TEST REPORT

IEEE Std C57.12.90-2021
IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE Std C57.12.28™-2014
IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity
For
Zhuzhou Chenxin Induction Equipment Co.,LTD
4-2# Huijia Huanbao Industrial Park, Aviation Street, Lusong, Zhuzhou, Hunan

Model: PR20-170/2.5

2023-11-13

This Report Concerns:	**Equipment Type:**
☒ Original Report	intermediate frequency transformer

Test Engineer:	Engine Chen / Engine Chen
Report Number:	TH2310260-C01-R01
Test Date:	2023-11-06 to 2023-11-13
Reviewed By:	Prince Huang / Prince Huang
Approved By:	Prince Huang / Prince Huang
Prepared By:	**Shenzhen Tian Hai Test Technology Co,.Ltd.** 4F, A3 BLDG, The Silicon Valley Power intelligent terminal industrial park, Guanlan street, Longhua district, Shenzhen Tel: +86-755-86615100 Fax: +86-755-86615105

Note: This test report is limited to the above client company and the product model only. It may not be duplicated without prior written consent of Shenzhen Tian Hai Test Technology Co,.Ltd.

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IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity

Report Reference No.....:	TH2310260-C01-R01
Tested by (signature).....:	Engine Chen /
Reviewed by (signature).....	Prince Huang /
Approved by (signature).....	Prince Huang /
Date of issue.....:	2023-11-13

Testing Laboratory Name.....:	**Shenzhen Tian Hai Test Technology Co., Ltd.**
Address.....:	4F, A3 BLDG, The Silicon Valley Power intelligent terminal industrial park, Guanlan street, Longhua district, Shenzhen

Applicant's Name.....:	**Zhuzhou Chenxin Induction Equipment Co.,LTD**
Address.....:	4-2# Huijia Huanbao Industrial Park, Aviation Street, Lusong, Zhuzhou, Hunan

Test specification

Standard.....:	IEEE Std C57.12.90-2021,IEEE Std C57.12.28™-2014
Test procedure .....:	N/A
Procedure deviation.....:	N/A

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Test item description.....:	**intermediate frequency transformer**
Trade mark.....:	/
Model No.....:	PR20-170/2.5
Manufacturer.....:	**wuxi yuanshan electric co., ltd**
Address.....:	No.7, Xinyuan Road, Xinjie Street, Yixing City
Rating(s).....:	0.75KV，2.5KHz，170kVA
Note:.....:	This test report is limited to the above client company and the product model (high temperature furnace) only.

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Test case verdicts	
Test case does not apply to the test object ……:	N/A(Not applicable)
Test item does meet the requirement ……..:	P(ass)
Test item does not meet the requirement……:	F(ail)
Testing:	
Date of receipt of test item……..:	2023-11-06
Date(s) of performance of test……..……..:	2023-11-06 to 2023-11-13

General remarks:

This test report shall not be reproduced, except in full, without the written approval of the testing laboratory.

The test results presented in this report relate only to the object(s) tested.

"(see remark #)" refers to additional information appended to the report.

"(see appended table)" refers to a table appended to the report.

General product information:

/

Test conclusion:

The products are tested according to IEEE Std C57.12.90-2021、IEEE Std C57.12.28TM-2014.

Test result:

Pass

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
4	**Service conditions**		P
4.1	Usual service conditions		P
4.1.1	General		P
	Transformers conforming to this standard shall be suitable for operation at rated kVA under the following usual service conditions.	170kVA	P
4.1.2	Temperature		P
4.1.2.1	Cooling air temperature limit		N/A
	When air-cooled, the temperature of the cooling air (ambient temperature) shall not exceed 40 °C, and the average temperature of the cooling air for any 24 h period shall not exceed 30 °C.		N/A
4.1.2.2	Liquid temperature limit		P
	The top liquid temperature of the transformer (when operating) shall not be lower than −20 °C. Liquid temperatures below −20 °C are not considered as usual service conditions.	26.2℃	P
4.1.2.3	Cooling water temperature limit		N/A
	When water-cooled, the temperature of the cooling water (ambient temperature) shall not exceed 30 °C, and the average temperature of the cooling water for any 24 h period shall not exceed 25 °C. Minimum water temperature shall not be lower than 1 °C, unless the cooling water includes antifreeze, which is suitable for −20 °C operation.		N/A
4.1.3	Altitude		N/A
	The altitude shall not exceed 1000 m (3300 ft).		N/A
4.1.4	Supply voltage		P
	The supply-voltage wave shape shall be approximately sinusoidal. The phase voltages supplying a polyphase transformer shall be approximately equal in magnitude and time displacement.	Sinusoidal	P
4.1.5	Load current		P
	The load current shall be approximately sinusoidal. The harmonic factor shall not exceed 0.05 per unit. Harmonic factor is defined in IEEE Std C57.12.80. Refer to IEEE Std C57.110™ [B20]11 for information on establishing transformer capability when supplying nonsinusoidal load currents.	Sinusoidal 0.02 per unit	P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
4.1.6	Operation above rated voltage or below rated frequency		P
4.1.6.1	Capability		P
	Transformers shall be capable of the following:		P
	a) Operating continuously above rated voltage or below rated frequency, at maximum rated kVA for any tap, without exceeding the limits of observable temperature rise in accordance with 5.11.1 when all of the following conditions prevail:	54.5℃	P
	1) Secondary voltage and volts per hertz do not exceed 105% of rated values	101.1%	P
	2) Load power factor is 80% or higher	90.6%	P
	3) Frequency is at least 95% of rated value.	97.7%	P
	b) Operating continuously above rated voltage or below rated frequency, on any tap at no load, without exceeding limits of observable temperature rise in accordance with 5.11.1, when neither the voltage nor volts per hertz exceed 110% of rated values.	53.8℃	P
	For multi-winding transformers or autotransformers, 4.1.6.1 applies only to specific loading conditions used as the basis of design. These loading conditions involve simultaneous coordination of kVA input and output, load power factors, and winding voltage combinations [see item j) of 4.3.3]. Differences in loading and voltage regulation for various output windings may prevent simultaneous achievement of 105% voltage on all output terminals. In no case shall the kVA outputs specified for any loading condition require continuous loading of any input winding in excess of its rating.		N/A
4.1.6.2	Maximum continuous transformer operating voltage		P
	The maximum continuous transformer operating voltage should not exceed the levels specified in ANSI C84.1.System conditions may require voltage transformation ratios involving tap voltages higher than the maximum system voltage for regulation purposes. However, the appropriate maximum system voltage should be observed under operating conditions.	Complied	P
4.1.7	Outdoor operation		P
	Unless otherwise specified, transformers shall be suitable for outdoor operation.	Complied	P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
4.1.8	Step-down operation		P
	Unless otherwise specified, transformers shall be designed for step-down operation.	Step-down operation	P
4.1.8.1	Generator step-up transformers		N/A
	Transformers identified as generator step-up transformers shall be designed for step-up operation.		N/A
4.1.8.2	System tie transformers		N/A
	Transformers identified as system tie transformers or autotransformers shall be designed for step-down operation, or step-up operation, or both, as specified by the user.		N/A
4.1.9	Tank or enclosure finish		N/A
	Temperature limits and tests shall be based on the use of a nonmetallic pigment surface paint finish. It should be noted that metallic-flake paints, such as aluminum and zinc, have properties that increase the temperature rise of transformers, except in direct sunlight.		N/A
4.2	Loading at other-than-rated conditions		P
	IEEE Std C57.91™ [B11] provides guidance for loading at other-than-rated conditions including the following:		P
	a) Ambient temperatures higher or lower than the basis of rating		N/A
	b) Short-time loading in excess of nameplate kVA with normal life expectancy	1.15 times	P
	c) Loading that results in reduced life expectancy		N/A
	IEEE Std C57.91 [B11] is an IEEE guide, and as such, it does not specify mandatory requirements. It provides the best-known general information for loading of transformers under various conditions based on typical winding insulation systems. It is based on the best engineering information available at the time of preparation. The guide discusses limitations of ancillary components other than windings that may limit the capability of transformers.When specified, ancillary components and other construction features (such as cables, bushings, tap-changers, insulating liquid expansion space, etc.) shall be supplied in a manner that will not limit the loading to less than the specified capability of the windings.		N/A
4.3	Unusual service conditions		N/A

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Conditions other than those described in 4.1 are considered unusual service conditions and, when prevalent, should be brought to the attention of those responsible for the design and application of the apparatus. Examples of some of these conditions are listed in 4.3.3.		N/A
4.3.1	Unusual ambient temperature and altitude conditions		N/A
	Transformers may be used at higher or lower ambient temperatures or at higher altitudes than those specified in 4.1.3, but special consideration should be given to these applications. IEEE Std C57.91 [B11] provides information on recommended practices.		N/A
4.3.2	Insulation at high altitude		N/A
	The dielectric strength of transformers that depend in whole or partly on air for insulation decreases as the altitude increases due to the effect of decreased air density. When specified, transformers shall be designed with larger air spacing between terminals using the correction factors of Table 1 to obtain adequate air dielectric strength at altitudes above 1000 m (3300 ft).		N/A
4.3.2.1	Insulation level		N/A
	The minimum insulation necessary at the required altitude can be obtained by dividing the standard insulation level at 1000 m (3300 ft) by the appropriate correction factor from Table 1.		N/A
4.3.2.2	Bushings		N/A

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<table>
<tr><th colspan="4">IEEE Std C57.12.90-2021</th></tr>
<tr><th>Clause</th><th>Requirement-Test</th><th>Result</th><th>Verdict</th></tr>
<tr><td></td><td>Bushings with additional length or arcing distance shall be furnished when necessary for operation above 1000 m (3300 ft).

