
Requirements

Classification: Internal

Status:  Relevant

Version: 3.02

TR3123 Transformers

Project development

Requirements, TR3123, Version 3.02,

Document replaces version 3.01

Relevant versions:

- [3.01](#) (2017-09-08 14:41)
- [3.02](#) (2019-06-05 13:56)

1	Objective, target group and provision	5
1.1	Objective	5
1.2	Target group	6
1.3	Provision	6
2	Common design requirements	6
2.1	General	6
2.2	Duty and rating	8
2.3	Windings	8
2.4	Neutral points	8
2.5	Core	9
2.6	Noise	9
2.7	Terminals and wiring	9
2.8	Labelling	10
2.9	Carriage	10
2.10	Surface treatment	10
2.11	Vibration damper	11
2.12	Tolerances	11
3	Liquid-immersed transformers	11
3.1	General	11
3.2	Windings	11
3.3	Insulating liquid	12
3.4	Tappings	12
3.4.1	On-load tap changer, OLTC	12
3.4.2	Off-circuit tap changer, OCTC	13
3.5	Cooling and allowed temperature rise	13
3.5.1	General	13
3.5.2	Conventional paper – oil insulation	13
3.5.3	High temperature insulation	14
3.6	Bushings	14
3.7	Current transformers	15
3.8	Tank	15
3.9	Protective housing for cable terminations	16
3.10	Control and monitoring	16
3.11	Testing	17
4	Dry insulated transformers	17
4.1	Windings	17

4.2	Tappings	18
4.3	Core	18
4.4	Cooling and allowed temperature rise	18
4.5	Protective housing	19
4.6	Requirement for climatic, environmental and fire behaviour classes	19
4.7	Control and monitoring	20
4.8	Testing	20
5	Additional information	20
5.1	Definitions and abbreviations	20
5.2	Changes from previous version	21
5.3	References	22

This document and its content, is for authorized company use only

1 Objective, target group and provision

1.1 Objective

The specification establishes requirements for design, construction and testing of high voltage transformers for onshore and offshore service.

The specification contains three parts. Section 2 is valid for all transformers, section 3 is applicable to liquid-immersed transformers, and section 4 is applicable for dry insulated transformers.

The referred standards are either based on IEC or based on IEEE. The standards have been referred to by one common number as shown in section 5.3. The IEEE standards are applicable in US or Canada, while IEC standards are applicable elsewhere.

The specification is based on IEC 60076 or IEEE C57 whichever are applicable, and the content specifies:

- In more detail specific IEC / IEEE requirements.
- Which one of several optional IEC / IEEE alternatives to be used.
- Requirements not covered in IEC / IEEE.
- Alternative requirements to be used instead of requirements described in IEC / IEEE.

The specification can be used for low voltage transformers, such as 690 - 400 V transformers.

The document can be used as basis for

- Subsea transformers, however requirements related to subsea environment are not part of this document.
- Generator step-up transformers to connect wind turbines to a network. These transformers are installed in the nacelle or in the tower or outside close to the wind turbine. Ref IEC 60076-16. Currently there is no comparable IEEE standard on this topic.

Reactors are not covered by this document.

In this document the IEC terminology is used for Earth instead of the ANSI terminology which is Ground.

1.2 Target group

The target group for this document is personnel involved in preparing technical and operational requirements and standards to be applied in project development work.

1.3 Provision

Provision is made in Management System (TR3020 Electrical, Technical Requirements and Standards).

2 Common design requirements

2.1 General

SR-47880 - Design of transformers shall be in accordance with:

IEC			IEEE		
IEC 60076-1	2011	Power transformers, Part 1: General	IEEE C57.12.00 IEEE C57.12.90	2010 2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-2	2011	Power transformers, Part 2: Temperature rise	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-3	2013	Power transformers, Part 3: Insulation levels, dielectric tests and external clearances in air	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-5	2006	Power transformers, Part 5: Ability to withstand short circuit	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating

					Transformers
IEC 60076-7	2005	Power transformers, Part 7: Loading guide for oil-immersed power transformers	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-10	2005	Power transformers, Part 10: Determination of sound levels	IEEE C57.12.90 IEEE C57.12.91	2010 2011	Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers Test Code for Dry-Type Distribution and Power Transformers
IEC 60076-11	2004	Power transformers, Part 11: Dry-type transformers	IEEE C57.12.01 IEEE C57.12.91	2005 2011	General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings. Test Code for Dry-Type Distribution and Power Transformers
IEC 60076-12	2008	Power transformers, Part 12: Loading guide for dry-type power transformers	IEEE C57.12.01	2005	General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings
IEC 60076-14	2013	Power transformers, Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials	IEEE 1276	2000	IEEE Guide for the application of High-Temperature Insulation Materials in Liquid-Immersed Power Transformers

2.2 Duty and rating

SR-47882 - All tapings shall be full-power tapings.

SR-47883 - Harmonic currents in e.g. converter transformers will increase losses and temperatures of the windings and nearby steel parts of the transformer. The effect of harmonic currents shall be taken into account according to IEC 61378-1 or IEEE C57.18.10 respectively.

SR-47884 - Ancillary components and construction features such as bushings, cable-end connections, tap-changing devices, internal leads, liquid expansion space etc., shall be dimensioned in a manner that will not limit the loading to less than the capability of the windings.

2.3 Windings

SR-47886 - For transformers rated above 16 MVA all tapped windings shall be separate windings. This means that there shall not be tapings made as an integrated part of a winding.

SR-47887 - One of the windings shall be delta connected. For a stabilizing winding both ends of at least one corner of the delta shall be brought out on separate bushings.

SR-47888 - For transformers with specifications based on IEC: The insulation level for low voltage transformers shall be according to $U_m \leq 1.1$ kV given by table 3 in section 12.1 in IEC 60076-11.

SR-47889 - Increased losses due to harmonic currents shall be taken into account in thermal dimensioning in accordance with IEC 61378-1 or IEEE C57.18.10 respectively.

2.4 Neutral points

SR-47891 - Neutral point(s) shall have uniform insulation if not otherwise stated in the datasheet. The transformer shall be designed for operation with neutral points directly earthed, earthed via a resistor or reactor, or isolated. The neutral point(s) shall be brought out on a separate bushing.

SR-47892 - The rated current of the neutral point shall be equal to the rated current of the corresponding transformer windings terminals.

SR-47893 - Where a Neutral Earth Resistor (NER) is specified in datasheet, then the resistor shall be connected between the neutral point and the earth bar. A current transformer shall be

provided for measuring the neutral point current. The current transformer and the NER shall be mounted in a separate purpose made enclosure mounted outside of the transformer housing.

SR-47894 - The CT shall be according to IEC 61869-2 or IEEE C57.13 respectively. All secondary leads shall be brought out to terminal blocks in the cabinet. The terminals shall be provided with short-circuiting links.

SR-47895 - The cable for connection of the NER to the transformer neutral point must be dimensioned for overvoltages due to e.g. failures in other part of the network.

2.5 Core

SR-47897 - All metal parts of the core, frame, tank etc. shall be bonded to earth.

SR-47898 - The core sheets of the magnetic circuit of transformers exceeding 16 MVA shall be bonded to the core clamping structure through at least one removable core-insulation test link. The link shall be placed in an accessible position. With the bond removed, the core sheets of the magnetic circuit shall be insulated from the core clamping and all structural parts.

2.6 Noise

SR-47900 - If not otherwise is specified in the datasheet at then the sound pressure level when the transformer is energised, plus when cooling equipment and any oil-circulating pumps are in service, shall not exceed 85 dB(A) at 1m distance measured according to IEC 60076-10 or IEEE C57.12.90 and IEEE C57.12.91 respectively.

2.7 Terminals and wiring

SR-47902 - Marking of internal components and wiring shall be according to TR3120 section 4.11.

SR-47903 - All signals from instruments, Current Transformers CTs, sensors etc. shall be connected in a separate cabinet. Internal wiring shall be according to TR3120 section 4.10.

SR-47904 - Light fixture and space heaters inside cabinets shall be according to TR3120 section 4.17.

