Commission Working Document with regard to small, medium and large power transformers

Brussels

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (1) and in particular Article 15(1) thereof,

After consulting the Ecodesign Consultation Forum,

Whereas:

(1) The Commission has carried out a preparatory study which analysed the environmental and economic aspects of transformers. The study has been developed together with stakeholders and interested parties from the Community and the results have been have made publicly available.

(2) The study showed that energy in the use phase is the most significant environmental aspect which can be addressed through product design. Significant amounts of raw materials (copper, iron, resin, aluminium) are used in the manufacturing of transformers, but market mechanisms seem to be ensuring an adequate end-of-life treatment, and therefore, for the time being, related mandatory ecodesign requirements are not being set out.

(3) Mandatory ecodesign requirements apply to products placed on the market or put into service wherever they are installed, therefore such requirements cannot be made dependant on the application in which the product is used.

(4) Ecodesign requirements for the energy performance of medium power transformers and for the energy efficiency of large power transformers should be set with a view to harmonising ecodesign requirements for these devices throughout the Community and contributing to the functioning of the internal market and to the improvement of their environmental performance.

(5) This Working Document should increase the market penetration of technologies and design options improving the energy performance of medium power transformers and the energy efficiency of large power transformers. The cost-effective improvement potential through design is about 16,2 TWh per year in 2025, which corresponds to 3,7 Mt of C02 emissions.

(6) A staged entry into force of the ecodesign requirements should provide an appropriate timeframe for manufacturers to redesign their products. The timing of the stages should be set in such a way that cost impacts for manufacturers, in particular SMEs, are taken into account, while ensuring timely achievement of the policy objectives.

(7) In the procurement of medium and large power transformers, most end-users (including public and private utilities and industrial site owners) perform loss capitalisation calculations in order to determine the financially optimal levels of energy losses. Wide variations in the estimates for long term marginal electricity prices and capital discount rates make it difficult for economic operators to compare design options across Member States. End-users and manufacturers are therefore advised to use reliable sources for the estimates of wholesale electricity prices, such as the Statistics and Market observatory provided by the European Commission[1]. End-users are furthermore advised to make an appropriate loss capitalisation calculation in their procurement process and use the transformer with the lowest evaluated cost including the lifetime cost of losses, if the level of efficiency achieved is higher than the one required by the Working Document. To allow an effective implementation of the Working Document, National Regulating Authorities are advised to take account of the effect of minimum efficiency requirements on transformer first cost and to allow for more efficient transformers than the Working Document requires if these are economically justified on a whole life cycle basis.

(8) In order to facilitate compliance checks, manufacturers should be requested to provide information in the technical documentation referred to in Annexes IV and V to Directive 2009/125/EC.

Chapter 1 - Subject matter and scope

This Working Document establishes ecodesign requirements for the putting into service of transformers with a minimum power rating of 1 kVA used in 50Hz electricity transmission and distribution networks or for industrial applications. The Working Document is only applicable to transformers purchased after the entry into force of the Working Document.

This Working Document shall not apply to the following categories of transformers:

- Instrument transformers
- Transformers with high current rectifiers
- Transformers for furnace applications
- Transformers for offshore applications and floating offshore applications
- Transformers for emergency mobile installations
- Transformers and auto-transformers for 16.7 Hz railway feeding systems
- Auto-transformers for 50 Hz railway feeding system
- Earthing transformers
- Traction transformers on rolling stock
- Starting transformers
- Testing transformers
- Welding transformers
- Explosion-proof and underground mining transformers
- Transformers for deep water (submerged) applications
- Medium Voltage (MV) to Medium Voltage (MV) interface transformers up to 5 MVA

[1] http://ec.europa.eu/energy/observatory/electricity/electricity_en.htm

Chapter 2 - Definitions

Transformers are considered as energy related products within the meaning of Article 2 (1) of Directive 2009/125/EC.

For the purpose of this Working Document and its annexes, the definitions set out in Directive 2009/125/EC shall apply. The following definitions shall also apply.

