



## ABSTRACT

The tenth part of the column on standards relevant to transformers covers a list of standards for the raw materials used in the manufacturing of the active parts of transformers. These standards are relevant to all engineers working in the field of transformer design and manufacturing.

## KEYWORDS

transformers, raw materials, conductors, IEC standard, IEEE standard, Indian standard

The standards cover raw materials used in active parts of transformers, such as insulated copper conductors, electrical steel lamination, electrical papers, etc.

# Standards relevant to transformers - Part X

## Raw materials

### 1. Introduction

The active part of transformers is made from many processed raw materials like insulated copper conductors, electrical

steel laminations, structural steel parts, electrical papers, pressboard, industrial plastic materials, paint, glues, and gaskets. The outer tank is fabricated from ferrous materials and surface pro-

tection is provided by various types of paints. National standards are available for these materials and this part of the column covers such relevant standards necessary for transformer engineers.

### 2. Standards

	IEC	ANSI	Indian standard
Magnetic materials – Part 8-7 – specifications for individual materials (cold-rolled grain-oriented electrical steel strip and sheet delivered in the fully processed state)	60404-8-7, Ed 5.0, 2020 (2008, 2017)	ASTM A 876 –17e1	IS 3024–2015 (2006)
Amorphous core material – strips	60404-8-11- 2018		IS 16585–2016
Vocabulary of magnetic materials and components	60050-221-1990 + AMD 1~3 (2007)		
Classification of magnetic materials	60404-1:2016		IS 649–1997
Classification of surface insulation	60404-1-1:2004		IS 649:1997
Measurement of magnetic properties -Epstein frame	60404-2, Ed. 3.1, 1996 + AMD 2018	JIS C 2550 ASTM A 343 /A 343M-14 (2019)	IS 649
Measurement of magnetic properties –single-sheet tester	60404-3, Ed. 3.0 – 1992 + AMD 2009	ASTM 804 /804M-04 (2021)	IS 3024
Measurement of DC magnetic properties	60404-4, 1995 + AMD 2008		
Determination of geometrical characteristics, including burr height	60404-9 – 2018 (1987)		

	IEC	ANSI	Indian standard
Determination of surface insulation resistance (Franklin test)	604404-11-2021(2012) 604404-12:1992 (temperature capability of surface insulation)	ASTM A 717 /A 717 M-12 (2018), A 737	
Ductility test (reverse bend test) of oriented electrical steel	ISO7799 and Clause 8.4.4.2 of IEC60404-8-7m Ed. 4.0, 2017 and IEC TR 63114, 2018	ASTM A721/A721M-02 (2021)	
Comparison of magnetic measurements on CRGO –single sheet test vs Epstein Test- Technical Report	IEC TR 62981, Ed. 1.0, 2017		
Measurement of resistivity, density, and stacking factor of electrical steel	60404-13, Ed. 2.0, 2018 (1995)	ASTM 719-97 (lamination factor)	
Measurement of magnetostriction	TR 62581, Ed. 1 1.0: 2010 -by single sheet and Epstein specimens using optical sensors and accelerometers.  60404-17: 2021 -by single sheet tester and optical sensor.		
Measurement of magnetic properties of Fe based amorphous strip	60404-2018		
Stainless steel		EN10088-1-5	
<b>ETP copper cathodes</b>  • LME Grade A – 99.97 % pure with conductivity > 101.5 %		ASTM B49 BSEN 1978:1998 GB/T-467-2010	
Copper rod drawing stocks for electrical purposes	ISO 197, parts 1-3: 1983 – copper and copper alloys –terms and definitions-  Material: unwrought products, wrought products	ASTM B49-10  EN 1977-1998 Products	
Aluminium wire rods			IS 5484
<b>Winding wires – General requirements</b>  • Round enamelled copper • Rectangular enamelled copper • Round enamelled aluminium	60317-0-2-2020		IS 13730-0-1-2012 IS 13730-0-2-2012 IS 13730-0-3-2012
<b>Winding wires – Specifications</b>  • Paper tape covered rectangular copper wire	60317-27, Ed. 4.0, 2013		
Paper covered copper conductors – round conductors			IS 13730-27-1996
PVA – Round copper – enamelled	60317-12-2020		
PVA – rectangle copper – class 120	60317-17-2020		IS 13730-27-1996