Table 1—Dielectric strength correction factor for altitudes greater than 1000 m (3300 ft)
<table><tr><th>Altitude m (ft)</th><th>Altitude correction factor for dielectric strength</th></tr><tr><td>1000 (3300)</td><td>1.00</td></tr><tr><td>1200 (4000)</td><td>0.98</td></tr><tr><td>1500 (5000)</td><td>0.95</td></tr><tr><td>1800 (6000)</td><td>0.92</td></tr><tr><td>2100 (7000)</td><td>0.89</td></tr><tr><td>2400 (8000)</td><td>0.86</td></tr><tr><td>2700 (9000)</td><td>0.83</td></tr><tr><td>3000 (10 000)</td><td>0.80</td></tr><tr><td>3600 (12 000)</td><td>0.75</td></tr><tr><td>4200 (14 000)</td><td>0.70</td></tr><tr><td>4500 (15 000)</td><td>0.67</td></tr><tr><td colspan="2">NOTE—An altitude of 4500 m (15 000 ft) is considered a maximum for transformers conforming to this standard.</td></tr></table></td><td></td><td>N/A</td></tr>
<tr><td>4.3.3</td><td>Other unusual service conditions</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Other unusual service conditions include the following:</td><td></td><td>N/A</td></tr>
<tr><td></td><td>a) Damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moisture or dripping water, etc.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>b) Abnormal vibration, tilting, shock, or seismic conditions.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>c) Ambient temperatures outside of normal range.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>d) Unusual transportation or storage conditions.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>e) Unusual space limitations.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>f) Unusual maintenance problems.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>g) Unusual duty or frequency of operation, or high-current short-duration loading.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>h) Unbalanced ac voltages, or departure of ac system voltages from a substantially sinusoidal wave form.</td><td></td><td>N/A</td></tr>
</table>

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	i) Loads involving abnormal harmonic currents such as those that may result where appreciable load currents are controlled by solid-state or similar devices. Such harmonic currents may cause excessive losses and abnormal heating. See IEEE Std C57.110 [B20] for more information.		N/A
	j) Specified loading conditions (kVA outputs, winding load power factors, and winding voltages) associated with multi-winding transformers or autotransformers.		N/A
	k) Excitation exceeding either 110% rated voltage or 110% rated volts per hertz.		N/A
	l) Planned short circuits as a part of regular operating or relaying practice.		N/A
	m) Unusual short-circuit application conditions differing from those described as usual in Clause 7.		N/A
	n) Unusual voltage conditions (transient overvoltages, resonance, switching surges, etc.) may require special consideration in insulation design.		N/A
	o) Unusually strong magnetic fields. It should be noted that solar magnetic disturbances may result in the flow of geomagnetically induced current (GIC) in transformer neutrals.		N/A
	p) Large transformers with high-current isolated-phase bus ducts. It should be noted that high-current isolated-phase bus ducts with strong magnetic fields may cause unanticipated circulating currents in transformer tanks and covers, and in bus ducts. Losses resulting from these unanticipated currents may result in excessive temperatures when corrective measures are not included in the design.		N/A
	q) Parallel operation. It should be noted that while parallel operation is not unusual, it is desirable that users advise the manufacturer when paralleling with other transformers is planned and identify the transformers		N/A
5	**Rating data**		P
5.1	Cooling classes of transformers		P
	Transformers shall be identified according to the cooling method employed. For liquid-immersed transformers, this identification is expressed by a four-letter code, described as follows. These designations are consistent with IEC 60076-2:2011 [B4].	Complied	P
5.2	Frequency		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Unless otherwise specified, transformers shall be designed for operation at a frequency of 60 Hz.	2.5KHz	P
5.3	Phases		P
5.3.1	General		P
	Transformers described in this standard are either single phase or three phase. Standard ratings are included in product standards for particular types of transformers. When specified, other phase arrangements may be provided.	Complied	P
5.3.2	Scott-connected or T-connected transformers		N/A
5.3.2.1	Phase transformation		N/A
	These may be provided to accomplish three-phase to two-phase transformation, or vice versa, or to accomplish three-phase to three-phase transformation. Common arrangements used to accomplish such transformations are described here in 5.3.2.2, 5.3.2.3, and 5.3.2.4.		N/A
5.3.2.2	Dissimilar single-phase transformers		N/A
	Two single-phase transformers are assembled in an enclosure, and permanently interconnected, with the following characteristics:		N/A
	a) Performance characteristics shall be based on bank operation of three-phase to two-phase transformation or vice versa.		N/A
	b) The single-phase transformers may not be identical or interchangeable.		N/A
5.3.2.3	Three-legged core		N/A
	Another arrangement uses a three-legged core with main and teaser coil assemblies located on the two outer legs, and a center leg that has no coil assembly. This provides a common magnetic circuit for the two outer legs.		N/A
5.3.2.4	Identical single-phase transformers		N/A
	When specified, two identical single-phase transformers shall be furnished		N/A
	a) The kVA rating of each transformer shall be half the bank output required. The rating of the individual units shall agree with the ratings established for single-phase transformers.		N/A
	b) Performance characteristics (except heating) shall be based on single-phase operation.		N/A

IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	c) The temperature rise shall be based on delivering the required bank capacity when transforming from threephase to two-phase or from two-phase to three-phase, as specified.		N/A
	d) Transformers shall be interchangeable as main and teaser.		N/A
	e) Regulating taps are not usually supplied on transformers for three-phase to two-phase or from two-phase to three-phase service. When taps are required, the teaser tap shall be 86.6% of the mean regulating taps (used here, mean refers to the midpoint of the range of regulating taps).		N/A
5.4	Rated kilovoltamperes		P
5.4.1	General		P
	The rated kVA of a transformer shall be the output that can be delivered for the time specified at rated secondary voltage and rated frequency without exceeding the specified temperature-rise limitations under prescribed conditions of test, and within the limits of established standards.	Complied	P
5.4.2	Preferred continuous kVA ratings	170kVA	P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**

Preferred continuous kVA ratings of single-phase and three-phase distribution and power transformers are based on an average winding rise of 65 °C, in accordance with 5.11.1.1 and are listed in Table 2.

Table 2—Preferred continuous kilovoltampere ratings

Single-phase transformers (kVA)	Three-phase transformers (kVA)
5	15
10	30
15	45
25	75
37.5	112.5
50	150
75	225
100	300
167	500
250	750
333	1000
500	1500
—	2000
833	2500
1250	3750
1667	5000
2500	7500
3333	10 000
—	12 000
5000	15 000
6667	20 000
8333	25 000
10 000	30 000
12 500	37 500
16 667	50 000
20 000	60 000
25 000	75 000
33 333	100 000

Complied — P

5.5	Voltage ratings and taps		P
5.5.1	General		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Standard nominal system voltages and maximum system voltages are included in ANSI C84.1 and listed in Table 3 and Table 4.	Complied	P
5.5.2	Voltage ratings		P
	The voltage ratings shall be at no load and shall be based on the turn's ratio.	Complied	P
5.5.3	Ratings of transformer taps		N/A
	Whenever a transformer winding is provided with taps for de-energized operation, they shall be full-capacity taps.Transformers with load tap-changing equipment may have reduced capacity taps, unless specified otherwise, for taps below rated winding voltage. When specified, other capacity taps may be provided. In all cases, the ampacityat each tap shall be stated on the nameplate.		N/A
5.6	Connections		N/A
	Standard connection arrangements are included in the standards for particular types of transformers and in IEEE Std C57.12.70.		N/A
5.7	Polarity, angular displacement, and terminal marking		P
5.7.1	Polarity of single-phase transformers		N/A
	Single-phase transformers 200 kVA and below with high-voltage ratings of 8660 V and below (winding voltage) shall have additive polarity. All other single-phase transformers shall have subtractive polarity. Transformer polarity is defined and illustrated in IEEE Std C57.12.90.		N/A
5.7.2	Angular displacement (nominal) between voltages of windings for three-phase transformers		N/A
	The angular displacement of a polyphase transformer is the time angle expressed in degrees between the line-toneutral voltage of the reference identified high-voltage terminal H1 and the line-to-neutral voltage of the corresponding identified low-voltage terminal X1.		N/A
5.7.3	Terminal markings		P
	Terminal markings shall be in accordance with IEEE Std C57.12.70.	Complied	P
5.8	Impedance		P
	The impedance shall be referred to the reference temperature defined as 20 °C plus the rated average winding rise. Preferred standard values of impedance are included in the product standards for particular types of transformers.	101MΩ	P

