

IEEE Guide for Determination of Hottest-Spot Temperature in Dry-Type Transformers

IEEE Power and Energy Society

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of the
IEEE Power and Energy Society

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Abstract: Methodologies for determination of the steady-state winding hottest-spot temperature in dry-type distribution and power transformers with ventilated, sealed, solid cast, and encapsulated windings built in accordance with IEEE Std C57.12.01™ and IEC 60726 are described in this guide. Converter transformers are not included in this guide.

Keywords: ambient temperature, average winding temperature rise, dry-type transformer, IEEE C57.134, production transformer, prototype transformer, temperature measurement, temperature sensors, transformer model, winding hottest-spot temperature

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Introduction

This introduction is not part of IEEE Std C57.134-2013, IEEE Guide for Determination of Hottest-Spot Temperature in Dry-Type Transformers.

The hottest-spot allowance is a number used in industry standards to establish the average temperature rise for rating purposes. The rated ambient temperature and hottest-spot allowance are subtracted from the rated insulation temperature class to determine the average temperature rise to be confirmed by thermal testing.

IEEE Std 1TM states that the value of the hottest-spot allowance is arbitrary, difficult to determine, and depends on many factors, such as size and design of the equipment. Based on the 1944 experimental works of Stewart and Whitman, and Satterlee, standards used a hottest-spot allowance of 30 °C for 80 °C average temperature rise. The 30 °C hottest-spot temperature allowance established in 1944 for 80 °C average temperature rise was approximately correct for ventilated dry-type transformers produced at that time.

The 220 °C insulation temperature class, 150 °C average temperature rise, was initially used in sealed units. For these units, the 30 °C hottest-spot temperature allowance was probably correct due to operation in the hotter inside gas. The 1959 Loading Guide, ANSI Appendix C57.96, used rated load limiting hottest-spot temperatures to 150 °C for ventilated units and 220 °C for sealed units. In 1965, NEMA Standard TR 27 extended the 220 °C insulation temperature class to ventilated units. In 1979, IEEE Std C57.12.01TM also adopted the 220 °C insulation temperature class for ventilated units. In both these documents, the 30 °C hottest-spot allowance for the 220 °C insulation temperature class was retained. In 1989, IEEE Std C57.12.01TM and the Loading Guide IEEE Std C57.96TM used a constant 30 °C hottest-spot allowance for all insulation temperature classes and all size transformers. By comparison, IEC 60726 (1982-01) used a variable hottest-spot allowance ranging from 5 °C to 30 °C.

The winding hottest-spot temperature rise and average winding temperature rise are related by a ratio that is dependent upon such factors as the following:

- a) Turn insulation
- b) Winding height
- c) Radial build
- d) Ventilating ducts

From this relation, it is apparent that no single winding hottest-spot temperature allowance is applicable to all types and ratings of transformers due to the variability of factors affecting the winding hottest-spot temperature. Laboratory test results reported by Pierce in 1993 validate this finding.

As a step to establishing appropriate temperature limits, the Dry-Type Hot-Spot Methodology Working Group members were encouraged to report their findings on winding hottest-spot temperature measurements. The report has confirmed the variability of the winding hottest-spot temperature ratio; however, the quantity of data compiled is insufficient for validation of winding hottest-spot temperature allowance. To aid consistency and repeatability of results, the working group decided to establish a methodology for determination of winding hottest-spot temperature by testing for qualification of a design family or mathematical model, and by testing or calculation for validation of production units.

The working group deemed it impractical to detail winding configurations and possible hottest-spot locations. The manufacturer has the detailed design knowledge and the responsibility for determining the winding hottest-spot rise. When additional information is available, it will be incorporated into future revisions of this guide.

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1. Overview

1.1 Scope

This guide describes methodologies for determination of the steady-state winding hottest-spot temperature in dry-type distribution and power transformers with ventilated, sealed, solid cast, and encapsulated windings built in accordance with IEEE Std C57.12.01TM and IEC 60076-11. Converter transformers are not included in this guide.¹

1.2 Purpose

Assumptions regarding the relation of winding hottest-spot temperature rise to average winding temperature rise are not representative of all dry-type transformer constructions and winding size. A uniform methodology for determination of winding hottest-spot temperature will provide consistency in testing and calculations for manufacturers’ verification of the winding hottest-spot temperature to the user, and for validation and review of winding hottest-spot temperature limits.

¹ Information on references can be found in Clause 2.