(1) "Power transformer" means a static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of alternating voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power.

(2) "Small power transformer" means a power transformer with a highest voltage for equipment not exceeding 1 kV.

(3) "Medium power transformer" means a power transformer with a high voltage for equipment higher than 1 kV, but not exceeding 36 kV and a rated power equal or higher than 5 kVA but lower than 40 MVA.

(4) "Large power transformer" means a power transformer with a high voltage for equipment exceeding 36 kV and a rated power equal or higher than 5 MVA.

(5) "Liquid-immersed transformer" means a power transformer in which the magnetic circuit and windings are immersed in liquid.

(6) "Dry-type transformer" means a power transformer in which the magnetic circuit and windings are not immersed in an insulating liquid.

(7) "Pole mounted transformer" means a power transformer suitable for outdoor service and designed to be mounted on the support structures of overhead power lines.

(8) "Winding" refers to the assembly of turns forming an electrical circuit associated with one of the voltages assigned to the transformer.

(9) Rated voltage of a winding (U_r) is the voltage assigned to be applied, or developed at no-load, between the terminals of an untapped winding, or of a tapped winding connected on the principal tapping.

(10) "High-voltage winding" refers to the winding having the highest rated voltage.

(11) "Rated power" (Sr) is a conventional value of apparent power assigned to a winding which, together with the rated voltage of the winding, determines its rated current.

(12) "Transformer load factor" means the ratio of energy supplied by a transformer during a given period of time to the energy it would have supplied if it had been operating at its maximum rated power for the same period of time.

(13) "Load loss" (Pk) means the absorbed active power at rated frequency and reference temperature associated with a pair of windings when the rated current (tapping current) is flowing through the line terminal(s) of one of the windings and the

terminals of the other windings are in short-circuit with any winding fitted with tappings connected to its principal tapping. Further windings, if existing, are open-circuited.

(14) "No load loss" (Po) means the active power absorbed at rated frequency when the transformer is energised and the secondary circuit is open. The applied voltage is the rated voltage, and if the energized winding is fitted with a tapping, it is connected to its principal tapping.

(15) Peak Efficiency Index (PEI) means the maximum value of the ratio of the transmitted apparent power of a transformer minus the electrical losses to the transmitted apparent power of the transformer. Annex II includes the calculation method for the calculation for the PEI.

Chapter 3 - Eco-design requirements

Energy losses in the use phase are by far the dominating environmental impact over the lifecycle of transformers.

Small, medium and large power transformer shall meet the ecodesign requirements set out in Annex I, including:

- Minimum energy performance requirements or minimum energy efficiency requirements (Peak Efficiency Index) for medium power transformers, according to their rated power
- Minimum energy efficiency requirements (Peak Efficiency Index) for large power transformers
- Product information requirements for small, medium and large power transformers

Chapter 4 - Form of the Implementing measure

The Commission intends to propose a directly applicable Implementing Working Document under Directive 2009/125/EC. The proposed Working Document is not expected to have a particular impact on the EU acquis. There are no overlaps with other Ecodesign Working Documents, as far as is known.

Chapter 5 - Conformity Assessment

A conformity assessment shall be carried out according to Chapter 8 of Directive 2009/125/EC, Annex IV (Internal design control) or Annex V (Management system for assessing conformity).

Chapter 6 - Verification procedure

When performing the market surveillance checks referred to in Directive 2009/125/EC, Chapter 3 (2), Member State authorities shall apply the verification procedure set out in Annex III.

Chapter 7 - Review

No later than three years after entry into force of the requirements set out in Annex I of this Working Document, the Commission shall review it in the light of technological progress and present the results of this review to the Consultation Forum. Specifically, the review will consider, at least, the following issues:

- The appropriateness of the levels set for the specific Ecodesign requirements in Tier 2 and the need to establish further Tiers for any type of transformers in the light of market development;
- The availability of the materials necessary to meet such requirements;
- The possibility to set out minimum values of the Peak Efficiency Index for all medium power transformers, including those with a rated power below 3150 kVA;
- The appropriateness of establishing minimum performance requirements for single-phase transformers, as well as for small power transformers.
- Verify whether concessions made for pole-mounted transformers and for special combinations of winding voltages for medium power transformers are still appropriate.
- The possibility to cover other environmental impacts than energy in the use phase.