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Clause	**Requirement-Test**	**Result**	**Verdict**
5.9	Total losses		P
	The total losses of a transformer shall be the sum of the no-load losses and the load losses.	Complied	P
	The losses of cooling fans, insulating liquid pumps, space heaters, and other ancillary equipment are not included in the total losses. When specified, power loss data on such ancillary equipment shall be furnished.	Complied	P
	The standard reference temperature for the load losses of power and distribution transformers shall be defined as 20 °C plus the rated average winding rise. The standard reference temperature for the no-load losses of power and distribution transformers shall be 20 °C.	Complied	P
	For Class II transformers (see 5.10), control/auxiliary (cooling) losses shall be measured and recorded. All stages of cooling, pumps, heaters, and all associated control equipment shall be energized, provided these components are integral parts of the transformer.		N/A
5.10	Insulation levels		P
	Transformers shall be designed to provide coordinated low-frequency and impulse insulation levels on line terminals and low-frequency insulation levels on neutral terminals. The primary identity of a set of coordinated levels shall be its maximum system voltage and basic lightning impulse insulation level (BIL). BIL will be selected dependent on the degree of exposure of the transformer and characteristics of the overvoltage protection system.		N/A
	The system voltage and the type of transformer may also influence insulation levels and test procedures. Therefore, power transformers are separated into two different classes as follows:		N/A
	a) Class I power transformers are any that are not categorized as Class II, described in item b).		N/A
	b) Class II power transformers shall include power transformers with high-voltage windings rated for 115 kV nominal system voltage and above, and also power transformers with high-voltage windings rated 69 kV through 115 kV nominal system voltage, having a top nameplate rating of at least 15 000 kVA for threephase transformers or 10 000 kVA for single-phase transformers.		N/A
	The following tables show various system voltages, insulation, and test levels for various classes of liquidimmersed power transformers:		N/A
	-Table 3 lists dielectric insulation and low-frequency test levels for distribution and Class I power transformers.	Complied	P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	--Table 4 lists dielectric insulation and low-frequency test levels for Class II power transformers.		N/A
	--Table 5 lists high-frequency test levels.		N/A
5.10.1	Front-of-wave insulation level		N/A
	Front-of-wave insulation levels and tests shall be specified when desired; otherwise, withstand insulation capability is not required.		N/A
5.10.2	Line terminals		P
5.10.2.1	Basic lightning impulse insulation level (BIL)		P
	A basic lightning impulse insulation level (BIL) from Table 3 or Table 4 shall be assigned to each line terminal of a winding. The associated insulation levels shall be provided regardless of whether tests are or can be performed.	Complied	P
5.10.2.2	Switching impulse insulation level		N/A

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**

Windings for system voltages 115 kV and above shall be designed for the basic switching impulse insulation levels (BSL) associated with the assigned BIL as shown in Table 5. In addition, low-voltage windings shall be designed to withstand stresses from switching impulse tests on high-voltage windings regardless of whether or not such tests are specified.

Table 5—Lightning and switching impulse (high-frequency) tests table

Lightning impulse (BIL) kV crest 1.2 × 50 µs	Chopped wave			Switching impulse (BSL)
	kV crest	Minimum time to flashover (µs)		
	1.1 × BIL	Class I and distribution	Class II	kV crest
Col 1	Col 2	Col 3	Col 4	Col 5
30	33	1.0	2.0	—
45	50	1.5	2.0	—
60	66	1.5	2.0	50
75	83	1.5	2.0	62
95	105	1.8	2.0	79
110	120	2.0	2.0	92
125	138	2.3	2.3	104
150	165	3.0	3.0	125
200	220	3.0	3.0	166
250	275	3.0	3.0	208
350	385	3.0	3.0	291
450	495	N/A	3.0	375
550	605	N/A	3.0	460
650	715	N/A	3.0	540
750	825	N/A	3.0	620
825	910	N/A	3.0	685
900	990	N/A	3.0	745
1050	1155	N/A	3.0	870
1175	1290	N/A	3.0	975
1300	1430	N/A	3.0	1080
1425	1570	N/A	3.0	1180
1550	1705	N/A	3.0	1290
1675	1845	N/A	3.0	1390
1800	1980	N/A	3.0	1500
1950[a]	2145	N/A	3.0	1550/1620
2050	2255	N/A	3.0	1700

[a]For 1950 kV BIL, a switching impulse (BSL) of 1550 kV is specified by some users. A common BSL of 1620 kV should be used for the 1950 kV BIL.

N/A

5.10.2.3	Wye-winding line terminal		N/A
	Each wye-winding line terminal shall be specified on the nameplate as suitable or unsuitable for ungrounded neutral operation.		N/A
5.10.2.4	Windings that have no terminals brought out		N/A
	Windings that have no terminals brought out shall be capable of withstanding voltages resulting from the various tests that may be applied to other terminals corresponding to their respective BIL.		N/A
5.10.3	Neutral terminals		P
5.10.3.1	Wye connection with an accessible neutral external to the tank		P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	A transformer winding designed for wye connection only and with an accessible neutral external to the tank shall be assigned a low-frequency test level for the neutral terminal. This assigned low-frequency test level may be lower than that for line terminals.	Complied	P
5.10.3.2	Neutral terminals that are solidly grounded		P
	The assigned low-frequency test level for neutral terminals that are solidly grounded directly or through a current transformer shall be not less than that specified in Column 4 of Table 3 and Table 4.	Complied	P
	The assigned low-frequency test level for other cases shall be coordinated with voltages that can occur between the neutral and ground during normal operation or during fault conditions, but shall be not less than those specified in Columns 3, 4, and 5 of Table 3 and Table 4.	Complied	P
	It should be noted that IEEE Std C57.32™ [B10] includes additional information on neutral insulation, application, etc.	Complied	P
5.10.3.3	Specific BIL		N/A
	When specified, neutral terminals shall be designed for a specific BIL and a low-frequency test level.		N/A
5.10.3.4	Insulation level of the neutral bushing		N/A
	The insulation level of the neutral end of a winding may differ from the insulation level of the neutral bushing being furnished or of the bushing for which provision for future installation is made. In any case, the insulation level of the neutral bushing shall be equal to or greater than the specified insulation level of the neutral end of the winding.		N/A
5.10.3.5	Neutral not brought out of the tank		N/A
	Insulation levels shall not be assigned where the neutral end of the winding is not brought out of the tank through a bushing and is solidly grounded to the tank.		N/A
5.10.4	Coordination of insulation levels		P
5.10.4.1	BIL levels		P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	The BIL chosen for each line terminal shall be such that the lightning impulse, chopped-wave impulse, and switching impulse insulation levels include a suitable margin in excess of the dielectric stresses to which the terminal will be subjected in actual service. For information on surge arrester characteristics and application, see IEEE Std C62.1™-1989 [B46], IEEE Std C62.2™-1989 [B47], IEEE Std C62.11™ [B48], and IEEE Std C62.22™ [B49]. It should be noted that it is recommended that surge-arrester protection be provided for tertiary windings that have terminals brought out.	Complied	P
5.10.4.2	BSL levels		P
	A switching surge impulse occurring at one terminal during test or in actual service will be transferred to other winding terminals with a magnitude approximately proportional to the turns ratio involved. This interaction should be considered when evaluating surge arrester application, evaluating expected magnitude of surges, and establishing coordinated insulation levels.	Complied	P
5.10.5	Low-frequency voltage tests on line terminals for distribution transformers and power transformers		P
5.10.5.1	General		P
	Low-frequency test requirements for distribution and power transformers shall be applied-voltage tests and induced-voltage tests. Table 3 specifies test levels for distribution and Class I power transformers; Table 4 specifies test levels for Class II power transformers.	Complied	P
5.10.5.2	Applied-voltage test requirements		P
	A voltage to ground (not necessarily to neutral) shall be developed at each terminal in accordance with the levels specified in Table 3 or Table 4. For ungraded windings, this voltage shall be maintained throughout the winding.	Complied	P
5.10.5.3	Induced-voltage test requirements for distribution and Class I power transformers		P
	A voltage shall be developed in each winding in accordance with the levels specified in Table 3. Inducedvoltage tests shall be conducted at 2.0 × nominal voltage for 7200 cycles.	Complied	P
5.10.5.4	Exceptions		N/A
	Exceptions to the applied-voltage and induced-voltage tests requirements are as follows:		N/A

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	a) Subject to the limitation that the voltage-to-ground test shall be performed as specified in 5.10.5.2 on the line terminals of the winding with the lowest ratio of test voltage to minimum turns, the test levels may otherwise be reduced so that none of the three test levels required in 5.10.5.3 need be exceeded to meet the requirements of the other two, or so that no winding need be tested above its specified level to meet the test requirements of another winding.		N/A
	b) For delta windings, the voltage-to-ground developed at each terminal shall be in accordance with Table 3 for the BIL specified; however, voltage within the winding may be reduced to 87% of the voltage developed at the terminals.		N/A
5.10.5.5	Induced-voltage test for Class II power transformers		N/A
	With the transformer connected and excited as it will be in service, an induced-voltage test shall be performed as indicated in Figure 2, at voltage levels indicated in Columns 6 and 7 of Table 4. Minimum line-to-ground induced test levels for Class II power transformers shall be a multiple of corresponding line-to-ground nominal system voltage as follows: 1.58 times for one-hour tests and 1.8 times for 7200 cycles enhancement level tests.		N/A
5.10.6	Low-frequency voltage tests on neutral terminals for all transformers		P
	Each neutral terminal shall receive an applied-voltage test at its assigned low-frequency insulation level in accordance with the test levels specified in Table 3 or Table 4.	Complied	P
5.10.7	Impulse tests		N/A
5.10.7.1	Lightning impulse tests		N/A
	When required, lightning impulse tests shall be performed on line and neutral terminals at the specified levels per Columns 1 and 2 of Table 5, as selected from either Table 3 or Table 4. Lightning impulse tests shall not be made on windings that do not have terminals brought out through the tank or cover. Lightning impulse tests are not required on terminals brought out from buried windings in the following cases:		N/A
	a) When a single terminal is brought out for the purpose of grounding the buried winding.		N/A
	b) When two terminals are brought out so that the delta connection may be opened for the purpose of testing the buried winding.		N/A

