

Comparisons of Standards - ANSI/IEEE and IEC

Waukesha Electric Systems

by H. Jin Sim

Subject Issue	ANSI/IEEE		IEC	
	Standard	Requirements	Standard	Requirements
Normal Service Conditions	C57.12.00-1993		76-1-1993	
Lowest Ambient temperature	4.1.2.2	-20 °C	1.2.1.b)	-25 °C
Harmonic Content Maximum	4.1.5	5 %	1.2.1.c)	5 % THC, 1 % even HC
Ratings	C57.12.00-1993		76-1-1993	
kVA	5.4	Several rated power. Impedance and load losses at base rating.	4.1	Top kVA is the rated kVA Impedance and load losses at top rating.
kVA	5.4	Output power at rated secondary voltage	4.1	Input power at rated primary voltage
Over Excitation	4.1.6	5% at FL, 10% at NL	4.4	5% at FL
Temperature rise at different tap positions	C57.12.90-1993	All transformers must meet temperature rise for all taps.	76-1-1993 5.6	Some transformers temp. rise applies to rated tap only.
Load rejection on GSU	C57.116	Extensive guide for these transformers	76-1-1993 8.3	1.4 p.u. voltage for 5 seconds
Tolerances on performances guaranteed	C57.12.00-1993	Generally less than IEC	Clause 9 and Table 1	Generally more than ANSI
Tapping for autotransformers resulting in variable Volts/turn		Does not acknowledge. Closest one is Annex E of C57.131, LTC Requirements	5.1	Subject to agreement
Tapping voltage variation	5.5.3	ANSI does not address this except a statement requiring full-capacity taps	5.2 5.3	Various methods discussed extensively including reduced kVA ratings CFVV, VFVV, CbVV

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Impedances for tap connections	C57.12.10-1988 4.6.3 C57.12.00-1993 Table 17 and 8.3	Percent departure should be within the % tap range. Rated and tap extremes for the first unit and additional tests for LTC	76-1-1993 5.5 10.4	Units with tapping range exceeding $\pm 5\%$, impedance values at tap extremes are quoted and tested.
Resistance Measurements - Cold temperature condition	C57.12.90-1993 5.1.2	Under oil without excitation for 3 to 8 hours min. Difference in top and bottom oil temperature should 5 °C maximum.	76-1-1993 10.2.3	Under oil without excitation for 3 hours min. Difference in top and bottom oil temperature should be small.
Load Loss & Impedance Measurements	C57.12.90-1993 9.3.3.1	Use rated current. Includes much more detailed requirements on corrections and tutorials on load losses through-out the section 9	76-1-1993 10.4	Use minimum 50 % of the rated current
No Load Losses and Excitation Current Measurements	C57.12.90-1993 8.3	Limits the Wave form correction to 5 % Includes much more detailed requirements on corrections and tutorials on no load losses through-out the section 8	76-1-1993 10.5	Average and RMS voltmeter readings should be within 3 %

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Temperature Rises	C57.12.00-1993		76-2-1993	
Top Oil Rise	5.11.1.3	65 °C	4.2	60 °C
Average winding rise for Directed oil unit	5.11.1.1	65 °C	4.2	70 °C
Hottest-spot rise allowance	5.11.1.1	80 °C		Not addressed
Hottest-spot temp. determination		Not addressed IEEE has a Task Force to address this. 4 methods are found in the current draft.	Annex B.2	Hot-spot factor X Gradient HSF = 1.1 for DT = 1.3 for MPT = ? for LPT
Altitude correction for over 1000 m	11.6	Equation 29	4.3.1	1 °C/400 m for OA 1 °C/250 m for FA
Temperature Rise Tests	C57.12.90-1993		76-2-1993	
TOR stabilization	11.2.a)	2.5% or 1 K for 3 hours	5.2.2.a)	1 K for 3 hours
“On-line” hot resistance measurements		Not addressed	5.2.2.b)	By d.c. current superimposed on the load current (per IEC 279)
Average winding rise correction	11.5.2.1.d)	Two methods, using Top oil or Average oil	5.2.2	Corrected for differences of oil temperature at total loss run and rated current run.
Top oil temperature	11.2.b)	One sensor 2” below the top liquid surface.	5.3.1	One or more sensors in the top area or in top headers.
Average winding temperature	11.3.1.2	Measure all phases.	5.4	Prefer middle limb.
“m” exponents for gradients	11.5.2.2.1	0.8 for OA, 0.9 for FA, 1.0 for FOA & FOW	5.6	0.8 for DT, 0.9 for FA, 1.0 for FOA