SR-47905 - Earthing of the transformer shall be according to TR3120 section 4.8 (high voltage equipment).

SR-47906 - The transformer shall be provided with a minimum of two earth terminals for connection to the external earth grid. The terminals shall be located on opposite sides of the

transformer to enable easy connection to the earth grid. Both terminals shall be boss type to enable connection via lugs.

SR-47907 - For transformers with specifications based on IEEE, 2 hole lugs shall be provided.

2.8 Labelling

SR-47909 - The requirement for labelling is stated in TR3120.

SR-47910 - The rating plate shall be in accordance with requirements in :

IEC			IEEE		
IEC 60076-1	2011	Power transformers, Part 1: General	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
			IEEE C57.12.90	2010	Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 61378-1	2011	Converter Transformers, Part 1: Transformers for industrial applications	IEEE C57.18.10	1998	Practices and Requirements for Semiconductor Power Rectifier Transformers

2.9 Carriage

SR-47912 - Transformers shall be provided with lifting lugs to enable lifting of the complete unit.

2.10 Surface treatment

SR-47914 - Surface and protective coating for transformers located outdoor in natural ventilated area shall be according to TR0042 cl 2. The manufacturer's standard painting system and standard colour are acceptable for transformers located in a mechanically ventilated area.

SR-47915 - Isocyanate-based products (e.g. polyurethanes) or products that release di-isocyanates when heated shall not be used.

2.11 Vibration damper

SR-47917 - Use of vibration dampers shall be evaluated to ensure that transformers do not cause unwanted vibration and noise to their surroundings.

2.12 Tolerances

SR-47919 - The tolerances shall be according to IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively.

SR-47920 - The plus tolerance for the noise level is zero, i.e. the measured noise level shall be equal to or below the stated limit.

3 Liquid-immersed transformers

3.1 General

SR-47923 - The transformer shall have IP-rating according to requirements for outdoor or naturally vented area in TR3120 cl 3.1.

3.2 Windings

See section 2.3 in this document for general requirements.

SR-47926 - For transformers based on IEEE specifications the insulation paper of the windings shall be thermally upgraded IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively.

See requirements for high temperature design in section 3.5.3.

SR-47928 - The rated withstand voltages for transformer windings shall be selected to the highest value as given in table 2 in IEC 60076-3. Values indicated with “note a” in table 2 in IEC 60076-3 shall not be used.

3.3 Insulating liquid

SR-47930 - Mineral inhibited oil according to IEC 60296 or IEEE C57.106 shall be used for transformers with U_m equal to or above 72,5 kV or 69 kV for IEC or IEEE based specifications, respectively.

SR-47931 - Silicone type oil can be used for transformers with U_m equal to or below 36 kV or 34,5 kV for IEC or IEEE based specifications.

SR-47932 - Silicone type oil shall not be used for transformers with On-Load Tap Changer, OLTC, due to the poor lubrication of the tap contacts.

SR-47933 - Use of insulation liquids for allowing temperatures above 105°C, e.g. listed in /9/, shall not be used for transformers with U_m equal to or above 72,5 kV or 69 kV for IEC or IEEE based specifications due to the limited experience of dielectric withstand capability of such insulating liquids.

3.4 Tappings

3.4.1 On-load tap changer, OLTC

SR-47936 - If an OLTC is specified, then the following shall apply:

- The OLTC and the corresponding motor drive cabinet shall be in accordance with IEC 60214-1 or IEEE C57.131 respectively.
- A protective device shall be installed to detect sudden pressure increase in the diverter switch oil compartment.
- Light fixture and space heaters inside cabinet shall be according to TR3120 section 4.17.
- Manholes shall be provided for accessing the contacts of the OLTC during servicing.

3.4.2 Off-circuit tap changer, OCTC

SR-47938 - If an OCTC is specified, then the following shall apply:

- The OCTC and the corresponding motor drive cabinet shall be in accordance with IEC 60214-1 or IEEE C57.131 respectively.
- The number of positions shall be 5 unless otherwise agreed.
- There shall be a locking device at the manual drive mechanism which requires a deliberate act by the operator to remove it before operating the drive. The manual drive mechanism shall be capable of being locked in any one of the tap positions.
- If a motor drive is specified, then the light fixture and space heaters inside cabinet shall be according to TR3120 section 4.17.