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Clause	**Requirement-Test**	**Result**	**Verdict**
	c) When temporary connections to terminals of a buried winding are brought out only for the purpose of factory tests.		N/A
5.10.7.2	Switching impulse tests		N/A
	When required, switching impulse tests shall be performed. Switching impulse tests on the high-voltage line terminals may over-test or under-test other line terminals depending on the relative BSL levels, the turns ratios between windings, and test connections. Regardless of this fact, tests on the high-voltage terminals shall be controlling, and a switching impulse test at the level specified in Column 5 of Table 5 shall be applied to the high-voltage terminals.		N/A
	The switching surge insulation of other windings shall be able to withstand voltages resulting from the required switching impulse tests to the high-voltage terminals, even though such voltages on the other windings may exceed their designated BSL listed in Table 5 when applicable.		N/A
	When the application of the switching impulse to the high-voltage terminals results in a voltage on another winding lower than the BSL requirement for that winding in Table 5, no additional test is necessary to demonstrate switching surge insulation withstand capability on that winding.		N/A
5.11	Temperature rise and loading conditions		P
5.11.1	Limits of observable temperature rise		P
5.11.1.1	Winding temperature rises		P
	The average winding temperature rise above ambient temperature shall not exceed 65 °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.	55.3°C	P
	The maximum (hottest-spot) winding temperature rise above ambient temperature shall not exceed 80 °C at rated kVA for the particular combination of connections and taps that give the highest maximum (hottestspot) winding temperature rise. The maximum (hottest-spot) winding temperature rise above ambient shall be determined by one of the following methods:		N/A

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	a) Direct measurement during a thermal test in accordance with IEEE Std C57.12.90. A sufficient number of direct reading sensors should be used at expected locations of the maximum temperature rise as indicated by prior testing or loss and heat transfer calculations. For additional guidance on the use and location of thermal sensors, refer to IEEE Std 1538™ [B8].		N/A
	b) Direct measurement on an exact duplicate transformer design per item a).		N/A
	c) Calculations of the temperatures throughout each active winding and all leads. The calculation method shall be based on fundamental loss and heat transfer principles and substantiated by tests on production or prototype transformers or windings.		N/A
	The maximum (hottest-spot) winding temperature rise above ambient temperature shall be included in the test report, with the other temperature rise data. A note shall indicate which of the preceding methods was used to determine the value.		N/A
5.11.1.2	Thermal rating for stabilizing windings (buried tertiary)		P
	In addition to the short-circuit duty (see 7.1.4.4), stabilizing windings shall be designed to withstand the transient and continuous thermal duty as specified by the user and in accordance with the allowable temperature limits of 5.11.1.	Complied	P
	In the event that no continuous thermal duty for the stabilizing winding can be established from the user's specification, the manufacturer shall design the stabilizing winding considering the circulating current in that winding resulting from a full single-phase load in the largest main secondary winding. The manufacturer shall determine the kVA rating for the stabilizing winding based on the transformer's equivalent circuit for a single-phase loading condition.	Complied	P
	The manufacturer shall calculate values of average and hottest-spot temperatures for the stabilizing winding to verify compliance with allowable temperatures. Initial conditions for these calculations shall be based on the transformer operating at its maximum continuous rating, before switching to the loading conditions described above in the first or second paragraph, whichever is applicable.	Complied	P
5.11.1.3	Other winding rises		N/A

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	Other winding rises may be recognized for unusual ambient conditions or for special applications. These are specified in appropriate applications or in certain product standards. Refer to IEEE Std C57.154™ [B28] for additional guidance on the design and application of high-temperature transformers.		N/A
5.11.1.4	Rises of metallic parts other than windings		P
	Metallic parts in contact with current-carrying conductor insulation shall not attain a temperature rise in excess of the winding hottest-spot temperature rise.	Complied	P
	The core hot spot temperature shall be limited to 130 °C for the condition of highest core over-excitation, rated load, and the maximum average daily ambient temperature for transformers filled with mineral oil. This is to avoid the problem of gas generation in the core caused by thermal breakdown of the thin oil film between the core laminations. Under the same operating conditions, the core surface temperatures shall be limited by the temperature capability of the insulation materials in contact with the core surfaces.	Complied	P
	Metallic parts other than those previously described shall not attain excessive temperature rises at maximum rated load. Excessive temperature rise shall be interpreted to mean a temperature rise that results in an operating temperature that would exceed the temperature limits of the insulation material that is in contact with the metallic part.	Complied	P
5.11.1.5	Liquid temperature rise		P
	The insulating liquid temperature rise above ambient temperature shall not exceed 65 °C when measured near the top of the main tank.	Complied	P
5.11.2	Conditions under which temperature rise limits apply		N/A
	Temperature limits shall not be exceeded when the transformer is operating on the connection that will produce the highest winding temperature rise above ambient temperature and is delivering the following:		N/A
	a) Rated kVA output at rated secondary voltage when there are no taps.		N/A
	b) Rated kVA output at the rated secondary voltage for that connection when it is a rated kVA tap connection.		N/A
	c) At the rated secondary voltage of that connection, the kVA output corresponding to the rated current of the tap, when the connection is a reduced kVA tap connection.		N/A

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	d) A specified combination of kVA outputs at specified power factors (for each winding) for multiwinding transformers.		N/A
	e) Rated kVA output at rated V/Hz.		N/A
5.11.3	Basis for temperature limits		P
	Transformers that meet the temperature and loading conditions in this standard shall be manufactured using thermally upgraded paper or an alternative insulation system that has been proven to possess minimum aging characteristics that either match or exceed those of thermally upgraded paper. Cellulose paper that has not been chemically modified to improve its thermal characteristics does not qualify as thermally upgraded insulation. This requirement applies to the insulation components that determine the minimum life expectancy, such as winding insulation, layer-to-layer insulation, lead insulation, and other components.	Complied	P
	The test procedures to determine the aging characteristics and the minimum life expectancy of an insulation system are provided in IEEE Std C57.100™ [B15].		P
5.12	Nameplates		P
5.12.1	General		P
	A durable metal nameplate shall be affixed to each transformer by the manufacturer. Unless otherwise specified, it shall be made of corrosion-resistant material. It shall bear the rating and other essential operating data as specified in 5.12.2. This standard recognizes the use of metric (SI) and imperial (U.S. customary) units for data appearing on transformer nameplates. It should be noted that although this standard recognizes the possibility of using SI units as an alternative to the U.S. customary units used in the past, it is not intended that both appear on the specific nameplate. However, units used shall be explicitly shown.	Complied	P
	In accordance with the requirements of IEEE Std C57.131, load tap changer (LTC) transformers shall also contain a tap-changer nameplate, permanently attached to the LTC compartment.		N/A
5.12.2	Nameplate information		P
	Unless otherwise specified, the minimum information shown on the nameplate shall be that specified in Table 6 and its associated notes, and shall be in accordance with the following categories:		P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	a) Nameplate A shall be used on transformers rated 500 kVA or below with a high-voltage BIL less than 150 kV.		N/A
	b) Nameplate B shall be used on transformers rated 500 kVA or below, which are not covered in item a).		N/A
	c) Nameplate C shall be used on transformers rated above 500 kVA.	Complied	P
5.12.3	Schematic representation	Complied	P
6	**Construction**		P
6.1	Bushings		P
	Transformers shall be equipped with bushings with an insulation level no less than that of the winding terminal to which they are connected, unless otherwise specified.	Complied	P
	Bushings for use in transformers shall have impulse and low-frequency insulation levels as listed in Table 9 and IEEE Std C57.19.01 or IEEE Std C57.19.04.	Complied	P
	Transformers using bushings that have dimensions in accordance with IEEE Std C57.19.01 or IEEE Std C57.19.04 shall have bushing mounting holes that are adequate to accommodate the maximum “P”dimensions for those bushings, as shown in the applicable tables.	Complied	P
6.2	Transformer accessories		N/A

Table 9—Electrical insulation characteristics of transformer bushings (applies only to bushings 34.5 kV and below not listed in IEEE Std C57.19.01 or IEEE Std C57.19.04)

Outdoor bushing								Indoor bushings[a]	
Power transformers[b]					Distribution transformers[b]				
System voltage[c] (kV)	Minimum creepage distance mm/(in)	Rated frequency withstand		Impulse full wave dry withstand (kV) (1.2/50 μs)	Rated frequency withstand		Impulse full wave dry withstand (kV) (1.2/50 μs)	Rated frequency withstand 1 min dry (kV)	Impulse full wave dry withstand (kV) (1.2/50 μs)
		1 min dry (kV)	10 s wet (kV)		1 min dry (kV)	10 s wet (kV)			
1.2	—	—	—	—	10	6	30	—	—
2.5	—	21	20	60	15	13	45	20	45
5.0	—	27	24	75	21	20	60	24	60
8.7	—	—	—	—	27	24	75	30	75
8.7	178/(7)	35	30	95	—	—	—	—	—
15.0	—	—	—	—	35	30	95	50[d]	110[d]
18.0	—	—	—	—	42	36	125	—	—
25.0	—	—	—	—	—	—	—	60	150
34.5	—	—	—	—	—	—	—	80	200

