

Testing forms an important phase of transformer manufacturing, ensuring that the product complies with the customer specifications and guaranteed technical particulars



**ABSTRACT**

Testing forms an important phase of transformer manufacturing, ensuring that the product complies with the customer specifications and guaranteed technical particulars. Transformer engineers must have a thorough knowledge of testing procedures as per national standards.

**KEYWORDS**

Standards, testing, IEC, Cigre, IEEE

In addition to the standards, transformer performance tests used for thermal evaluation of insulation systems and painting are also covered

# Standards relevant to transformers - Part VII

## Transformer testing

### 1. Introduction

In Part VI of this column, we covered national standards for different types of transformers used for various appli-

cations. In this part, we have compiled transformer testing standards available to power engineers. In addition to standards for various transformer tests, tests used for thermal evaluation of insulation

systems and painting are also covered. However, transformer oil and diagnostic tests are not included as they will be covered in the forthcoming parts of this column.

### 2. Standards

Details of tests	IEC Standard/CIGRE TB	ANSI/IEEE Standard	EN/ Indian Standard
General, oil-filled transformer testing	60076-1 - Ed 3.1-2011 (2000)	C57.12.90 - 2015 (2010)	
HVDC transformer		IEEE/ IEC 60076-57-129 2017 (2007)	
General, testing of dry-type transformers		C57.12.91 – 2020 (2011)	
Test code for dry-type reactors and smoothing reactors for DC transmission		1277 - 2020 (2010)	
Test guide for electrical measurements		IEEE 120 - 1989	
Dielectric tests	60076-3 Ed 3.0-2013 / AMD 1:2018 (2000)	C57.12.90 - 2015 (2010)	IS 2026 (Part 3): 2018 / IEC 60076-3(2013)
Impulse / switching surge test	60076-4 Ed 1.0 - 2002	C57.98 - 2011 (1993)	
Software for Impulse test measurement system	61083-2 Edition 2.0 - 2013 (1996)	Impulse testing C57.138-2016 (1998) Recommended practice for impulse test of distribution transformers	



Details of tests	IEC Standard/CIGRE TB	ANSI/IEEE Standard	EN/ Indian Standard
Telephone influence factor - recommended practice for voice –frequency electrical noise tests for distribution transformers  Electronic reporting of DT test data		IEEE 469 – 1988 (1977)  C57.12.37 - 2015 (2006)	
PD testing of Oil-filled transformer	60270 - Ed 3.0 2000 (1981)  60076-3 Ed 3.0-2013 /  AMD 1:2018 (2000)	C57.113 - 2010 (1991)	
PD testing-acoustic method	TS 62478 - Ed 1.0 - 2016	C57.127 - 2018 (2007)	
PD testing – dry-type transformers		C57.124 - 1991	
Insulation resistance measurement for rotating machinery  Insulation resistance test of oil-filled transformers – diagnostic field testing		IEEE Std 43 - 2013 (2000)  C57.152 - 2013 - Clause 7.2.13	
High voltage testing	60060-1 Ed 3.0 - 2010 (general definitions and test requirements)  60060-2 Ed 3.0 - 2010 (measuring system)  61180-Ed 1.0 - 2016 (test techniques for LV equipment)	IEEE Std 4 - 2013 (1995)	
High voltage site testing	60060-3 - Ed 1.0 2006		
Temperature rise test - oil-filled transformer	60076-2 Ed 3.0 - 2011 (1997)	C57.12.90 - 2010 (2010)	IS 2026 (Part 2): 2010 / IEC 60076-2 (1993)
Determination of max winding temperature rise in liquid-filled transformers		IEEE Std 1538 - 2000 (R2011)	
Dry-type transformer -determination of hot spot temperature of dry-type transformers  Transient voltage analysis of a dry-type transformer coil		C57.134 - 2013 (2000)  C57.12.58 - 2017 (1991)	
Temperature rise test above rated load		C57.119 - 2018 (2001)	
Test for thermal evaluation of dry-type transformers (cast resin and resin encapsulated)		C57.12.60 - 2020 (2009)	
Test for thermal evaluation of dry-type transformers (ventilated dry-type)		C57.12.56 - 1986  (withdrawn)	
Test for thermal evaluation of dry-type transformers (Dry-type specialty and general purpose)		IEEE 259 - 1999	
Guide for determination of maximum winding temperature rise in liquid-filled transformers		IEEE 1538 - 2000	

