

Draft 6A

Changes to Table 21/D6

Draft 6 of the proposed new **Table 21 of C57.12.00, Routine, design, and other tests for liquid-immersed transformers**, follows below. Draft 6 builds upon the existing Table 21 in standard C57.12.00/D3 (balloted April 2006) and the prior *table* drafts circulated since October 2005 to this C57.12.00 Working Group and the Distribution Transformer's Subcommittee.

The changes to this table are an attempt to reconcile numerous comments that have been addressed by this working group since 2001. Generally, the changes are identified by the following working group topics :

WG Item 40(d) –(April 2002) Agreed to modify note 9 to remove the words “coolers, heaters, LTC drive motor, lamps, and all other devices operated from the fan control box”, to the new sentence shown in the table.

WG Item 40(g) – (March 2003) Agreed to add a new note to the table for dissolved gasses in oil analysis, as shown by note 19 in the table.

WG Item 53 – (October 2004) Agreed to change the test description for “Zero-phase sequence impedance voltage” to the description listed in the table. Also agreed to require this as a “Routine” test and a “Design” test, and to remove the mark from the “Other” test column. A new note 18 will be added as shown in the table.

WG Item 58 – (March 2005) Request to revise and expand Table 19 (21) to specifically spell out the test requirements between Class I and Class II power transformers by adding a third set of three columns. The table below attempts to satisfy this request.

WG Item 61 – (October 2005) Agreed to add a new sentence in note 4 as shown in the table.

WG Item 67 - (March 2006) Request to make **load loss testing** and **resistance measurements** a routine test for distribution transformers. As a result of a survey of the Distribution Transformer's Subcommittee and the ensuing discussions, a consensus appears to be that routine load loss measurements are acceptable to all parties, but routine resistance measurements are **not**. Therefore, the changes in the table reflect that consensus.

WG Item 74 – (March 2006) Request to review and clarify the intent of note 1. In light of the just conducted survey, the new note 1 should satisfy that request.

WG Item 76 – (March 2006) Request to add a mark in the “Other” test column for the resistance test of transformers 500 kVA and smaller. Feedback on this request was split – some people think it is necessary to have a test delineated as an “Other” test to allow the user to specify it should they want the test performed, while other people feel it is not necessary, that users can always specify any test they want.

Draft 5 changes are notated in blue. At the autumn 2006 meeting, the Working Group recommended that the table be restructured into the categories of Distribution Transformers, Class I Power transformers, and Class II Power Transformers. This revision attempts to accomplish that. Eight (8) asterisks have been added to the table, and one (1) removed. Additional editorial changes reflect input from Bipin Patel.

Draft 6 changes are notated in green and reflect suggested changes from the Spring 2007 meeting.

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Table 21 – Routine, design, and other tests for liquid-immersed transformers

Tests	Distribution Transformers			Class I Power Transformers			Class II Power Transformers			Comments
	Routine	Design	Other	Routine	Design	Other	Routine	Design	Other	
Resistance measurements of all windings on the rated voltage tap and at the tap extremes of the first unit made on of a new design (see NOTE 1)	*	*	*	*			*			For distribution transformers rated 500 kVA and smaller this is an “ Other ” test, rated 2500 kVA and smaller it is a “ Design ” test, greater than 2500 kVA it is a “ Routine ” test.
Winding Insulation resistance (see NOTE 14 and NOTE 17)			*			*	*			
Core insulation resistance (see NOTE 14 and NOTE 17)			*			*	*			The insulation resistance between the core(s) and ground shall be measured after complete assembly of the transformer at a level of at least 500 V DC, for a duration of 1 minute.
Ratio tests on the rated voltage connection and on all tap positions as listed on the nameplate (for LTC units, see 8.3.1)	*			*			*			For LTC units, see 8.3.1
Polarity and phase relation tests on the rated voltage connection	*			*			*			
Insulation power factor and capacitance (see NOTE 14 and NOTE 17)			*			*	*			
Control (auxiliary) and cooling consumption losses (see NOTE 9 and NOTE 17)			*			*	*			Power consumption (auxiliary/cooling) losses associated with fans and pumps shall be measured.
Single phase excitation tests on the rated voltage connection (see NOTE 8 and NOTE 17)			*			*			*	This test shall be performed on all phases of each winding only when terminals are brought out and accessible for suitable connections. Only line-to-ground voltage suitable for the winding shall be applied during this measurement.
No-load losses and excitation current at 100% and 110% of rated voltage and at rated power frequency on the rated voltage tap connection(s) (see NOTE 16 and NOTE 17)	*			*			*			
No-load losses and excitation current at 110% of rated voltage and at rated power frequency on the rated voltage tap connection(s)			*	*			*			