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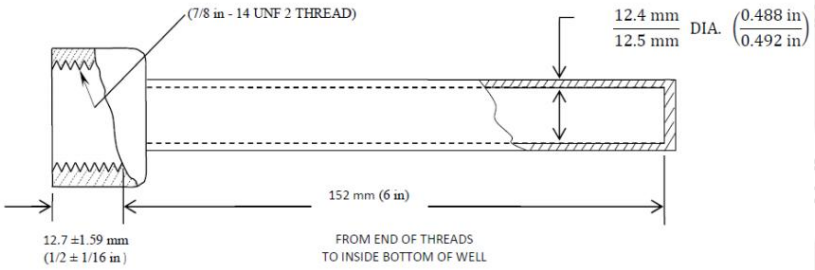
Clause	**Requirement-Test**	**Result**	**Verdict**
	Specific information on accessories is contained in the standards applying to particular types of transformers.		N/A
6.3	Bushing current transformers		N/A
	Bushing current transformers used with bushings having dimensions in accordance with IEEE Std C57.19.01 or IEEE Std C57.19.04 shall have an inside diameter to accommodate the maximum “D” dimensions for those bushings, as shown in the applicable tables.		N/A
6.4	Thermometer wells		N/A
	Unless otherwise specified in the standard applying to the particular type of transformer, dimensions for thermometer wells shall be as shown in Figure 4.  **Figure 4—Dimension of thermometer well**		N/A
	The thermometer well shall be positioned in such a way that it is at least 25.4 mm (1 in) below the liquid level at minimum operating temperature (either –20 °C or as specified by the user).		N/A
6.5	Tank pressure requirements		N/A
6.5.1	Maximum under rated conditions		N/A
	Tank pressure under rated conditions for sealed transformers shall not exceed two atmospheres (203 kPa) absolute pressure unless requirements of applicable sections of the ASME Boiler and Pressure Vessel Code (BPVC) are met.14		N/A
6.5.2	Limits and tests		N/A
	Specific pressure limits and tests are included in standards applying to particular types of transformers.		N/A
6.6	Liquid insulation system		P
6.6.1	Insulating liquids		P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	Transformers shall be filled with a suitable insulating liquid such as the following:		P
	a) Mineral oil. New, unused mineral oil shall meet the requirements of ASTM D3487.		N/A
	b) Less-flammable hydrocarbon fluid. New, unused less-flammable hydrocarbon fluid shall meet the requirements of ASTM D5222.		N/A
	c) Silicone insulating fluid. New, unused silicone insulating fluid shall meet the requirements of ASTM D2225.		N/A
	d) Natural ester insulating liquid. New, unused natural ester insulating liquid shall meet the requirements of ASTM D6871.	Complied	P
6.6.2	Insulating liquid preservation		P
	Transformers shall be equipped with an insulating liquid preservation system such as the following:		P
	a) Sealed tank	Complied	P
	b) Gas-insulating liquid seal		N/A
	c) Conservator		N/A
	d) Conservator/diaphragm		N/A
6.6.3	Nitrogen inert-gas pressure system		N/A
	Nitrogen for use with inert-gas-protected transformers shall be in accordance with ASTM D1933, Type III.Nitrogen shall be supplied in 5.66 m3 (200 ft3) cylinders equipped with Connection No. 580 of CGA V-1.The filling pressure shall be 15.2 MPa (2200 lbf/in2) at 21.1 °C (70 °F).		N/A
6.7	Grounding		P
6.7.1	Transformer grounding		P
	Transformer grounding facilities shall be furnished in accordance with the standards for particular types of transformers.	Complied	P
6.7.2	Grounding of core		P
	The transformer core shall be grounded to the transformer tank for electrostatic purposes	Complied	P
6.7.2.1	Grounding of wound cores		P

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	In transformers with wound cores, five-legged three phase and three-legged single phase, low-voltage/highvoltage winding construction and a high-voltage winding greater than or equal to 25 kV (15 kV to ground), the transformer core shall be properly grounded to the tank. Said grounding may be from the inside or outside of the core as long as there are not two ground locations in the same core. In order to validate that the core will not be susceptible to partial discharges during normal operation, a design test, specific for this type of wound core transformer, is specified in Table 17, and the procedure is described in IEEE Std C57.12.90-2021 subclause 10.7.7.	Complied	P
6.8	Minimum external clearances of transformer live parts		P
	Table 10 describes the minimum external clearances between transformer live parts to ground and to different phases. In the establishment of these clearances, it was recognized that bushing ends normally have rounded electrode shapes. It is also assumed that conductor clamps would be suitably shaped so that they would not reduce the withstand strengths, and the arrangement of the incoming conductors would not reduce the effective clearances provided by the transformer bushing. In other words, the clearances were established based on electrostatic fields that were usually not divergent.	Complied	P
	Where adequate previous experience has indicated that smaller clearances are acceptable, the smaller clearances may be applied when agreed on by both the user and the manufacturer. The clearances in this clause are for in service conditions. Factory test conditions may require larger clearances than those defined here. Minimum external clearances shall comply with Table 10 except where suitable grading of local stresses may allow smaller clearances.	Complied	P
	The nominal clearance values indicated are subject to normal manufacturing tolerances. Normal manufacturing tolerances should not significantly increase the likelihood of a flashover because the clearances listed in Table 10 are conservative.	Complied	P
7	**Short-circuit characteristics**		P
7.1	Requirements		P
7.1.1	General		P

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<table>
<tr><th colspan="4">IEEE Std C57.12.90-2021</th></tr>
<tr><th>Clause</th><th>Requirement-Test</th><th>Result</th><th>Verdict</th></tr>
<tr><td></td><td>Liquid-immersed transformers shall be designed and constructed to withstand the mechanical and thermal stresses produced by external short circuits under the conditions specified in 7.1.3, 7.1.4, and 7.1.5. The external short circuits shall include three-phase, single line-to-ground, double line-to-ground, and line-to-line faults on any one set of terminals at a time. Multi-winding transformers shall be considered to have system fault power supplied at no more than two sets of unfaulted terminals rated greater than 35% of the terminal kVA of the highest capacity winding. For other fault conditions, the requirements shall be specified by those responsible for the application of the transformer.</td><td>Complied</td><td>P</td></tr>
<tr><td></td><td>Short-circuit withstand capability can be adversely affected by the cumulative effects of repeated mechanical and thermal overstressing produced by short circuits and loads above the nameplate rating. It is not feasible to continuously monitor and quantitatively evaluate the degrading effects of such duty; short-circuit tests, when required, should be performed prior to placing transformer(s) in service.</td><td>Complied</td><td>P</td></tr>
<tr><td></td><td>The intention here is not that every transformer be short-circuit tested to demonstrate adequate construction.</td><td>Complied</td><td>P</td></tr>
<tr><td></td><td>When specified, short-circuit tests shall be performed as described in IEEE Std C57.12.90.</td><td>Complied</td><td>P</td></tr>
<tr><td>7.1.2</td><td>Transformer categories</td><td></td><td>P</td></tr>
<tr><td></td><td>Four categories for the rating of transformers are recognized, as shown in Table 11.
Table 11—Category of transformer ratings
<table>
<tr><th>Category</th><th>Single phase (kVA)</th><th>Three phase (kVA)</th></tr>
<tr><td>I[a]</td><td>5 to 500</td><td>15 to 500</td></tr>
<tr><td>II</td><td>501 to 1667</td><td>501 to 5000</td></tr>
<tr><td>III</td><td>1668 to 10 000</td><td>5001 to 30 000</td></tr>
<tr><td>IV</td><td>Above 10 000</td><td>Above 30 000</td></tr>
<tr><td colspan="3">NOTE—All kVA ratings listed are minimum nameplate kVA for the principal windings.</td></tr>
</table></td><td>I[a]</td><td>P</td></tr>
<tr><td>7.1.3</td><td>Short-circuit current duration</td><td></td><td>P</td></tr>
<tr><td>7.1.3.1</td><td>General</td><td></td><td>P</td></tr>
</table>

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IEEE Std C57.12.90-2021			
Clause	**Requirement-Test**	**Result**	**Verdict**
	The short-circuit current duration that a transformer shall withstand is defined in 7.1.3.1. The mechanical behavior of the transformer shall be ascertained by short-circuit tests conducted per IEEE Std C57.12.90; the test duration shall be as defined in 7.1.3.2. The short-circuit thermal behavior of the transformer shall be determined by calculations per 7.4; the minimum short-circuit duration applicable for these calculations shall be those defined in 7.1.3.1.	Complied	P
	For Category I transformers, the duration of the short circuit shall be determined by Equation (5).	Complied	P
	For Category II, III, and IV units, the duration of the short-circuit current as defined in 7.1.4 is limited to 2 s, unless otherwise specified by the user.		N/A
	When used on circuits having reclosing features, transformers in all categories shall be capable of withstanding the resulting successive short circuits without cooling to normal operating temperatures between successive occurrence of the short circuit, provided that the accumulated duration of the short circuit does not exceed the maximum duration permitted for single short circuits as defined in 7.1.3.1.		N/A
	For currents between rated current and maximum short-circuit current, the allowable time duration should be obtained by consulting the manufacturer.		N/A
	IEEE Std C57.12.90 defines a procedure by which the mechanical capability of a transformer to withstand short-circuit stresses may be demonstrated. The prescribed tests are not designed to verify thermal performance. Conformance to short-circuit thermal requirements shall be by calculation in accordance with 7.4.	Complied	P
7.1.3.2	Duration of short-circuit tests		P
	When short-circuit tests are performed, the duration of each test shall be 0.25 s except that one test satisfying the symmetrical current requirement shall be made for a longer duration on Category I, II, and III transformers. T	Complied	P
7.1.4	Short-circuit current magnitude		P
7.1.4.1	Category I		P