3.5 Cooling and allowed temperature rise

3.5.1 General

The external cooling medium is either air or water.

SR-47942 - The yearly average ambient cooling medium temperature is stated in the datasheet. Otherwise the yearly average temperature shall be as stated in IEC 60076-2 or IEEE C57.12.00 respectively.

SR-47943 - In case of water cooling, the coolers shall be of double wall design, and shall be equipped with a leakage monitoring system. All water exposed materials in the cooler shall be compatible with the cooling water.

SR-47944 - Plate and Frame Heat Exchangers shall be according to cl 2 in TR0041. The flanges for the water side of the heat exchanger shall be according to cl 2 in TR2000.

3.5.2 Conventional paper – oil insulation

The stated yearly average temperature of the external cooling medium is 20 °C for IEC and 30 °C for IEEE based specifications.

SR-47947 - The average temperature rise of the transformer windings at rated power shall not exceed 65 K, and the top oil temperature shall not exceed 60 K. Reference is made to IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively.

SR-47948 - If the yearly average temperature of the external cooling medium given by the

datasheet exceeds the stated yearly average temperature from the standards (IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively), then the average temperature rise limit of the transformer windings and top oil shall be reduced by the same amount as the excess. Three examples are given for yearly average external cooling medium excess temperatures of 0 K, 10 K and 20 K respectively.

Table 1: Allowed temperature rises of average windings and top oil

Yearly average excess temperature of external cooling medium	Limit for average temperature rise of transformer windings	Limit for temperature rise of transformer top oil
0 K	65 K	60 K
10 K	55 K	50 K
20 K	45 K	40 K

3.5.3 High temperature insulation

High temperature insulation design is based on temperatures in excess of thermal class 105 °C, for the solid insulation, see reference IEC 60076-14 or IEEE 1276 respectively.

SR-47952 - The high temperature design shall as a minimum be based on hybrid insulation system. The average temperature rise of the transformer windings at rated power shall not exceed 95 K, and the top oil temperature shall not exceed 60 K. Reference to other requirements in IEC 60076-14 or IEEE 1276 respectively..

SR-47953 - Minimum thermal class for the high-temperature solid insulation shall be 155 °C.

SR-47954 - If the yearly average temperature of the external cooling medium from the datasheet exceeds the stated yearly average temperature from the standards (IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively), then the average temperature rise limit of the transformer windings and top oil shall be reduced by the same amount as the excess.

3.6 Bushings

Type of bushings will be described in datasheet.

SR-47957 - For air insulated bushings the IP code of the protective housing for cable terminations shall be according to section 3.1, if not otherwise stated.

SR-47958 - For plug-in type bushing or equivalent touch proof solution, a portable earthing device shall be delivered, if not otherwise stated.

SR-47959 - It shall be provision for measuring voltage at the bushing to be able to check if the

transformer is energized.

SR-47960 - The transformer bushings shall be of outdoor type, and shall comply with IEC 60137 or IEEE C57.19.00 respectively..

3.7 Current transformers

SR-47962 - The CT shall be according to IEC 61869-2 or IEEE C57.13 respectively..

3.8 Tank

See requirements in section 2.9.

SR-47965 - The transformer tank shall be designed for a static overpressure of at least 1 barg.

SR-47966 - The transformer skid base shall be designed for handling of the liquid filled transformer.

SR-47967 - Jacking pads should be available on the transformer tank to allow jacking of the liquid filled transformer.

SR-47968 - There shall be valves provided for at least:

- Liquid filling, draining and venting of all liquid volumes.
- Liquid sampling from top of the tank. The valve shall be placed within reach from the floor such that there is no need to use of scaffolding or a ladder for sampling.
- Isolating external cooling equipment from transformer tank.
- Isolating each compartment of the conservator tank from the transformer tank.

SR-47969 - A moisture-removing breather shall be provided for each chamber of the oil conservator tank.

