

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

Sponsor

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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 C57.12.01-1998 and IEC 60726 (1982-01) are described in this guide. Converter transformers are not included in this guide.

Keywords: ambient temperature, average winding temperature rise, dry-type transformer, 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 C57.134-2000, 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 1-1986 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 of 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 standard C57.12.01 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 C57.12.01 and the Loading Guide IEEE C57.96 used a constant to 30 °C hottest-spot allowance for all insulation temperature classes and all size transformers. IEC 60726 (1982-01) uses a variable hottest-spot allowance 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 evidenced 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 was encouraged to report their findings on winding hottest-spot temperature measurements. Those reporting have 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 limits. To ensure 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.

This guide represents the state-of-the-art at the time of publication. It was not possible to provide detailed information on determining the hottest-spot temperature or magnitude for the many dry-type transformer designs manufactured. The guide also applies to future designs that incorporate different materials or design concepts not currently produced. 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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