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<table>
<tr><th colspan="4">IEEE Std C57.12.90-2021</th></tr>
<tr><th>Clause</th><th>Requirement-Test</th><th>Result</th><th>Verdict</th></tr>
<tr><td></td><td>The symmetrical short-circuit current shall be calculated using transformer impedance only, except that the maximum symmetrical current magnitudes shall not exceed the values listed in Table 12.
Table 12—Distribution transformer short-circuit withstand capability
<table><tr><th>Single phase (kVA)</th><th>Three phase (kVA)</th><th>Withstand capability[a] per unit of base current (symmetrical)</th></tr><tr><td>5 to 25</td><td>15 to 75</td><td>40</td></tr><tr><td>37.5 to 100</td><td>112.5 to 300</td><td>35</td></tr><tr><td>167 to 500</td><td>500</td><td>25</td></tr></table></td><td>Complied</td><td>P</td></tr>
<tr><td>7.1.4.2</td><td>Category II</td><td></td><td>N/A</td></tr>
<tr><td></td><td>The symmetrical short-circuit current shall be calculated using transformer impedance only.</td><td></td><td>N/A</td></tr>
<tr><td>7.1.4.3</td><td>Categories III and IV</td><td></td><td>N/A</td></tr>
<tr><td></td><td>The symmetrical short-circuit current shall be calculated using transformer impedance plus system impedance, as specified by the transformer user. When system impedance is not specified, data from 7.1.5.3 shall be used.</td><td></td><td>N/A</td></tr>
<tr><td>7.1.4.4</td><td>Stabilizing windings</td><td></td><td>N/A</td></tr>
<tr><td></td><td>Stabilizing windings in three-phase transformers (Δ-connected windings with no external terminals) shall be capable of withstanding the current resulting from any of the system faults specified in 7.1.1, recognizing the system grounding conditions. Appropriate stabilizing winding kVA, voltage, and impedance shall be provided.</td><td></td><td>N/A</td></tr>
<tr><td>7.1.5</td><td>Short-circuit current calculations</td><td></td><td>P</td></tr>
<tr><td>7.1.5.1</td><td>Symmetrical current (two-winding transformers)</td><td></td><td>P</td></tr>
</table>

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Clause	**Requirement-Test**	**Result**	**Verdict**
	It should be noted that for multi-winding transformers and autotransformers, the required rms value of symmetrical current in each winding shall be determined by calculation as shown in Equation (6) and Equation (7), based on applicable system conditions and fault types. $I_{SC} = \frac{I_R}{Z_T + Z_S}$ (6) $I = \frac{I_{SC}}{I_R}$ (7) where I is the symmetrical short circuit current in multiple of normal base I_{SC} symmetrical short circuit current (A, rms) I_R is the rated current on the given tap connection (A, rms) Z_T is the transformer impedance on the given tap connection, in per unit on the same apparent power base as I_R Z_S is the impedance of the system or permanently connected apparatus, in per unit on the same apparent power base as I_R	Complied	P
7.1.5.2	Asymmetrical current		P
	The first-cycle asymmetrical peak current that the transformer is required to withstand shall be determined as shown in Equation (8) and Equation (9): $I_{SC}(\text{pk asym}) = KI_{SC}$ (8) $K = \left\{1 + \left[e^{-\left(\phi + \frac{\pi}{2}\right)\frac{r}{x}}\right]\sin\phi\right\}\sqrt{2}$ (9) where ϕ is arc tan (x/r) (radians) e is the base of natural logarithm x/r is the ratio of effective ac reactance to resistance, both in ohms, in the total impedance that limits the fault current for the transformer connections when the short circuit occurs (When the system impedance is included in the fault-current calculation, the x/r ratio of the external impedance shall be assumed equal to that of the transformer, when not specified. Since the system x/r is much smaller than the transformer x/r, the assumed system ratio will have little impact on the asymmetrical peak calculation. The effect it will have is to make the design of the transformer slightly more conservative.) Values of K are given in Table 13.	Complied	P
7.1.5.3	System characteristics		N/A
	For Categories III and IV, the characteristics of the system on each set of terminals of the transformer (system fault capacity and the ratio of X0/X1) should be specified. For terminals connected to rotating machines, the impedance of the connected equipment should be specified. In lieu of specified system fault capacities and rotating machine impedances, values shall be selected for each source from Table 14 and Table 15. In lieu of a specified X0/X1 ratio, a value of 1.0 shall be used.		N/A
7.1.5.4	Present limitations		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Conventional transformer materials and constructions have inherent short-circuit withstand capability limitations. An example is the tensile withstand capability of annealed copper, which places a limit on the permissible hoop tensile stress in the outer winding of a core form transformer. New materials and construction techniques have been, and will continue to be, developed to extend the withstand capability limitations.	Complied	P
	However, in certain circumstances, it may not be possible to provide the requisite strength in the transformer.In such situations, it would become necessary to limit the fault current with additional impedance external to the transformer windings. For example, it may not be possible to design a reduced-capacity auxiliary winding to withstand a fault directly on its terminals. When the current requirements of 7.1.4 cannot be met, limits of fault-current capability of the transformer shall be specified by the manufacturer in the proposal and shall be identified on the transformer nameplate.		N/A
	For distribution transformers, the short-circuit withstand capability limits of Table 12 have been accepted as being representative for conventional materials and constructions.		N/A
7.1.5.5	Application conditions requiring special consideration		P
	The following situations affecting fault-current magnitude, duration, or frequency of occurrence require special consideration and should be identified in transformer specifications:		N/A
	a) Regulating transformers with extremely low impedance that depend on the impedance of directly connected apparatus to limit fault currents.		N/A
	b) Generator transformers susceptible to excessive overcurrents produced by connection of the generator to the system out of synchronism.		N/A
	c) Transformer terminals connected to rotating machines (such as motors or synchronous condensers) that can act as generators to feed current into the transformer under system fault conditions.		N/A
	d) Operating voltage that is higher than rated maintained at the unfaulted terminal(s) during a fault condition.		N/A
	e) Frequent overcurrents arising from the method of operation or the particular application (for example, furnace transformers, starting taps, applications using grounding switches for relay purposes, and traction feeding transformers).		N/A

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Clause	**Requirement-Test**	**Result**	**Verdict**
	f) Station auxiliary transformers or main generator step-up transformers directly connected to a generator that may be subjected to prolonged duration terminal faults as a result of the inability to remove the voltage source quickly. See IEEE Std C57.116™ [B24] for more information.		N/A
	g) Faults initiated by circuit breakers that may, under certain conditions, cause fault current in excess of those calculated in accordance with this clause.	Complied	P
7.2	Components		N/A
	Transformer components such as leads, bushings, LTCs, de-energized tap-changers, and current transformers that carry current continuously shall comply with all the requirements of 7.1.3 and 7.1.4. However, when not explicitly specified, LTCs are not required to change taps successfully under short-circuit conditions.		N/A
7.3	Base kilovoltamperes		N/A
7.3.1	Base kVA of a winding		N/A
	This is the self-cooled rating of a winding as specified by the nameplate or as determined in accordance with Table 16.		N/A
	For a transformer without a self-cooled rating, the applicable multiplying factor from Table 16 shall be applied to the maximum nameplate kVA rating to obtain the equivalent base kVA rating. **Table 16—Base current calculation factors** Type of transformer / Multiplying factor Water-cooled (ONWF) / 1.0 Natural or forced liquid-cooled with either forced-air cooled or forced-water cooled (ONAF, OFAF, ODAF and OFWF, ODWF), and similarly for designations of other insulating fluids / 0.60		N/A
7.3.2	Base current of windings without autotransformer connections		N/A
	For transformers with two or more windings without autotransformer connections, the base current of a winding is obtained by dividing the base kVA of the winding by the rated kV of the winding on a per-phase basis.		N/A
7.3.3	Base current of windings with autotransformer connections		N/A
	For transformers with two or more windings, including one or more autotransformer connections, the base current and base kVA of any winding other than the series and common windings are determined as described in 7.3.2.		N/A

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Clause	**Requirement-Test**	**Result**	**Verdict**
	The base current of the series winding is equal to the base kVA per phase at the series line terminal, H, divided by the minimum full capacity tap voltage at the series line terminal, H, in kV line to neutral.		N/A
	The base current of the common winding is equal to the line current at the common winding terminal, X, minus the line current at the series winding terminal, H, under loading conditions resulting in the maximum phasor difference. All conditions of simultaneous loading authorized by the nameplate should be considered to obtain the maximum value. Base currents are calculated based on self-cooled loading conditions or equivalent (use multiplying factors).		N/A
7.3.4	Base current in windings of a regulating transformer		N/A
	The base current for each winding of a regulating transformer is the maximum current that can occur in that winding for any loading condition authorized by the nameplate. Base currents are calculated based on selfcooled loading conditions or equivalent (use multiplying factors). It should be noted that these base current definitions are applicable only to windings designed for connection to load.		N/A
7.3.5	Temperature limits of transformers for short-circuit conditions		P
	The temperature of the conductor material in the windings of transformers under the short-circuit conditions specified in 7.1.1 through 7.1.4, as calculated by methods described in 7.1.4, shall not exceed 250 °C for copper conductor or 200 °C for EC (electrical conductor grade) aluminum conductor. A maximum temperature of 250 °C shall be allowed for aluminum alloys that have resistance to annealing properties at 250 °C equivalent to EC aluminum at 200 °C, or for applications of EC aluminum where the characteristics of the fully annealed material satisfy the mechanical requirements. In setting these temperature limits, the following factors were considered:	Complied	P
	a) Gas generation from insulating liquid or solid insulation		N/A
	b) Conductor annealing	Complied	P
	c) Insulation aging	Complied	P
7.4	Calculation of winding temperature during a short circuit		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	The final winding temperature, Tf, at the end of a short circuit of duration, t, shall be calculated as shown in Equation (10) through Equation (16), on the basis of all heat stored in the conductor material and its associated turn insulation. All temperatures are in degrees Celsius. $T_f = (T_k + T_s)m(1 + E + 0.6m) + T_s$ (10) $m = \frac{W_s t}{C(T_k + T_s)}$ (11) $E = E_r\left(\frac{T_k + T_r}{T_k + T_s}\right)^2$ (12) $W_s = \frac{W_r N^2}{M}\left(\frac{T_k + T_s}{T_k + T_r}\right)$ (13)	Complied	P

