEE accessories as listed in IEEE C57.12.10, Table 4, under the "Power BIL" column.

NOTE: For 500 kVA transformers, the accessory requirements under the column heading 750 – 10,000 Power BILs shall apply, since IEEE C57.12.10 does not cover 500 kVA transformers, whereas this DEP does.

- b) Gas-sampling valve.
- c) Automatic-resetting tank pressure relief device with indication of operation and one Form C alarm contact.
- d) Nitrogen purge nozzle and shut-off valve.
- e) Dial-type thermometer shall have two Form C contacts, one for alarm and one for fan control when required, that are adjustable from 65°C to 110°C; it shall also have a hand-reset pointer to register the highest temperature attained.

- f) Liquid level indicator shall have one nonadjustable Form C alarm contact set to close at the minimum safe operating level of the insulating liquid.
- g) All contacts shall:
 - 1) be wired with color cycled cable; and,
 - 2) have permanent labeling (wire markers) at the control box end, in conformance with IEEE C57.12.10 Section 9.7.2; and,
 - 3) have wiring that corresponds to the identifications shown on the Manufacturer's wiring and control schematics.
- h) Pressure-vacuum gauge shall have alarm contacts
- i) All accessories, auxiliary equipment and associated wiring methods shall be suitable for the area classification in which the equipment is installed. This requirement pertains to all equipment referenced throughout Part III.
- j) Globe-type combination drain and lower filter valve with oil-sampling connection:
 - 1) The oil sample valve shall not be located under or above the radiators.
 - 2) Shall have a plug installed.
- k) Globe-type upper filter valve.
- l) Schrader valves shall not be used.
- m) If specified on the data sheet, a pressure-rated oil level sight glass, type Portage Mfg model 51-WP or equal, shall be provided

NOTE: Gas sampling valves and Nitrogen purge nozzle w/ shut off valve are not applicable for conservator type transformers. See 11.2 for additional accessories for conservator transformers.

Add new clause:

6.2.2 Accessories location

- a) All switches and devices (except tap changers) that are operated or tested shall be located at a maximum height of 60" above the transformer base.
- b) Devices mounted above this height shall be legible from the grade.
- c) The view of the instruments from the grade level shall be unobstructed.
- d) All wiring of the accessories shall be properly supported and routed to minimize damage.

Add new clause:

6.2.3 Fan control contacts

Transformers requiring fan control using winding temperature for control shall have one winding temperature simulator with contacts adjustable from 95°C to 125°C.

Add new clauses:

6.2.4 Current monitoring system for cooling fans

6.2.4.1 General requirement

If specified, transformer fans shall have a current monitoring system.

At minimum, the current monitoring system shall have:

- a) two (2) normally open (NO) alarm contacts, and
- b) two (2) normally closed (NC) alarm contacts.
- c) Alarm contacts shall indicate non-functional fans to the customer:
 - 1) with the fan control switch in the manual mode, or

2) in the automatic mode when the fan operation is required.

6.2.4.2 Manufacturer responsibility

The Manufacturer shall provide a complete description of the current monitoring system with the quotation.

Add new clauses:

6.2.5 Dissolved gas monitoring system

6.2.5.1 Insulating liquid

- a) If specified, mineral oil insulating liquid shall be provided with a dissolved gas monitoring system.
- b) The dissolved gas monitoring system shall continuously monitor the dissolved gases in the insulating liquid.

6.2.5.2 Manufacturer responsibility

The Manufacturer shall provide a complete description of the proposed dissolved gas monitoring system with the quotation.

Add new clause:

6.2.6 Pressure rate-of-rise relay

Unless otherwise specified, transformers 1000 kVA and above shall have a rapid pressure rise relay.

Relays shall:

- a) Be suitable for testing with normal testing tools while the transformer is energized, and
- b) not require the installation of additional equipment for testing.
- c) Have relay contacts provided for alarm and shutdown. Contact rating shall be at least 125 V DC, 5 amperes.

Add new clause:

6.2.7 General hardware requirements

All hardware shall be made of 300 series stainless steel, including:

- a) bolts
- b) fasteners
- c) caps
- d) plugs, etc.

Hexagonal nuts shall be used for welded studs.

Bolts shall have captive hexagon heads.

Add new clause:

6.2.8 Alarm and control devices

Unless otherwise specified, alarm and control devices shall have single-pole, double-throw contacts (Form C), rated 125VDC, 5A.

Alarm and control devices shall:

- a) be clearly identified on the drawings; and,
- b) have identification plates nearby.

Identification plates for alarm and control devices shall:

- a) unless otherwise specified, be made of stainless steel, and
- b) be mounted with screws.

For offshore installations, all wiring methods and devices external to the tank shall be suitable for Class I Division 2 and all junction boxes shall be NEMA 4X minimum.

Add new clause:

6.2.9 Neutral grounding resistors

If specified, neutral grounding resistors shall be provided. If resistors are required, and if they are specified for mounting on the transformer, the Manufacturer shall provide provisions for mounting the resistors. The Principal shall provide details, as applicable, on the resistor and enclosure technical requirements.

Notes to specifying engineer:

1. Use the transformer data sheet to indicate whether resistors are required and if they will be mounted on the transformer.
2. Provide a separate data sheet to provide technical details on the resistor and resistor enclosure in accordance with project specifications.

6.3 BUSHING CURRENT TRANSFORMERS

Change title to: CURRENT TRANSFORMERS

Add new clause:

6.3.1 Current transformers general

Current transformers (CT) shall be supplied in accordance with the data sheet. Current transformers shall comply with IEEE C57.12.10 paragraph 9.8 as well as the applicable requirements in 6.3.2, 6.3.3 and 6.3.4.

Insert original 6.3 clause content:

6.3.2 Additional requirements for bushing current transformers

Bushing current transformers used with bushings having dimensions in accordance with IEEE Std C57.19.01 shall have an inside diameter to accommodate the maximum D dimensions for those bushings, as shown in the applicable tables.

Add new clause:

6.3.3 Additional requirements for all current transformers

The following are requirements for all current transformers:

- a) Unless otherwise specified, CTs used for metering shall meet the accuracy class rating shown in Table 6 in IEEE C57.13.00.
- b) Compression-type, insulated sleeve, seamless ring tongue connectors shall be used for CT circuits.
- c) CT wiring shall be No. 10 AWG stranded copper, minimum.
- d) One side of the secondary winding of each current transformer circuit shall be grounded at the CT terminal block.
- e) Terminal blocks shall be clearly marked designating the CT phase and tap number.
- f) Polarity marking for CT wiring shall be shown at all terminals.
- g) Current transformers shall be selected so that they don't saturate under short circuit conditions, based on the short circuit current available through the transformer.
- h) Terminal blocks for CT wiring shall have provisions for shorting the CT circuits.