	IEC	ANSI	Indian standard
<b>Winding wires – Test methods</b> <ul style="list-style-type: none"> <li>• Part 1 – General</li> <li>• Part 2 – Determination of dimensions</li> <li>• Part 3 – Mechanical properties</li> <li>• Part 4 – Chemical properties</li> <li>• Part 5 – Electrical properties</li> <li>• Part 6 – Thermal properties</li> </ul>	60851-1, ed. 2.0, 1996 + AMD 1 (2003) +2 (2009) 60851-2, ed. 3.1, 2015 60851-3, ed. 3.1, 2013 60851-4, ed. 4.1, 2011 60851-5, ed. 4.1, 2011 60851-6, ed. 3.0, 2012		IS 7404
Copper rod for electrical purposes			IS 12444
Rectangular copper strip			IS 1897
<b>Non-impregnated densified, laminated wood for electrical purposes</b> <ul style="list-style-type: none"> <li>• Part 1 – Definitions:</li> <li>• Part 2 – Testing methods</li> <li>• Part 3-1 – Specifications for sheets</li> <li>• Part 3-2 – Specifications for rings</li> </ul>	61061, ed. 3.0, 2006 61061-2, ed 1.1, 2001 61061-3-1, ed 1.0, 1998 (low and medium density) 61061-3-2ed1.0-2001		IS 3513
<b>Electrical papers</b> <ul style="list-style-type: none"> <li>• Part 1 – Definitions</li> <li>• Part 2 – Testing methods</li> <li>• Part 3-1 – General Purpose paper; Kraft paper up to 0.125 mm</li> <li>• Part 3-2 – Capacitor paper</li> <li>• Part 3-3 – Crepe paper</li> <li>• Part 3-4 – Electrolytic capacitor paper</li> <li>• Part 3-5 – Special papers</li> </ul>	60554-1-1977 (AMD 1, 1983) 60554-2-2001 60554-3-1-1979 60554-3-2-1983 60554-3-3 -1980 (0.05–0.5 mm thick) 60554-3-4-1979 60554-3-5-1984	ASTM D 202 ASTM D 202	IS 9335
Viscometrical degree of polymerization – measurement for new and aged electrical papers	60450, Ed. 2.1, 2007 (60450-2004 + A1, 2007)	ASTM D4243-16	
<b>Non-cellulose papers for electrical purposes</b> <ul style="list-style-type: none"> <li>• Part 1 – General requirements</li> <li>• Part 2 – Testing methods</li> <li>• Part 3-1 Specifications for individual materials – filled glass paper</li> <li>• Part 3-2 – Inorganic paper</li> <li>• Part 3-3 – Aramid paper</li> <li>• Part 3-4 – Aramid paper with mica</li> </ul>	60819-1, Ed. 3.0, 2009 60819-2-2001 60819-3-12001  60819-3-2-2010 60819-3-3, Ed. 3.0, 2011 60819-3-4, Ed. 2.0, 2013		
<b>Plastic films for electrical purposes</b> <ul style="list-style-type: none"> <li>• Part 1 – General requirements</li> <li>• Part 2 – Testing methods</li> <li>• Part 3-1 – Specifications for individual materials-PP film for capacitors</li> <li>• Part 3-2 – PET films</li> <li>• Part 3-3 – Polycarbonate film</li> <li>• Part 3-4 – Polyamide film</li> <li>• Part 3-7 – FEP film</li> </ul>	60743-1, Ed. 1.0, 1981 60743-2, Ed. 2.0, 1988 60743-3-1-2011  60743-3-2-2019 60743-3-3-1992 60743-3-4-1993 60743-3-7-1992		