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Clause	**Requirement-Test**	**Result**	**Verdict**
4	**Enclosure security**		P
4.1	Test requirements		P
	In addition to passing the tests defined in this standard, the construction of pad-mounted enclosure shall comply with the requirements of 4.1.1 through 4.1.9.	Complied	P
4.1.1	Enclosure mounting		P
	The bottom edge of the enclosure shall provide for flush mounting on a flat, rigid mounting surface.	Complied	P
4.1.2	Water resistance		P
	The enclosure shall restrict the entry of water (other than flood water) into the enclosure so as not to impair the operation of the apparatus inside.	Complied	P
4.1.3	Sharp corners		P
	External sharp corners and projections shall be minimized	No sharp corners	P
4.1.4	Panel assembly		P
	Panels shall be fastened or hinged to resist disassembly, breaking, or prying open from the outside with the doors in the closed and locked position. Normal entry shall be possible only with the use of proper access tools. There shall be no exposed screws, bolts, or other fastening devices that are externally removable (with the exception of pentahead bolts provided for extra security) that would provide access to energized parts in the enclosure.	Complied	P
4.1.5	Door hardware		P
	Locking bolts and associated threaded receptacles, hinges, and hinge pins shall be AISI6 type 304 stainless steel or material of equivalent corrosion resistance.	corrosion resistance	P
4.1.6	Handhole covers		N/A
	If handhole covers are exposed, they shall be secured from the inside of the enclosure		N/A
4.1.7	Locking/latching devices		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	The latching device(s) shall be designed and constructed of such a material so as to resist breaking or bending. The provision for locking device(s) on the enclosure door(s) shall be designed and located as to comply with the defined tests.	Complied	P
4.1.8	Enclosure access		P
	All access doors shall be fastened with a device that uses a pentahead tool to permit unlatching the door only after the padlock has been removed. This pentahead device or bolt shall be coordinated such that the padlock cannot be inserted into hasp until the access door is fully latched and the pentahead device is securely engaged.	Complied	P
	Enclosures without latches shall have padlock and pentahead bolt provisions, and shall be coordinated to prevent insertion of a padlock until the access door is fully closed and the pentahead device or bolt is securely engaged. The padlock shall be removed before the pentahead bolt can be disengaged.	Complied	P
	A minimum of one pentahead device or bolt and padlocking means shall be provided. The pentahead device or bolt shall be surrounded by a non-rotating guard or shall be recessed such that the pentahead device or bolt can be engaged only by the proper tool. The dimensions of the pentahead bolt and nonrotating recess shall comply with Figure 1. The pentahead device or bolt shall not be readily removable until the padlock has been removed. More than one door may be fastened with a single padlock and pentahead device or bolt. In the event that the pentahead bolt is missing, the design shall be such that the cabinet shall remain inaccessible through the bolt hole. The bolt hole shall be blocked from the back and all sides to prevent wire probe entry.	Complied	P
4.1.9	Fire resistance		P
	The enclosure shall be constructed of fire-resistant material.	Complied	P
4.2	Test equipment		P
4.3	Resistance to foreign objects		P
	The following tests are to be performed on the enclosure. The enclosure shall resist the entry of foreign objects such as sticks, rods or wires.	Complied	P
4.3.1	General		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	The pad-mounted enclosure shall be mounted on a flat surface according to the manufacturer's specification. With the access door(s) closed and locked using a padlock with an 8 mm (5/16 inch) diameter shackle, the following sequence of tests shall be performed:		P
	a) Pry tests	Complied	P
	b) Wire probe tests	Complied	P
	c) Pull tests	Complied	P
	d) Repeat wire probe tests	Complied	P
	e) Deflection tests	Complied	P
4.3.2	Pry tests		P
	The pry bar shall be used on all joints, crevices, hinges, locking means and other objects that exist between the enclosure components, including the enclosure/pad interface. The pry bar shall be permitted to be placed at any angle to the enclosure surface. The tip of the bar shall first be inserted in the opening being tested using the value of axial force specified in Table 1. Then, with that axial force being maintained, the prying force specified in Table 1 applied alternatively first in one direction and then in the opposite direction (i.e. once in each direction). Application of either or both axial and prying force shall be maintained so long as relaxation is occurring. When relaxation ceases, or if no relaxation occurs, the pry bar shall be removed and pry test reapplied at the same location. When relaxation ceases or no relaxation occurs after the second test, the pry bar shall be removed and applied at an untested location.	Complied	P
4.3.3	Pull tests		P
	A pulling force shall be applied to the critical points of all enclosure parts that can be engaged by the pulling hook. A pulling force indicated in Table 1 shall be exerted at any angle to the enclosure surface. This force is to be maintained during any relaxation. When relaxation ceases, or if no relaxation occurs, the pull test shall be terminated. The hook shall then be inserted into any other part in which it can engage, and the test shall be repeated at the new location. All parts that can be engaged by the pull hook shall be tested once.	Complied	P
4.3.4	Wire probe tests		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Following the pry tests and pull tests described in 4.3.2 and 4.3.3, an attempt to penetrate the enclosure with the probe wire shall be made. This penetration shall be attempted at all crevices and joints. The wire shall be straight with no prebends and shall be gripped by the tester with his or her bare hands. If the wire enters the joint, the wire shall be continually pushed and bent until either it can no longer be pushed or it has entered the enclosure completely. This test is passed if an inspection determines the probing wire either has not entered the enclosure, or if visible, the probing wire is restricted by a barrier from intrusion into the interior.	not entered the enclosure	P
4.3.5	Deflection tests		P
	The deflection test shall be applied to all sides and walls of the enclosure. This test is passed if the specific force (see Table 1) applied perpendicularly to the surface of the enclosure does not impair the dielectric, mechanical or corrosion performance of the equipment.	No impair the dielectric, mechanical or corrosion performance of the equipment	P
4.3.6	Operation test		P
	Following all of the above tests, the unit shall be lifted at least one meter in accordance with manufacturer's standard lift instructions and then set again on the flat surface. The doors shall be easily opened, closed, latched and locked without requiring adjustments to the cabinet, latch mechanism and/or enclosure door(s). All of the door latch points must fully engage when the door is closed.	fully engage	P
4.3.7	Test Repetition		N/A
	These design tests shall be repeated whenever the enclosure design is changed so as to modify performance, or at least every five years whichever is shorter		N/A
4.4	Test values		P
	The minimum test values for which entry shall be prevented are provided in Table 1.	Complied	P
5	**Enclosure design and coating system requirements**		P
5.1	Enclosure design requirements–objective		P
	The objective of this clause is to describe design and performance requirements for carbon steel padmounted enclosures not situated in coastal or other severe environments. Other performance requirements may be needed to provide long field life in other environments.	Complied	P

