Test Procedures for Distribution Transformers

SNOPR Public Meeting

Definition of a Distribution Transformer

Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

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Definition Overview

- **Purpose: to identify the transformers to which the Department's test procedure would apply**
- **The SNOPR proposal provides generalized numerical criteria and specific exclusions**
  - Consistent with scope of IEEE definition; NEMA TP-1 / TP-2
  - Provides definitions of exclusions for clarity
- **Previous proposed definition had emphasized application description**
  - "…transfer electrical energy from a primary distribution circuit, to a secondary distribution circuit, or within a secondary distribution circuit, or to a consumer's service circuit."

Comparison with NEMA TP-1 / TP-2 Scope

- kVA range for liquid-immersed and dry-type is the same
- Primary and secondary voltage ranges are the same
- DOE exclusions list is largely the same as the exclusions in NEMA TP-1 / TP-2, however:
  - Harmonic transformers are treated differently by DOE
  - DOE does not exclude “retrofit transformer”

Distribution Transformer Definition

"Distribution transformer means a transformer with a primary voltage of equal to or less than 35 kV, a secondary voltage equal to or less than 600 V, a frequency of 55-65 Hz, and a capacity of 10 kVA to 2500 kVA for liquid-immersed units and 15 kVA to 2500 kVA for dry-type units, and does not include the following types of transformers:

(1) autotransformer;
(2) drive (isolation) transformer;
(3) grounding transformer;
(4) harmonic mitigating transformer;
(5) K-factor transformer;
(6) machine-tool (control) transformer;
(7) non-ventilated transformer;
(8) rectifier transformer;
(9) regulating transformer;
(10) sealed transformer;
(11) special-impedance transformer;
(12) testing transformer;
(13) transformer with tap range greater than 15%;
(14) uninterruptible power supply transformer; or
(15) welding transformer."

Specific Areas where the Department Invites Comment

- Exclusion of 5 and 10 kVA dry-type units
- Exclusion of sealed and non-ventilated units
- Definition of special-impedance (normal impedance tables)
- K-factor threshold of K-13 for exemption
- Retrofit transformers

Exclusion of 5 and 10 kVA Dry-type Units

- The DOE's prior proposed definition considered these kVA ratings distribution transformers
- Stakeholders commented that 5kVA and 10kVA are not found in distribution applications
- The Department proposes to exclude these ratings, but invites further input on this subject

Exclusion of Sealed and Non-ventilated Units

- Comments received in the 1999 Re-Opening Notice indicated that unique features for these products may impose a hardship for some manufacturers in testing them
- Very small market share, and excluding would not result in loss of significant energy savings
- These transformers are listed as exclusions in NEMA TP-1 / TP-2
- The Department invites discussion or input on its proposal to adopt this exclusion

Defining a Special-Impedance Transformer (Slide 1 of 3)

"Special-impedance transformer means any transformer built to operate at an impedance outside of the normal impedance range for that transformer's kVA rating. The normal impedance range for each kVA rating is shown in Tables II.1 and II.2."

- No precise IEEE definition exists for special-impedance transformer
- DOE's proposed definition is based on defining what constitutes normal impedance ranges (next two slides)
- Comment on the tables of normal impedance ranges is invited

Defining a Special-Impedance Transformer (Slide 2 of 3)

Table II.1. Normal Impedance Ranges for Liquid-Immersed Transformers

Single-Phase Transformers		Three-Phase Transformers	
kVA	Impedance (%)	kVA	Impedance (%)
10	1.0-4.5	15	1.0-4.5
15	1.0-4.5	30	1.0-4.5
25	1.0-4.5	45	1.0-4.5
37.5	1.0-4.5	75	1.0-5.0
50	1.5-4.5	112.5	1.2-6.0
75	1.5-4.5	150	1.2-6.0
100	1.5-4.5	225	1.2-6.0
167	1.5-4.5	300	1.2-6.0
250	1.5-6.0	500	1.5-7.0
333	1.5-6.0	750	5.0-7.5
500	1.5-7.0	1000	5.0-7.5
667	5.0-7.5	1500	5.0-7.5
833	5.0-7.5	2000	5.0-7.5
		2500	5.0-7.5

Defining a Special-Impedance Transformer (Slide 3 of 3)

Table II.2. Normal Impedance Ranges for Dry-Type Transformers

Single-Phase Transformers		Three-Phase Transformers	
kVA	Impedance (%)	kVA	Impedance (%)
15	1.5-6.0	15	1.5-6.0
25	1.5-6.0	30	1.5-6.0
37.5	1.5-6.0	45	1.5-6.0
50	1.5-6.0	75	1.5-6.0
75	2.0-7.0	112.5	1.5-6.0
100	2.0-7.0	150	1.5-6.0
167	2.5-8.0	225	3.0-7.0
250	3.5-8.0	300	3.0-7.0
333	3.5-8.0	500	4.5-8.0
500	3.5-8.0	750	5.0-8.0
667	5.0-8.0	1000	5.0-8.0
833	5.0-8.0	1500	5.0-8.0
		2000	5.0-8.0
		2500	5.0-8.0

Exclusion of K-factor Transformer K-13 or Greater

"K-factor transformer means a transformer with a K-factor of 13 or greater that is designed to tolerate the additional eddy-current losses resulting from harmonics drawn by non-linear loads, usually when the ratio of the non-linear load to the linear load is greater than 50 percent."

- NEMA TP-1 excludes "harmonic transformers", and "transformers designed for high harmonics"
- DOE's definition instead excludes "harmonic mitigating" and "K-factor" transformers, and defines both
- Minnesota adopted NEMA TP-1, but increased use of K-4 transformers followed
- The Department proposed a cut-off of K-13 for excluding K-factor transformers, to avoid the problem experienced in Minnesota
- Stakeholder comment on this proposal is invited

No Exclusion for Retrofit Transformer

- Department sought specific input from stakeholders in both the Test Procedure NOPR and Re-opening Notice
- Comments indicate that retrofit transformers may be larger than existing ones which could impose expensive installation costs such as breaker / switch-gear replacement, adjusting terminal locations and/or enlarging the transformer room or access doors
- Additional clarification or specific information pertaining to a definition of a retrofit transformer was not provided in response to the Re-opening Notice

Other Issues?

- An opportunity for stakeholders to discuss other exclusions or issues related to the definition of a distribution transformer.