Details of tests	IEC Standard/CIGRE TB	ANSI/IEEE Standard	EN/ Indian Standard
Test procedure for thermal evaluation of insulation systems for liquid-immersed transformers	IEC TS 62332-1 –Ed 2.0 2011 (2005) General requirements IEC TS 62232-2-Ed 1.0 2014 Simplified test	C57.100 - 2011	
Electrical insulation - thermal evaluation and designation	60085 Ed 4.0-2007(2004)		
Evaluation and qualification of electrical insulation system Electrical Insulation systems – procedures for thermal evaluation Electrical insulation systems - thermal evaluation of modifications to an established wire wound EIS Electrical insulation system – short time evaluation of combined thermal and electrical stresses	60505 Ed 4.0-2011/COR1: 2017 (2003) TR 61857 (all parts) Part-2, 2015 - Selection of test method 61858-2 Ed 1.0 - 2014 TS 62101Ed 1.0 - 2005		
Test procedure for thermal evaluation of insulation system of dry-type transformer		C57.12.60 - 2009 Amendment 1 - 2013	
Short circuit withstand requirements and testing	60076-5 Ed 3.0 - 2006 (2000)	C57.12.90 - 2015 (2010)	IS2026(Part 5): 2011 / IEC60076-5 (2006)
Determination of sound levels Application guide	60076-10 Ed 2.0 - 2016 (2001) 60076-10-1: Ed 2.0 - 2016 (2005)	C57.136 - 2000	IS 2026: Part 10: 2009 / IEC 60076-10 IS 2026: Part 10: Sec 1: 2018 / IEC 60076-10-1
Loss measurement	TS 60076-19 Ed 1.0 2013 – Uncertainties in loss measurements	C57.123 - 2019 (2010)	IS 2026: Part 19: 2018 / IEC 60076-19
Test code for resistance measurement		IEEE118 - 1978	
Guide for conducting functional life test on switch contacts in oil-filled transformers		C57.157 - 2015	
Dielectric frequency response test (DFR)	CIGRE Brochure 254 - 2002 and 812-2020	C57.161 - 2018	
Sweep frequency response analysis (SFRA)	IEC 60076-18 - Ed 1.0 2012 CIGRE Brochure-342 - 2008	C57.149 - 2012	
High current testing	62475 Ed1.0 - 2010		
Power quality Monitoring power quality		IEEE 1159 - 2019 (2009)	
Insulator testing Artificial pollution test for ceramic and polymer insulators for DC	IEC/TS 61245 Ed 2.0 - 2015 (1993)		

Details of tests	IEC Standard/CIGRE TB	ANSI/IEEE Standard	EN/ Indian Standard
<p>Electrical insulating materials - properties of thermal endurance</p>	<p>60216-1 Ed 6.0 – 2013 (2001) Ageing procedures and evaluation of tests</p> <p>60216-5 Ed 3.0, 2008 / COR 1:2009 (2003)</p> <p>Determination of relative thermal endurance index (RTE) of an insulating material</p> <p>60216-6 Ed 2.0-2006 (2005) Determination of thermal endurance indices (TI &amp; RTE) of an insulating material using the fixed timeframe method</p>		
<p>Painting</p>	<p>ISO 2178:1982, Non-magnetic coatings on magnetic substrates – Measurement of coating thickness – Magnetic method</p> <p>ISO 2409:2007, Paints and varnishes – Cross-cut test.</p> <p>ISO 12944 (all parts), Paints and varnishes – Corrosion protection of steel structures by protective paint systems</p> <p>ISO 8501-88 Preparation of steel substrates before a plication of paints and related products - Visual assessment of surface cleanliness.</p> <p>ISO 9227: 2017 Salt spray test</p> <p>ISO 1513 - Examination and preparation of test samples</p> <p>ISO 1514 – Panels for testing</p> <p>ISO 1519- 2011 – Bend test</p> <p>ISO2808-2008 Determination of film thickness</p> <p>ISO 2813 – Determination of gloss</p> <p>ISO2409-2013 Cross-cut test for adhesion</p> <p>ISO 4618 -2006 Terms and definitions</p> <p>ISO4624: 2016 Pull-off test for adhesion</p> <p>ISO 7784-2: 2016 Resistance to abrasion</p> <p>ISO 6270-2: 2007 Resistance to humidity</p> <p>ISO 2812 -2 007 Resistance to liquids</p> <p>ISO 15528 –Sampling</p> <p>ISO 18872- Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing</p> <p>IEC60068-2 - 1, 2, 11, 14, 30, 78 - environmental testing</p>	<p>ASTM B117-90: “Standard test method of salt spray (fog) testing”</p> <p>ASTM D1735-87: “Standard practice for testing water resistance of coatings using water fog apparatus”</p> <p>ASTM D523-89: “Standard test method for specular gloss”</p> <p>ASTM D3363-74 “Standard test method for film hardness by pencil test”</p>	