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Clause	**Requirement-Test**	**Result**	**Verdict**
5.1.1	Accessibility		P
	The enclosure shall be designed such that all exterior surfaces are accessible for proper surface preparation and the application of a uniform amount of the coating materials. Additionally, all exterior surfaces of the enclosure shall be accessible for the purposes of inspection and maintenance of the enclosure over the life of the equipment.	Complied	P
5.1.2	Contaminant accumulation		P
	The enclosure shall be designed to shed water and minimize areas where corrosive elements can accumulate.	Complied	P
5.1.3	Welds–surface preparation		P
	All welds shall be treated to prepare the weld area and the heat affected zones for coating. Weld splatter shall be removed. All welds shall be made in accordance with appropriate industrial welding standards.	Complied	P
5.2	Substrate requirements		P
	The substrate shall be a material which, when coated or otherwise processed, will maintain the structural integrity of the enclosure over the life of the apparatus.	Complied	P
5.3	Coating system requirements		P
5.3.1	General		P
	All coated or gel-coated surfaces on the exterior or interior of the enclosure that may be exposed to the atmosphere shall be capable of meeting the performance tests required by this standard.	Complied	P
5.3.2	Specification of coating characteristics		P
	If more than one coating system is used for different areas of the enclosure, the areas in which each is used shall be identified. The laboratory test performance data of each coating system shall be identified. The laboratory test performance data of each coating system shall be submitted for approval upon request. This data shall be reconfirmed whenever there are changes in the method and/or materials, or at least every two years whichever is shorter.	Complied	P
5.3.3	Coating touch-up prior to shipment		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Touch-up when required, shall be done at final inspection before any equipment is shipped. In areas where the integrity of the coating system is violated, the touch-up shall blend smoothly and meet all performance criteria of this standard.		P
5.3.4	Enclosure color		P
	Unless otherwise specified, the topcoat color shall be Munsell Number "7GY 3.29/1.5 high gloss" or "7GY 3.29/1.5 SG semi-gloss" pad-mount green. The color variation of the coated product shall not exceed the Munsell Color Standard8 by more than a ΔE (Hunter) value of four.	7GY 3.29/1.5 high gloss	P
5.4	Coating system test specimens		N/A
	Test specimens shall consist of panels of the same material composition used in production. Test specimens shall be in accordance with Figure 5, Figure 6, Figure 7, and 0 as to size and type. Quantity and type of panels in each test are identified under the specific test. All panels shall be cleaned, coated and cured using the production coating system. Coated test panels shall be conditioned at room temperature and humidity for a minimum of 7 days prior to any testing.		N/A
5.5	Coating system performance requirements		P
5.5.1	Cross hatch adhesion test		N/A
	One coated test panel, per Figure 6, shall be scribed to bare metal in accordance with ASTM D33599. Method A shall be used for films thicker than 0.13 mm (5 mils or 0.005 inch) and method B shall be used for films less than or equal to 0.13 mm (5 mils or 0.005 inch). There shall be 100% adhesion to the substrate and between layers. A rating of 5A for method A and 5B for method B per ASTM D3359 is required.		N/A
5.5.2	Humidity test		P
	Two coated panels, per Figure 5, shall be tested for 1000 hours in accordance with ASTM D4585 except that the test shall be conducted at 45 °C ± 1 °C (113 °F ± 2 °F). Upon completion of the test, panels shall be evaluated for:		P
	a) Blistering There shall be no blistering observed per ASTM D714 on the surface of the panels when inspected within 15 min after removal from the cabinet.	no blistering observed	P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	b) Softening After removal from the cabinet, allow the panels to air dry for 24 ± 1 hours. There shall be no more than one pencil hardness change when tested per ASTM D3363.	No change	P
	c) Any color change shall be noted.	No change	P
5.5.3	Impact test		P
	One coated panel, prepared per Figure 6, shall be impacted at room temperature on a concrete floor using procedures described in ASTM D2794 at 9 N·m (80 inch-pounds force). The impacted test panels shall be exposed to 24 hours of salt spray per ASTM B117. There shall be no red rust visible in the impact (intrusion) area of the panel.	no red rust visible	P
5.5.4	Insulating fluid resistance tests (for liquid filled equipment only)		P
	Partially immerse one coated panel, per Figure 6, in the insulating liquid for 72 hours at 100 °C – 105 °C (212 °F – 221 °F). On the immersed portion of the panel, there shall be no loss of adhesion per ASTM D3359, no blisters, no streaking and no more than one pencil hardness change per ASTM D3363, using either method.	no blisters, no streaking and no more than one pencil hardness change	P
5.5.5	Ultraviolet accelerated weathering test (QUV)		N/A
	The following test is required for all coated surfaces on the exterior of the enclosure. Expose two test panels, per Figure 6, for 500 hours per ASTM D4587, utilizing the FS-40 bulb with a cycle of 4 hours ultraviolet at 60 °C (140 °F) followed by 4 hours condensation at 50 °C (122 °F). Loss of gloss shall not exceed 50% of original gloss per ASTM D523. The coating shall not exhibit cracking per ASTM D661 or checking per ASTM D660 under unaided visual inspection.		N/A
5.5.6	Simulated corrosive atmospheric breakdown (SCAB)		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	This test requirement shall apply to the coating systems applied to both the exterior and interior cabinet/frontplate surfaces of the pad-mounted enclosure. Three coated panels, per Figure 5, shall be prepared and tested in accordance with the procedure described in Annex A. The scribe shall be prepared for evaluation using ASTM D1654, procedure A, method 2. Upon completion of 15 cycles of SCAB, the scribe line shall be divided into fourteen zones, 6.4 mm (0.25 inch), and the worst spot in each zone will be evaluated by measuring the amount of creepage along the scribe line [except the first 6.4 mm (0.25 inch) of the scribe at each end of the scribe line]. The average of the 14 readings shall be rated per ASTM D1654, Table 1. After a rating has been set for each of the three panels, the average rating of the three shall not be less than a 6 rating. The area away from the scribe shall have no blisters per ASTM D714.	no blisters	P
5.5.7	Abrasion resistance Taber Abraser		P
	The following test is required only for coated surfaces on the exterior of the enclosure. One coated panel, per Figure 7, having the minimum dry film thickness of the total coating system shall be tested using CS-10 wheel, 1000 g weight, in accordance with ASTM D4060. A total number of 3000 cycles shall be run with the wheels resurfaced before testing and after each 500 cycle run. The abraded panel shall be exposed to 24 hours of salt spray per ASTM B117. There shall be no visible red rust.	After test ,no visible red rust	P
5.5.8	Gravelometer		P
	The following test is required only for coated surfaces on the exterior of the enclosure. Two coated panels shown in 0, are to be tested per ASTM D3170 at room temperature using 414 kPa (60 psig) gauge air pressure. Expose the test panels for 24 hours in salt spray per ASTM B117. Remove from salt spray, rinse and dry panels. Evaluate panels per SAE J400 for quantity and size of rusted chipped areas. The rating shall be 4B to 9B per SAE J400 and no rusted chip shall be greater than 3 mm in diameter.	< 3 mm	P
6	**Labels**		P
6.1	Purpose		P

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Clause	**Requirement-Test**	**Result**	**Verdict**
	Labeling can be an important aspect of pad-mounted enclosure integrity. Labeling can alert or inform an individual of potential hazard. Pad-mounted enclosures should be designed to achieve a high degree of integrity. When labels are attached to pad-mounted enclosures, they should be located as near the hazard as practicable. Labels should be concise and simple to understand, and should accurately communicate the type and degree of hazard.	Complied	P
6.2	Application		P
	The application of any labels, whether intended for interior or exterior use, shall be subject to an agreement between the purchaser and the manufacturer.	Complied	P
7	**General**		P
7.1	Shipment		P
	The manufacturer shall provide a method of shipment that will allow the enclosure to be received by the purchaser such that it still meets the performance tests required by this standard.	Complied	P
7.2	Coating repair procedure		P
	A coating system repair procedure shall be recommended by the manufacturer.	Complied	P

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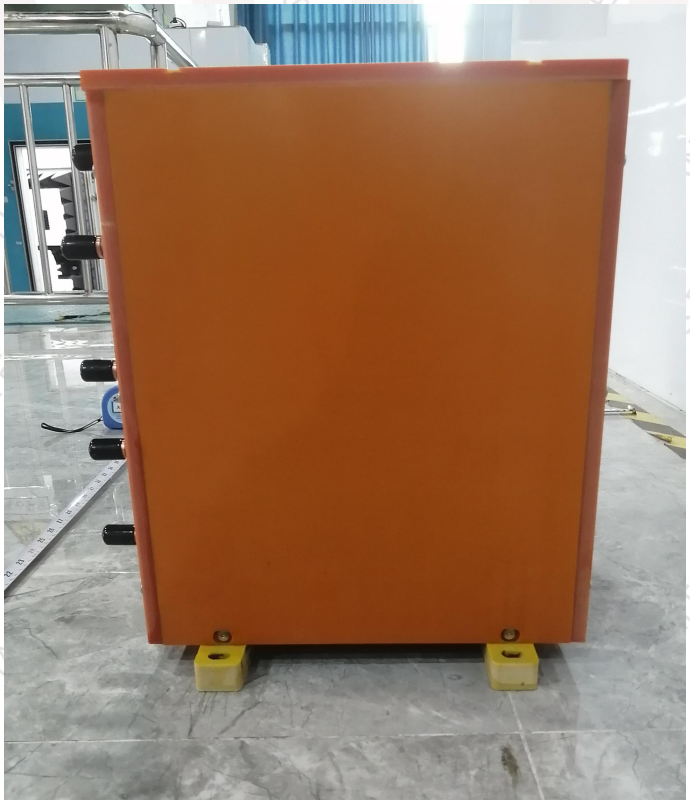

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China National Accreditation Service for Conformity Assessment

LABORATORY ACCREDITATION CERTIFICATE

(Registration No. CNAS L5885)

Shenzhen Tianhai Test Technology Co., Ltd.

(Legal Entity: Shenzhen Tianhai Test Technology Co., Ltd.)

4B/F., Building A3, The Silicon Valley Power Intelligent Terminal Industrial Park, Guanlan Street, Longhua District, Shenzhen, Guangdong, China

is accredited in accordance with ISO/IEC 17025: 2017 General Requirements for the Competence of Testing and Calibration Laboratories(CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence to undertake the service described in the schedule attached to this certificate.

The scope of accreditation is detailed in the attached schedule bearing the same registration number as above. The schedule forms an integral part of this certificate.

Effective Date：2019-01-22

Expiry Date：2025-01-21

Signed on behalf of China National Accreditation Service for Conformity Assessment

China National Accreditation Service for Conformity Assessment(CNAS) is authorized by Certification and Accreditation Administration of the People's Republic of China (CNCA) to operate the national accreditation schemes for conformity assessment. CNAS is a signatory of the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement (ILAC MRA) and the Asia Pacific Laboratory Accreditation Cooperation Mutual Recognition Arrangement (APLAC MRA).

The validity of the certificate can be checked on CNAS website at http://www.cnas.org.cn/english/findanaccreditedbody/index.shtml