SR-47970 - Transformers with U_m equal to or above 24 kV shall have a diaphragm-type oil preservation system to avoid direct contact between the transformer oil and air. A flexible diaphragm or bladder shall be used for this purpose.

SR-47971 - The liquid conservator shall have a separate compartment for the OLTC diverter switch oil if OLTC is part of the transformer. For this compartment a free breathing system can be used.

SR-47972 - 316L stainless steel shall be used for fasteners (screws, bolts, nuts, etc.) up to and including a diameter of 10 mm. For diameters above 10 mm fasteners shall be hot dip

galvanised in accordance with ASTM A153 or coated with PTFE with anticorrosion pre-treatment such as cermet.

The requirement for fasteners does not apply to fasteners inside the transformer tank.

3.9 Protective housing for cable terminations

SR-47975 - The IP rating for protective housing shall be according to requirements in section 3.1.

SR-47976 - It shall be possible to measure voltage at the terminals before removal of the protective housing of the cable terminals.

3.10 Control and monitoring

SR-47978 - The following instrumentations shall be provided as a minimum:

- Oil level gauges for each compartment of the conservator tank. The gauges shall have contacts for high and low oil level.
- Gas relay installed in the pipe between transformer tank and conservator. The relay shall have contacts for alarm and trip indicating slow gas development or rapid pressure build up.
- Hermetically sealed transformers shall be equipped with pressure relief device. The device shall have contact for the trip circuit.
- Top oil temperature measurement enabling local and remote reading. There shall be two sets of contacts. One for the alarm circuit and one for the trip circuit.
- Winding temperature indication based on thermal image enabling local and remote reading. There shall be two sets of contacts. One for the alarm circuit and one for the trip circuit.
- For OLTC pressure increase device (see section 3.4.1), there shall be contact for the trip circuit.
- In case of OFWF cooling – there shall be a water leakage monitoring system enabling remote indication.
- In case of Oil Forced, OF, cooling – there shall be an oil flow indicating system enabling remote indication.

3.11 Testing

SR-47980 - Routine tests shall be in accordance with IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively..

SR-47981 - The following non-routine tests listed in IEC 60076-1 or IEEE C57.12.00 and IEEE C57.12.90 respectively shall be performed:

- Temperature-rise test for transformers rated 16 MVA and above.
- Determination of capacitances windings-to-earth, and between windings for all converter transformers
- Audible sound level.

SR-47982 - If several identical transformers are ordered, the non-routine test should be performed on one transformer only.

SR-47983 - A dissolved gas in oil analysis shall be performed according to IEC 60076-2 or IEEE C57.12.00 respectively.

4 Dry insulated transformers

4.1 Windings

See section 2.3 in this document for general requirements.

SR-47987 - The insulation level shall be according to:

- List 2 in table 3 of section 12.1 for the IEC-based specification IEC 60076-11.
- The highest indicated basic lightning impulse level stated in table 5 in section 5.10 for the IEEE based specification IEEE C57.12.01 and IEEE C57.12.91.

SR-47988 - The minimum winding insulation class shall be:

- 155°C (insulation class F) for IEC based specifications (IEC 60076-11)
- 150°C for IEEE based specifications (IEEE C57.12.01 and IEEE C57.12.91).

SR-47989 - Corresponding winding hot spot temperature shall be in accordance with IEC 60076-12 or IEEE C57.12.01 respectively.

SR-47990 - The windings shall be solid-casted or VPI.

SR-47991 - All terminals shall be of copper type. This also applies when aluminium windings is specified.

4.2 Tappings

SR-47993 - The tapping shall be on the primary windings, with steps of approximately $\pm 2 \times 2.5\%$ of rated voltage if not specified otherwise.

SR-47994 - OCTC tapping selection should be made by the use of bolted links instead of off-circuit tap-changers

SR-47995 - If OLTC is specified, then the corresponding motor drive cabinet shall be in accordance with IEC 60214-1 or IEEE C57.131 respectively.

4.3 Core

SR-47997 - The transformer core shall be dimensioned for continuous operation at 110 % of rated voltage referred to the principal tapping and rated power. This is an additional requirement to IEC 60076-11 or IEEE C57.12.01 and IEEE C57.12.91 respectively.