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Tests	Distribution Transformers			Class I Power Transformers			Class II Power Transformers			Comments
	Routine	Design	Other	Routine	Design	Other	Routine	Design	Other	
Zero-phase sequence impedance voltage and load loss on the rated tap connection (see NOTE 18)			*		*		*			Zero-phase sequence impedance shall be performed when a neutral is brought out. This test is not applicable to single-phase, shell-form, or transformers with 5-legged cores.
Temperature rise At minimum and maximum ratings of the first unit of a new design		*			*			*		
At minimum and maximum ratings when temperature-rise tests are specified			*			*			*	
Dielectric tests										
Low frequency test on auxiliary devices and control and current transformer circuits (see NOTE 10 and NOTE 14)			*			*	*			Control and voltage transformer secondary circuits shall be tested at 1500 V AC 60 Hz, and current transformer circuits shall be tested at 2.5 kV AC 60 Hz for a maximum of 1 minute duration.
Lightning impulse (see NOTE 3)	*	*	*		*	*	*			A special routine impulse test for distribution transformers is required for overhead, pad-mounted, and underground type liquid-immersed distribution transformers. This test is specified in Section 10.4 of IEEE C57.12.90 – 2006.
Front of wave impulse						*			*	
Switching impulse, phase-to-ground (see NOTE 12)						*			*	Switching impulse tests are routine for transformers with high voltage windings operating at 345 kV and above.
Low frequency	*			*			*			
Partial discharge test (see NOTE 14 and NOTE 17)			*			*	*			

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Tests	Distribution Transformers			Class I Power Transformers			Class II Power Transformers			Comments
	Routine	Design	Other	Routine	Design	Other	Routine	Design	Other	
Audible sound level (see NOTE 4)		*	*		*	*		*	*	The transformer shall be connected for and energized at, rated voltage, frequency, and at no load. Noise-contributing elements of the transformer, such as pumps and fans, shall be operated as appropriate for the rating being tested. As a minimum, one test shall be performed at the cooling stage for the minimum rating and one test at the cooling stage for the maximum rating. When it is impractical or undesirable to include the appropriate cooling equipment, the self-cooled sound level may be corrected for cooling noise contribution, if suitable corrections are available and it is mutually agreeable to those concerned. Transformers shall meet standard audible sound levels as listed in NEMA Standard TR1, Table 0-1.
Short-circuit capability (see NOTE 5)		*	*			*			*	Testing of large transformers may not be practical because of test facility limitations.
Operation tests of all devices (see NOTE 13)	*			*			*			All electrical and electro-mechanical devices such as fans, pumps, motors, LTC, etc., shall be operated both in auto and manual mode for proper sequencing/staging and function.
Dissolved gasses in oil analysis (see NOTE 14 and NOTE 17 NOTE 19)			*			*	*			As a minimum, dissolved gasses in oil analysis shall be performed on oil samples drawn before the start of all tests (after oil filling), and after the completion of all tests.
Mechanical										
Lifting and moving devices (see NOTE 15)		*			*			*		The mechanical adequacy of the lifting and moving devices may be determined either by test or mathematical analysis.
Pressure		*			*			*		
Leak	*			*			*			
Telephone influence factor (TIF) (see NOTE 6 and NOTE 7)			*							A test method for measuring TIF may be found in IEEE Std 469-1988. This test is not practical for transformers larger than 50 kVA because of test facility limitations.

