

**SUURTE JÕUTRAFODE ($U_M > 36 \text{ kV}$ VÕI $S_R \geq 40 \text{ MVA}$)
ENERGIASUUTLIKKUS**

Energy performance of large power transformers ($U_M > 36 \text{ kV}$ or $S_R \geq 40 \text{ MVA}$)

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

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English Version

Energy performance of large power transformers ($U_m > 36$ kV or
 $S_r \geq 40$ MVA)

Performance énergétique des transformateurs de grande
puissance ($U_m > 36$ kV ou $S_r \geq 40$ MVA)

Energiekennwerte von Großleistungstransformatoren ($U_m >$
36 kV oder $S_r \geq 40$ MVA)

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Foreword

This document (EN 50629:2015) has been prepared by CLC/TC 14, "Power transformers".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-06-25
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2018-06-25

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For the relationship with requirements of Commission Regulation (EC) see informative Annex ZZ, which is an integral part of this document.

Introduction

This European Standard has been prepared at the request of the European Commission under the mandate EC 24/2011 and applies to large power transformers covered by the COMMISSION REGULATION (EU) N. 548/2014 of 21 May 2014.

For large power transformers (LPT) the strict definition of efficiency based on transmitted and absorbed active power alone is not useful for evaluating the energy performance because the losses are either fixed (no load loss), or depend on current (load loss) and therefore conventional efficiency would be zero if only reactive power is transmitted (reactive power transmission is very important for network operation). The conventional calculation of efficiency is therefore not helpful for comparing transformer designs which may be used over a range of operating conditions.

In general for LPT it is not possible to give optimal values for load and no load losses for a particular rated power because of the variety of applications which affect the energy performance.

In order to define an index that is specific to the transformer design, but applicable to a wide range of uses, rather than a figure that varies from second to second depending on system conditions, it is essential to characterize the energy performance of power transformers. For this reason a metric – Peak Efficiency Index (PEI) – has been developed which is based on real power losses and total power transmitted and is independent of load phase angle, load factor and rated power.

This document provides a standard method for evaluating the energy performance of power transformers through the use of the Peak Efficiency Index, gives benchmark figures for PEI and the reasons why certain transformers may have efficiencies which are higher or lower than the benchmark.

Setting a reasonable value of minimum Peak Efficiency Index will be effective in improving the overall efficiency of the installed transformer population by eliminating transformers with poor efficiency, with the exception of some transformers subject to specific limitations.

The use of a minimum value of Peak Efficiency Index sets a floor for transformer efficiency performance, but the use of proper loss capitalisation for purchasing transformers is essential to select a transformer with the optimal economically justified level of efficiency. Users not using loss capitalisation are strongly encouraged to investigate the benefits of doing so.

For large units above 100 MVA the economically achievable efficiency of a transformer may be limited by the technical parameters of the network (e.g. impedance), and specific transport and installation constraints. As the units concerned are usually purchased by large transmission system owners, who typically use high values of loss capitalization, those units above 100 MVA already tend to be state of the art as far as efficiency is concerned.

For transformers with unusual configurations and/or very severe size or weight limitations it may be unreasonable to meet the minimum efficiency requirement for either technical or economic reasons. In these cases it will be acceptable to demonstrate that the highest reasonable level of efficiency has been achieved (see Clause 6).

It is considered that the approach to energy performance set out in this document could also be applicable in principle to transformers outside the scope of this standard.

1 Scope

This European Standard applies to new three-phase and single-phase power transformers with a highest voltage for equipment exceeding 36 kV and a rated power equal or higher than 5 kVA, or a rated power equal to or higher than 40 MVA regardless of the highest voltage for equipment.

The scope of this European Standard is the following:

- Defining the appropriate energy efficiency criteria;
- Setting of benchmark minimum efficiency levels for new transformers based on an assessment of the energy efficiency of the European transformer population installed in the last 10 years;
- Proposing higher minimum efficiency levels for improving the energy efficiency of new transformers;
- Providing guidance for consideration of Total Cost of Ownership.