	IEC	ANSI	Indian standard
<p><b>Pressboard and press paper for electrical purposes</b></p> <ul style="list-style-type: none"> <li>• Part 1 – Specifications</li> <li>• Part 2 – Testing methods</li> <li>• Part 3-1 – Pressboard                             <ul style="list-style-type: none"> <li>◦ calendared low density</li> <li>◦ pre-compressed high density</li> </ul> </li> <li>• Part 3-2 – Press paper</li> </ul>	<p>60641-1 60641-2-2004 60641-3-1, Ed. 2.0, 2008 B4.1 B3.1 60641-3-2</p>	<p>ASTM D4063 -2.1.1  ASTM D 4063-3.2.1</p>	<p>1576  16498-3-1</p>
<p><b>Laminated press board</b></p> <ul style="list-style-type: none"> <li>• Part 1 – Definitions</li> <li>• Part 2 – Testing methods</li> <li>• Part 3-1 – Specifications                             <ul style="list-style-type: none"> <li>◦ Laminated PB (casein glued)</li> <li>◦ Laminated PB (polyester)</li> </ul> </li> </ul>	<p>60763-1, Ed. 2.0, 2010 60763-2, Ed. 2.0, 2007 60763-3-1, Ed. 2.0, 2010 60763 A.1 60763 A.2</p>		<p>16499-3-1:2010</p>
<p><b>Corrugated pressboard and press paper</b></p> <ul style="list-style-type: none"> <li>• Part 1 –Definitions</li> <li>• Part 2 –Testing methods</li> </ul>	<p>I61628-1, Ed. 1.0, 1997 61628-2, Ed. 1.1, 1998</p>		
<p><b>Aramid PB</b></p> <ul style="list-style-type: none"> <li>• Part 1 – Definitions, designations and general requirements</li> </ul>	<p>61629-1</p>		
<p><b>Industrial rigid round laminated tubes and rods based on thermosetting resins</b></p> <ul style="list-style-type: none"> <li>• Part 3 – Specifications for individual materials</li> </ul>	<p>61629-3</p>		
<p>Silica gel – Specifications</p>			<p>3401:1992 (2003)</p>
<p><b>Steel</b></p> <ul style="list-style-type: none"> <li>• Hot-rolled steel – high tensile flat steel</li> </ul>	<p>EN10025-6 :2004+A1</p>		
<p><b>Painting system</b></p> <ul style="list-style-type: none"> <li>• Paints and varnishes – anti-corrosion protection of steel structures by protective paint systems – general Introduction</li> <li>• Classification of environments</li> <li>• Design considerations</li> <li>• Types of surface and surface preparation</li> <li>• Protective paint systems</li> <li>• Laboratory performance test method</li> <li>• Execution and supervision of paint work</li> <li>• Testing</li> </ul>	<p>ISO 12944-1: 2017  ISO12944-2: 2017 ISO 12944-3: 2017 ISO12944-4: 2017 ISO12944-5: 2017 ISO 12944-6: 2017 ISO 12944-7: 2017 ISO 2178:1982, Non-magnetic coatings on magnetic substrates – measurement of coating thickness – magnetic method ISO 2409:2013, Paints and varnishes – cross-cut test ISO 2808:2008 – thickness of coating ISO 9227-2017 –Salt spray test ISO 2812- Chemical resistance test</p>		

	IEC	ANSI	Indian standard
<b>Gaskets</b> • Cork gasket • Nitrile rubber			IS 4253 (Part 2) 1980 – Type RC-70C IS 11149, 1984 – Type IV, Class C – hardness 70 +/-5
Gasket testing Compression set	ISO815-1 -2014	ASTM D 395	
Gasket testing – general	60068-2-1 – Cold test 60068-2-2 – Dry heat test 60068-2-5 – Simulated solar radiation 60068-2-14 – Thermal shock test 60076-2-30 – Cyclic damp heat 60076-2-78 – Steady state damp heat ISO7619-1 – Determination of indentation hardness ISO 37-2011 – Determination of tensile stress-strain properties		
Nitrogen gas		ASTM D 1933	

**These standards are relevant to all engineers working in the field of transformer design and manufacturing**

### 3. Conclusion

Raw materials required for transformer manufacturing are procured and tested for quality control in line with the above standards. Transformer engineers are to be well-versed in these standards.

### Authors



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