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NOTES

- 1- Resistance is a design test for distribution transformers rated 2500 kVA and smaller. Resistance, impedance, and load-loss tests may be omitted on transformers rated 500 kVA and smaller, when a record of such tests made on a duplicate or essentially duplicate unit in accordance with this standard is available.
- 2- For duplicate units, these measurements shall be taken only at the rated voltage connection for a two-winding unit, and for three or more at all rated voltage connections for the case of a units with three or more windings unit. The tested load loss of duplicate transformers shall be corrected to reference temperature by assuming the same stray and eddy loss as the design test transformer.
- 3- Lightning impulse tests are routine for Class II power transformers. A special routine impulse test for distribution transformers is required for overhead-type, pad-mounted type, and underground-type liquid-immersed distribution transformers. This test is specified in 10.4 of IEEE C57.12.90 – 1999.
- 4- The transformer shall be connected for, and energized at, rated voltage, frequency, and at no load. Noise-contributing elements of the transformer, such as pumps and fans, shall be operated as appropriate for the rating being tested. As a minimum, one test shall be performed at the cooling stage for the minimum rating and one test at the cooling stage for the maximum rating. When it is impractical or undesirable to include the appropriate cooling equipment, the self-cooled sound level may be corrected for cooling noise contribution, if suitable corrections are available and it is mutually agreeable to those concerned. Transformers shall meet standard audible sound levels as listed in NEMA Standard TR1, Table 0-1.
- 5- Testing of large transformers may not be practical because of test facility limitations.
- 6- A test method for measuring TIF may be found in IEEE Std 469-1988. This test is not practical for transformers larger than 50 kVA because of test facility limitations.
- 7- This test is not practical because of test facility limitations for transformers larger than 50 kVA.
- 8- This test is a single-phase test and shall be performed on all phases of any each winding only when terminals are brought out and accessible for suitable connections. Only line-to-ground, low-frequency voltage suitable for the winding shall be applied during this measurement.
- 9- Power consumption (auxiliary/cooling) losses associated with fans and pumps, coolers, heaters, LTC drive motor, lamps, and all other devices operated from the fan control box shall be measured on all Class II transformers.
- 10- Control and voltage transformer secondary circuits shall be tested at 1500 V AC 60 Hz, and current transformer circuits shall be tested at 2.5 kV AC 60 Hz for a maximum of 1 min. duration.
- 11- The insulation resistance between the core(s) and ground shall be measured after complete assembly of the transformer at a level of at least 500 V DC, for a duration of 1 min. This test shall be routine test for Class II power transformers and other test for Class I transformers.
- 12- Switching impulse tests are routine for transformers with high voltage windings operating at 345 kV and above.
- 13- All electrical and electro-mechanical devices such as fans, pumps, motors, LTC, etc. shall be operated both in auto and manual mode for proper sequence/staging and function.
- 14- This test shall be a routine test for Class II power transformers and an other test for less than Class II transformers.

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- 15- The mechanical adequacy of the lifting and moving devices may be determined either by test or mathematical analysis.
- 16- No-load losses and excitation test at 110% of rated voltage is an other test for 500 kVA and smaller transformers, except that it is a routine test for Class II transformers.
- 17- Winding insulation resistance (Megger), core insulation resistance (Megger), insulation power factor, control (auxiliary) cooling losses, single phase excitation, no-load losses, and excitation current test at 110% voltage, partial discharge and dissolved gas in oil analysis tests are not applicable to distribution class transformers.
- 18- Zero-phase sequence impedance shall be a design test for Class I transformers having performed when a neutral is brought out. This test is not applicable to single-phase, shell-form, or transformers with 5-legged cores.
- 19- As a minimum, dissolved gasses in oil analysis shall be performed on oil samples drawn before the start of all tests, and after the completion of all tests.