4.4 Cooling and allowed temperature rise

SR-47999 - The yearly average ambient cooling air temperature is stated in the datasheet. Otherwise the yearly average temperature shall be as stated in IEC 60076-11 or IEEE C57.12.01 and IEEE C57.12.91 respectively..

SR-48000 - The stated yearly average temperature of the external cooling medium is 20 °C for IEC and 30 °C for IEEE based specifications. The corresponding average temperature rise of the transformer windings at rated power shall not exceed 100 K for IEC and 90 K for IEEE based specifications. Reference is made to IEC 60076-11 or IEEE C57.12.01 and IEEE C57.12.91 respectively.

SR-48001 - If the yearly average temperature of the external cooling air given by the datasheet exceeds the stated yearly average temperature from the standards IEC 60076-11 or IEEE C57.12.01 and IEEE C57.12.91 respectively, then the average temperature rise limit of the transformer windings shall be reduced by the same amount as the excess.

4.5 Protective housing

See requirements in TR3120.

SR-48004 - The transformer shall be in a housing that is cooled by external air or water

SR-48005 - The IP rating for the protective housing shall be according to requirements in section 3.1.

SR-48006 - Doors and panels shall be hinged. There shall be isolating bars behind the doors. The bars shall be coloured yellow and black (zebra stripes) if not otherwise required by national regulation.

SR-48007 - Transformer enclosures for ratings equal to or greater than 315 kVA should be equipped with windows that allow thermo graphic inspection.

4.6 Requirement for climatic, environmental and fire behaviour classes

SR-48009 - The climatic, environmental and fire behaviour classes shall be selected according to Table 2 below unless otherwise agreed in e.g. datasheet.

Table 2 Requirement for climatic, environmental and fire behaviour classes

Climatic C1	The transformer is suitable for operation at ambient temperature not below -5°C but may be exposed during transport and storage to ambient temperatures down to -25°C.
Environmental E1	Occasional condensation can occur on the transformer (for example, when the transformer is de-energised). Limited pollution is possible.
Fire F1	Transformers subject to a fire hazard. Restricted flammability is required. The emission of toxic substances and opaque smokes shall be minimized.

For transformers based on IEC standards further information can be found in section 13 of IEC 60076-11.

4.7 Control and monitoring

SR-48013 - The following instrumentations shall be provided as a minimum:

- Winding temperatures enabling local and remote reading. Temperatures shall be measured on the windings, two measuring point per phase. The sensors shall be located where hot spot temperatures are anticipated. There shall be two sets of contacts. One for the alarm circuit and one for the trip circuit.

4.8 Testing

SR-48015 - Routine testing shall be in accordance with IEC 60076-11 or IEEE C57.12.01 and IEEE C57.12.91 respectively.

SR-48016 - The following non-routine tests shall always be performed (ref IEC 60076-11 or IEEE C57.12.01 and IEEE C57.12.91 respectively):

- Temperature-rise test together with the planned protective housing unless otherwise agreed upon.
- Partial discharge measurement special test.
- Determination of capacitances windings-to-earth and between windings for all converter transformers.

SR-48017 - If several identical transformers are ordered, the non-routine test should be performed on one transformer only.

5 Additional information

5.1 Definitions and abbreviations

Shall (requirement)	Requirement strictly to be followed in order to confirm to the document and from which no deviation is permitted, unless a deviation permit is approved.
Should (recommendation)	Indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is

	preferred but not necessarily required, or that (in the negative form) possibility or course of action is deprecated but not prohibited.
May	Indicates a course of action permissible within the limits of the document.
Can	Statements of possibility and capability, whether material, physical or causal.
AC	Alternating current
AF	Air Forced
AN	Air Natural
Converter transformer	Transformer feeding a converter load
CT	Current Transformer
DEH	Direct Electric Heating
IP	Ingress Protection
NER	Neutral Earth Resistor
OCTC	Off Circuit Tap Changer
OFWF	Oil Forced Water Forced
OLTC	On Load Tap Changer
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
U_m	Highest voltage for equipment
VPI	Vacuum Pressure Impregnation

5.2 Changes from previous version

Changes in version 3.02:

Document updated from template to template. Wording "" changed to ""'. Insignificant changes, performed by system administrator, on behalf of author/owner.

