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Rules for the determination of uncertainties in the measurement of the losses on power transformers and reactors

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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Foreword

This Technical Report was prepared by the Technical Committee CENELEC TC 14, Power transformers.

The text of the draft was submitted to vote in accordance with the Internal Regulations, Part 2, Subclause 11.4.3.3 (simple majority) and was approved by CENELEC as CLC/TR 50462 on 2008-03-07.

Contents

Figures

Tables

Introduction

Although the efficiency of a power transformer is very high, the losses (no load and load losses) are object of guaranty and penalty in the majority of the contracts. As a matter of fact, considering the long power transformer life (20 years and more) the cost of the losses play an important role in the evaluation of the total (service) costs and therefore in the investments involved.

A further reason that justifies the attention paid to the losses is that from the generation to the final user, the energy is passing through a number of transformers: step up transformers of generation power stations, interconnecting units for transmission systems, distribution transformers for primary systems (from 100 kV to 400 kV), medium voltage to low voltage transformers in small distribution substations (from 10 kV to 20 kV feeders).

The sum of the losses accrued in the transformer chains may be significant and therefore of importance in nationwide efforts to save energy. A large number of European Countries have instituted measures to conserve energy where losses in electric transmission are an important part.

In power transformers the direct measurement of the efficiency is not recommended because of the uncertainty of this method.

The indirect method based on the measurement of the losses is largely preferred even if the conditions in which such losses are measured differ a little from those that occur in operation.

EN ISO/IEC 17025 requires that the result of any measurement shall be qualified with the evaluation of its uncertainty. A further requirement is that known corrections shall have been applied before evaluation of uncertainty.

This document deals with the measurement of the losses that from a measuring point of view consist of the estimate of a measurand and the evaluation of the uncertainty that affects the estimate itself.

It is well known that when a test result is expressed as numerical quantity it is not an exact number but suffers from uncertainty.

The uncertainty range depends on the quality of the test installation and measuring system, on the skill of the staff and on the intrinsic measurement difficulties presented by the test objects.

The submitted test results is to be considered the most correct estimate and therefore this value has to be accepted as it stands.

The uncertainty shall not be involved in the judgment of compliance for guarantees, tolerances and penalties thresholds.

Guaranty and penalty calculations should refer to the estimated values without consideration of the measurement uncertainties.

1 Scope

This Technical Report illustrates the procedures and criteria to be applied to evaluate the uncertainty affecting the measurements of no load and load losses during the routine tests on power transformers.

Even if the attention is especially paid to the transformers, the document can be also used for the measurements of reactor losses, when applicable.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 60076 series, Power transformers (IEC 60076 series)

EN 60076-1:1996, Power transformers – Part 1: General (IEC 60076-1:1993, mod.)

3 Definitions

For the purposes of this document, the terms and definitions given in EN 60076 apply.

4 Symbols

4.1 General symbols

c sensitivity factor for contribution to uncertainty, see C.3.4;

F_D parameter related to correction of power for effect of phase displacement in measuring circuit;

I_M current measured by the ammeter (normally corresponding to rated current);

I_N reference current (normally rated current);

k_{CN} rated transformation ratio of the current transformer;

k_{VN} rated transformation ratio of the voltage transformer;

P power;

P_2 power measured at load loss test, but referred to the reference current I_N;

P_{LL} load loss at reference conditions and corrected for known systematic deviations in the measurement;

P_{NLL} no-load loss at reference conditions and corrected for known errors in the measurement;

P_W power measured by the power meter;

R_1 winding resistance measured at cold winding resistance test according to EN 60076-1, 10.1;

R_2 winding resistance estimated for the load loss test;

R_r winding resistance at reference temperature according to EN 60076-1, 10.1;

t parameter related to the thermal coefficient of winding resistance;