This European Standard provides also a form for efficiency data collection to inform future efficiency benchmark levels.

NOTE 1 This standard covers the transformers under the EU Regulation N. 548/2014 and gives additional specific guidance for single phase transformers, autotransformers, multi winding transformers and for transformers with OD and OF cooling systems, necessary for the correct application of energy efficiency requirements to these categories of transformers.

Transformers considered to be out of the scope of this document are the following:

- instrument transformers, specifically designed to supply measuring instruments, meters, relays and other similar apparatus,
- transformers with low-voltage windings specifically designed for use with rectifiers to provide a DC supply,
- transformers specifically designed to be directly connected to a furnace,
- transformers specifically designed for offshore applications and floating offshore applications,
- transformers specially designed for emergency installations,
- transformers and auto-transformers specifically designed for railway feeding systems,
- earthing or grounding transformers, this is, three-phase transformers intended to provide a neutral point for system grounding purposes,
- traction transformers mounted on rolling stock, this is, transformers connected to an AC or DC contact line, directly or through a converter, used in fixed installations of railway applications,
- starting transformers, specifically designed for starting three-phase induction motors so as to eliminate supply voltage dips,
- testing transformers, specifically designed to be used in a circuit to produce a specific voltage or current for the purpose of testing electrical equipment,
- welding transformers, specifically designed for use in arc welding equipment or resistance welding equipment,
- transformers specifically designed for explosion-proof and underground mining applications,
- transformers specifically designed for deep water (submerged) applications,
- medium Voltage (MV) to Medium Voltage (MV) interface transformers up to 5 MVA,
- large power transformers where it is demonstrated that for a particular application, technically feasible alternatives are not available to meet the minimum efficiency requirements set out by EU REGULATION N. 548/2014,
- large power transformers which are like for like replacements in the same physical location/installation for existing large power transformers, where this replacement cannot be achieved without entailing disproportionate costs associated to their transportation and/or installation.

For dry type large power transformers Minimum PEI values have been published in European Regulation and these values are included in Annex A.

NOTE 2 To retain consistency, the same list of exclusions in the EU Regulation N. 548/2014, has also been reproduced here. Within the above EU exclusion list, some had been excluded simply because no PEI data was available to CENELEC at the time on which to base appropriate PEI levels. Consequently, as such information becomes available in the future, it may be possible to derive suitable PEI Levels. Accordingly these particular categories are listed in Clause 6 as suitable for future consideration.

2 Normative references

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

EN 60076 (all parts), *Power transformers (IEC 60076, all parts)*

EN 60076-19, *Power transformers — Part 19: Rules for the determination of uncertainties in the measurement of the losses on power transformers and reactors (IEC/TS 60076-19)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 60076-1:2011 and the following apply.

3.1

Large Power Transformer

LPT

power transformer with a highest voltage for equipment exceeding 36 kV and a rated power equal or higher than 5 kVA, or a rated power equal to or higher than 40 MVA regardless of the highest voltage for equipment

3.2

load factor

k

ratio of actual input current over the rated current of transformer

Note 1 to entry: Normally $0 \leq k \leq 1$.

3.3

transmitted apparent power

kS_r

product of the load factor and the rated power

3.4

Efficiency Index

EI

ratio of the transmitted apparent power of a transformer minus electrical losses to the transmitted apparent power of the transformer

3.5

Peak Efficiency Index

PEI

highest value of efficiency index that can be achieved at the optimum value of load factor

3.6

load factor of Peak Efficiency Index

k_{PEI}

load factor at which Peak Efficiency Index occurs

3.7

declared value

regulatory value given in Table 1 which is to be used for market surveillance activities

Note 1 to entry: According to EN 60076-1, 'declared value' and 'guaranteed value' refer to two different concepts. 'Guaranteed Values' relate to the values cited in the commercial contract, whereas 'declared values' are those values which are cited to establish compliance with EU Regulation N. 548/2014.