Details of tests	IEC Standard/CIGRE TB	ANSI/IEEE Standard	EN/ Indian Standard
Coatings – Hot dip galvanized coatings on fabricated iron and steel parts - specifications and test methods	ISO 1461: 2009		
Non-destructive testing - Ultrasonic testing spec for calibration block No. 2	ISO 7963		
Non-destructive testing- Ultrasonic testing of welds  Terms used  Indication in drawing acceptance levels testing of welds testing of welds in austenitic steels and nickel based alloys	ISO857-1  ISO 2553 - 1999  ISO/DIS 11666 ISO/DIS 17640  ISO 22825		
Brazing and soldering  Terms used  Indication in drawing  Filler metal  Imperfections in brazing  Destructive tests  Non-destructive examination	ISO 857-2 - 2005  ISO 2553 - 1992  ISO 3677 - 2016  ISO 18279 - 2003    ISO 12797 - 2000  ISO 12799 - 2000		
General requirements for test competence and calibration labs	IEC/ISO17025 Ed. 3.0 - 2017		
Uncertainty in measurements	IEC/TS 60076-19 ed 1.0 -2013  ISO/IEC Guide 98, Part 1-4  ISO 5725 Part 1-6		
Measurement management system	ISO 10012 - 2003		
Weibull analysis	IEC 61649 Ed 2.0 - 2018 (2008)		

## Transformer engineers must have a thorough knowledge of testing procedures as per national standards

### 3. Conclusion

Testing forms an important phase of transformer manufacturing. This ensures that the product complies with the customer specifications and the technical particulars guaranteed by the manufacturer. Transformer engineers must have a thorough knowledge of testing procedures as stipulated in the national standards. In-process, tests are also relevant for assuring product quality and reliability.

### Authors

**P. Ramachandran** started his career in the transformer industry in 1966 at TELK, Kerala, a Hitachi Joint venture, in India. He worked with ABB India during 1999-2020. He has more than 50 years of experience in the design and engineering of power products, including power transformers, bushings, and tap-changers. He received a Bachelor of Science Degree in Electrical Engineering from the University of Kerala, India, and a Master of Business Administration Degree from Cochin University, India. He is a Fellow of the Institution of Engineers (India), and he represented India in CIGRE Study Committee A2 for transformers during 2002 – 2010.

**A. S. Jhala** started his professional career with T&R India Limited Ahmedabad in 2005 and is now Deputy General Manager. He has been associated with various functions during his career viz. Testing, Designs and Technology Development. He was actively involved with several development projects including establishment and institutionalizing licensed technology for 765 kV transformers and 400 / 765 kV shunt reactors. He has been associated with Bureau of Indian Standards (BIS) responsible for standardisation activities in India, Central Board of Irrigation and Power (CBIP) and Indian Electrical and Electronics Manufacturers Association (IEEMA). He is also on the board of Managing committee of Electrical Research and Development Association (ERDA). He has contributed about 30 technical papers in national / international seminars.