

Power transformers - Part 19-1: Rules for the determination of uncertainties in the measurement of the losses of power transformers

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

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English Version

**Power transformers - Part 19-1: Rules for the determination of  
uncertainties in the measurement of the losses of power  
transformers  
(IEC 60076-19-1:2023)**

Transformateurs de puissance - Partie 19-1: Règles pour la  
détermination des incertitudes de mesure des pertes des  
transformateurs de puissance  
(IEC 60076-19-1:2023)

Leistungstransformatoren - Teil 19: Regeln für die  
Bestimmung von Unsicherheiten in der Messung der  
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(IEC 60076-19-1:2023)

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## European foreword

The text of document 14/1105/FDIS, future edition 1 of IEC 60076-19-1, prepared by IEC/TC 14 "Power transformers" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60076-19-1:2023.

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IEC 60060-2	NOTE	Approved as EN 60060-2
IEC 61869-1	NOTE	Approved as EN 61869-1
IEC 61869-2	NOTE	Approved as EN 61869-2
IEC 61869-3	NOTE	Approved as EN 61869-3
ISO/IEC 17025:2017	NOTE	Approved as EN ISO/IEC 17025:2017 (not modified)

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Power transformers –**

**Part 19-1: Rules for the determination of uncertainties in the measurement of the losses of power transformers**

**Transformateurs de puissance –**

**Partie 19-1: Règles pour la détermination des incertitudes de mesure des pertes des transformateurs de puissance**



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# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



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**Power transformers –**

**Part 19-1: Rules for the determination of uncertainties in the measurement of the losses of power transformers**

**Transformateurs de puissance –**

**Partie 19-1: Règles pour la détermination des incertitudes de mesure des pertes des transformateurs de puissance**

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ICS 29.180

ISBN 978-2-8322-7024-0

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## POWER TRANSFORMERS –

**Part 19-1: Rules for the determination of uncertainties in the measurement of the losses of power transformers**

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Draft	Report on voting
14/1105/FDIS	14/1107/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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## INTRODUCTION

The losses of power transformers (no-load and load losses) are the object of guarantee and penalty in many contracts and play an important role in the evaluation of the total (service) costs and therefore in the investments involved. Furthermore, regional regulations, such as the Ecodesign Directive of the European Union (Directive 2009/125/EC), can also pose requirements on the establishment of reliable values for losses.

According to ISO/IEC 17025 and ISO/IEC Guide 98-3, the result of any measurement should be qualified with the evaluation of its uncertainty. A further requirement of those documents is that known corrections shall have been applied before evaluation of uncertainty. These provisions have been applied in this document.

Corrections and uncertainties are also considered in IEC 60076-8 where some general indications are given for their determination.

This document deals with the measurement of the losses, which from a measuring point of view consist of the estimate of a measurand and the evaluation of the uncertainty that affects the measurand itself. The procedures can also be applied to loss measurements of power transformers:

- as evaluation of the achievable performance of a test facility in the course of prequalification processes,
- as estimations of achievable uncertainty in the enquiry stage of an order or prior to beginning final testing at the manufacturer's premises; and for
- evaluations of market surveillance measurements.

Evaluation of uncertainty in testing is often characterized as "top-down" or "bottom-up", where the first one relies on inter-laboratory comparisons on a circulated test object to estimate the dispersion and hence the uncertainty. The latter method instead relies on the formulation of a model function, where the test result  $y$  is expressed as a function of input quantities. This function is often the formula used for the calculation of the result. The "bottom-up" method is applied in this document.

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 tested objects.

The procedures developed in this document for evaluation of measurement uncertainty are provided as a tool to assess the soundness of results of loss measurements. Uncertainty is understood as a "parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand" [SOURCE: IEV 311-01-02].

In cases where the losses are required to conform to stated tolerance limits, it is recommended that measurement systems are of such quality that their estimated uncertainty is less than the tolerance limit. (As an example, a measurement with a 5 % uncertainty on a test where the tolerance limit is 5 % is acceptable if the measured value lies within the tolerance limit.) This situation can occur for example in market surveillance activities. It can be noted that an uncertainty 3 % is regarded as state-of-the-art for uncertainty of loss.

Treatment of measurement results is defined as follows in IEC 60076-8:1997, 10.1: "The submitted test result shall contain the most correct estimate that is possible, based on the measurements that have been carried out. This value shall be accepted as it stands. The uncertainty margin shall not be involved in the judgement of compliance for guarantees with no positive tolerance or tolerance ranges for performance data of the test object."

In Annex A to Annex C of this document, examples of uncertainty calculations are reported for no-load and load loss measurements on large power and distribution transformers. Annex D provides information on determination of the exponent for applied voltage in no-load loss measurement. Annex E provides information on uncertainty in measurement. Annex F provides information on calculation of uncertainty of losses with different reference temperatures and/or winding material.

International Standards, Technical Reports and Guides which are mentioned in the text of this document, but which are not indispensable to its application, are listed in the Bibliography at the end of this document.

Loss of reactors is not within the scope of this document. A separate part of IEC IEC60076-19 to handle loss of reactors is under consideration.

A problem with symbols has been rectified, where the symbol for voltage has been changed from  $U$  to  $V$  to avoid confusion with expanded uncertainty. The new symbol is accepted in IEC 60050-121:2002, 121-11-27 for the case when the corresponding electric field is irrotational.

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## POWER TRANSFORMERS –

### Part 19-1: Rules for the determination of uncertainties in the measurement of the losses of power transformers

#### 1 Scope

This part of IEC 60076 defines the procedures that are applied to evaluate the uncertainty affecting the measurements of no-load and load losses during the routine tests on power transformers.

This document centres on measuring systems utilizing digital instruments, although the procedures can be adapted to evaluation of systems with analogue instruments where further uncertainty sources have to be taken into account.

This document specifies how to determine measurement uncertainty and how to apply corrections for known errors in the measurement chain. Information vis-à-vis judgement and traceability are given in IEC 60076-8:1997, 10.1 and 10.2.

#### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60076-1, *Power transformers – Part 1: General*

IEC 60076-2, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-11:2018, *Power transformers – Part 11: Dry-type transformers*

#### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60076-1, IEC 60076-2, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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##### 3.1 uncertainty

<of measurement> parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[SOURCE: ISO/IEC Guide 98-3:2008, 2.2.3, modified – Notes to entry omitted.]