Changes in version 3.01:

Published in new minor version as part of the GEM-project (Governing Element Management). TR-document is digitalized, and each requirement element is now identified with a unique ID.

Changes in version 3:

- General: Editorial changes, updated IEC / IEEE references and added references to TR3120
- Section 2.1: Deleted requirements for base case transformers
- Section 2.3: Deleted requirement for uniform winding insulation and included reference to IEC 61378-1
- Section 2.5: Removed requirement for 110 % core dimensioning is required for all type of transformers
- Section 2.9: Non-technical information removed
- Section 2.11: New section added for vibration dampers
- Section 3.6: Updated text and that bushing type will be described in datasheet
- Section 3.7: Removed requirement for CT for thermal image
- Section 4.3: The transformer core shall be dimensioned for continuous operation at 110 % of rated voltage referred to the principal tapping and rated power.
- Section 4.6: Fire class updated from F0 to F1

5.3 References

The documents listed below include provisions and guidelines which, through reference in this specification, constitute provisions and guidelines of this specification.

SR-48025 - Latest issue of the referred document shall be used unless otherwise agreed.

Other recognized standards may be used provided it can be shown that they meet or exceed the requirements and guidelines of the standards referenced below.

Note that references in this specification (e.g. references to clause numbers in standards) are based on year of issue as listed below.

Table 3: Standards that are the basis for transformer specification

IEC			IEEE		
IEC 60076-1	2011	Power transformers, Part 1: General	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
			IEEE C57.12.90	2010	
					Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEC 60076-2	2011	Power transformers, Part 2: Temperature rise	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-3	2013	Power transformers, Part 3: Insulation levels, dielectric tests and external clearances in air	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-5	2006	Power transformers, Part 5: Ability to withstand short circuit	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-7	2005	Power transformers, Part 7: Loading guide for oil- immersed power transformers	IEEE C57.12.00	2010	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEC 60076-10	2005	Power transformers, Part 10: Determination of sound levels	IEEE C57.12.90 IEEE C57.12.91	2010 2011	Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers Test Code for Dry-Type Distribution and Power Transformers
IEC 60076-11	2004	Power transformers, Part 11: Dry-type transformers	IEEE C57.12.01 IEEE C57.12.91	2005 2011	General Requirements for Dry- Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings. Test Code for Dry-Type Distribution and Power Transformers
IEC 60076-12	2008	Power transformers, Part 12: Loading guide for dry- type power transformers	IEEE C57.12.01	2005	General Requirements for Dry- Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings
IEC	2013	Power transformers, Part	IEEE 1276	2000	IEEE Guide for the application

60076-14		14: Design and application of liquid-immersed power transformers using high-temperature insulation materials			of High-Temperature Insulation Materials in Liquid-Immersed Power Transformers
IEC 60214-1	2003	Tap-changers, Part 1: Performance requirements and test methods	IEEE C57.131	2012	Requirements for Load Tap Changers
IEC 61378-1	2011	Converter Transformers, Part 1: Transformers for industrial applications	IEEE C57.18.10	1998	Practices and Requirements for Semiconductor Power Rectifier Transformers
IEC 60137	2008	Insulated bushings for alternating voltages above 1000 V	IEEE C57.19.00	2004	General Requirements and Test Procedure for Power Apparatus Bushings
IEC 60296	2012	Fluids for electrotechnical applications – unused mineral insulating oils for transformers and switchgear	IEEE C57.106	2006	Guide for Acceptance and Maintenance of Insulating Oil in Equipment
IEC 61869-2	2012	Instrument transformers – Part 2: Additional requirements for current transformers	IEEE C57.13	2008	Requirements for Instrument Transformers
IEC 60076-16	2011	Power transformers, Part 16: Transformers for wind turbine applications	NA	NA	NA

Table 4: Other technical requirements

TR0041	Plate and Frame Heat Exchangers
TR0042	Surface preparation and protective coating
TR2000	Piping and Valve spec.
TR3120	Electrical equipment, general requirements