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Insulation Levels and Dielectric Tests	C57.12.00-1993 C57.12.90-1993		76-3-1980	
Use of "Test" bushings and temporary box connections	10.1.5.3 & 10.1.5.4 of C57.12.90	Requires approval of users	2.0 and Appendix A	Permitted.
Insulation levels for Lightning Impulse and Low Frequency Test levels	C57.12.00, Tables 3,4,&5	Similar to IEC, generally higher for several voltage classes	Tables II, III, IV,V	Similar to ANSI, generally lower for several voltage classes
Switching surge test levels	C57.12.00, Table 5	Starts at 115 kV and typically higher than IEC	Table V	Starts at 300 kV and generally lower than ANSI
Applied Potential Tests	C57.12.90, 10.6.3	More specific on raising and lowering voltage and 1/4 level switching on and off ...smoke, bubbles, audible sound, sudden increase in current...	10.0	Use "rapidly" raise and lower voltage and 1/3 level switching on and off collapse of test voltage
Induced Potential Tests	10.7.3		11.1 & 11.2	
Failure detection	10.6.4 10.7.6			
Induced Potential Tests	10.8.3	1 Φ for 1 Φ units and 3 Φ for 3 Φ units 1hour & PD	11.3 & 11.4	Allows 1 Φ testing for 3 Φ transformers 5 minutes + 5 seconds + 30 minutes & PD
PD measurements	Figure 2 of C57.12.00 10.8.5	PD \leq 100 μ V Δ PD \leq 30 μ V No sudden \uparrow last 20 min	Figure 3 11.4	1.3 pu \rightarrow 300 pC or 1.5 pu \rightarrow 500 pC max.

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	Standard	Requirements	Standard	Requirements
Lightning Impulse Tests	C57.12.90-1993		76-3, Cl.12	
Maximum voltage on terminals not tested	10.3.2.1	Max. 80 %	12.3.1	Max. 70 %
Max. value of Tail Resistors	Table 3	450, 350, or 300 Ω based on voltage level	12.3.1	400 Ω
Transferred surge method		Not addressed	12.3.3 & Appendix B	Simultaneous testing of HV & LV
Chopped Wave	Table 5 of C57.12.00	Part of standard impulse test, typically 1.1 pu FW, minimum 3 μ S to flashover. (minimum 2.0 μ S for 110 kV BIL)	13.1	Special test, same crest value as the FW, 2 to 6 μ S to flashover
Sequence of tests	10.3	1RFW + 2CW + 1FW or 1RFW + 2FOW + 2CW + 1FW	13.3	1RFW + 1FW + RCW's + 2CW + 2FW
Switching Impulse Tests	C57.12.90-1993		76-3, Cl.14	
Wave shape	10.2.2.2	100 X 1000 μ S	14.1	20 X 500 μ S
Sequence of tests	10.2.1	1RSW(50-70%) + 2FSW	14.2	1RSW(50-75%) + 3FSW
PD measurement guide	C57.113-1991		Appendix A	More detailed description on procedures after failure
Impulse Test Guide	C57.98-1993	More detailed tutorial than IEC guide	Pub. 722	Similar to ANSI
External clearances in air	C57.12.00, Table 11	NEMA TR1 table is also used widely in US	76-3-1-1987	Similar to ANSI

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Short-Circuit withstand capability	C57.12.00-1993 C57.12.90-1993		76-5-1976	
Typical impedance	C57.12.10 Table 10	Based on BIL and LTC or Non-LTC	1.2.1.2	Based on rated kVA (Top rating)
System impedance	C57.12.00 Table 14	Larger available MVA, lower system impedance, larger fault current compared to IEC	1.2.1.4 Table II	Smaller available MVA, higher system impedance, smaller fault current compared to ANSI
Use of larger system impedance	7.1.5.4	Manufacturer to specify the capability in the proposal and incorporate on the nameplate.	1.2.2	Requires the user to limit the fault current.
Asymmetry factor K	7.1.5.2 and Table 13	No limit. Calculate K using x/r . For $x/r \geq 14$, K is greater than 2.55, generating higher mechanical stress.	2.2.3 and Table V	Unless specified, limit to 2.55
Symmetrical current tolerance	C57.12.90, 12.4.6	$\geq 95\%$	2.2.4	$\pm 10\%$
Excitation before fault	12.4.3	≤ 1.1 pu	2.2.5.1	≤ 1.15 pu
Total number and duration of faults	12.4.4	6 tests, 2 asymmetrical currents per phase, duration vary for different categories.	2.2.5.4	Category I, 9 tests, 3 on each limb, $0.5 S \pm 10\%$. Other category subject to agreement.
Dielectric test level after SCT	12.5.2	100 %	2.2.6.4	75 %

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	Standard	Requirements	Standard	Requirements
Sound Level Tests	C57.12.90-1993		Pub. 551-1987	
Background noise limit (total-ambient)	13.3.1	≥ 5 dBA with correction per Table 8 (as much as 1.6 dBA)	5.1	≥ 3 dBA with correction per Table I (as much as 3 dBA)
Distance for the contour	13.3.4	2 m away from radiators, coolers, or cooling tubes cooled by forced air, 0.3 m from all other parts	5.2.2	2 m from all parts.
Environmental Correction for reflected sound from walls and other equipment		Not allowed	6.1	Allowed up to 7 dBA, calculated per Appendix A
Loading Guide	C57.91-1995		Pub. 354-1991	
Application Guide	C57,105		Pub.606-1978	Being Updated now.
Bushing Standards	C57.19 series		Pub.137-1984	
Terminal markings	C57.12.70		Pub.616-1978	

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General Comments on IEC and ANSI/IEEE Standards on Transformers

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Style	More Customer oriented Includes more tutorial/educational texts	More designer oriented
Acceptance	National standard in US Referred to in several countries	International standard Ratified as national standard in many countries