Chapter 8 - Entry into force

The Working Document shall enter into force on the 20th day following its publication in the Official Journal of the European Union.

The requirements set out in Annex I shall apply in accordance with the timetable provided for therein.

This Working Document shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, xx xx 2014

Annex I: Ecodesign requirements

a) Specific requirements for medium power transformers

The minimum energy performance requirements for medium power transformers consist of maximum allowed load and no-load losses or the Peak Efficiency Index (PEI) values given in Tables I.1 to I.6.

a.1) Specific requirements for three-phase medium power transformers with rated power ≤3150kVA

Table I.1: Maximum load and no-load losses for three-phase **liquid-immersed** medium power transformers with the high-voltage winding rated ≤ 24 kV and the other winding rated ≤ 1,1 kV

	Tier 1 (from 1 July 2015)		Tier 2 (from 1 July 2021)	
RATED POWER (kVA)	**Maximum load losses (in Watts) ***	**Maximum no-load losses (in Watts)***	**Maximum load losses (inWatts)***	**Maximum no-load losses (in Watts)***
25	Ck (900)	Ao(70)	Ak(600)	Ao-10% (63)
50	Ck (1100)	Ao(90)	Ak(750)	Ao-10%(81)
100	Ck (1750)	Ao(145)	Ak(1250)	Ao-10%(130)
160	Ck (2350)	Ao(210)	Ak(1750)	Ao-10%(189)
250	Ck (3250)	Ao(300)	Ak(2350)	Ao-10%(270)
315	Ck (3900)	Ao(360)	Ak(2800)	Ao-10%(324)
400	Ck (4600)	Ao(430)	Ak(3250)	Ao-10%(387)
500	Ck (5500)	Ao(510)	Ak(3900)	Ao-10%(459)
630	Ck (6500)	Ao(600)	Ak(4600)	Ao-10%(540)
800	Ck (8400)	Ao(650)	Ak(6000)	Ao-10%(585)
1000	Ck (105000)	Ao(770)	Ak(7600)	Ao-10% (693)
1250	Bk (11000)	Ao(950)	Ak(9500)	Ao-10%(855)
1600	Bk(14000)	Ao(1200)	Ak(12000)	Ao-10%(1080)
2000	Bk (18000)	Ao(1450)	Ak(15000)	Ao-10%(1305)
2500	Bk (22000)	Ao(1750)	Ak(18500)	Ao-10%(1575)
3150	Bk (27500)	Ao(2200)	Ak(23000)	Ao-10%(1980)

*Maximum losses for kVA ratings that fall in between the ratings given in Table I.1 shall be obtained by linear interpolation.

Table I.2: Maximum load and no-load losses for three –phase **dry-type** medium power transformers with the high-voltage winding rated ≤ 24 kV and the other winding rated ≤ 1,1kV

	Tier 1 (1 July 2015)		Tier 2 (1 July 2021)	
RATED POWER (kVA)	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***
50	Bk (1700)	Ao(200)	Ak(1500)	Ao-10%(180)
100	Bk (2050)	Ao(280)	Ak(1800)	Ao-10%(252)
160	Bk (2900)	Ao(400)	Ak(2600)	Ao-10%(360)
250	Bk (3800)	Ao(520)	Ak(3400)	Ao-10%(468)
400	Bk (5500)	Ao(750)	Ak(4500)	Ao-10%(675)
630	Bk (7600)	Ao(1100)	Ak(7100)	Ao-10%(990)
800	Ak (8000)	Ao(1300)	Ak(8000)	Ao-10%(1170)
1000	Ak (9000)	Ao(1550)	Ak(9000)	Ao-10%(1395)
1250	Ak (11000)	Ao(1800)	Ak(11000)	Ao-10%(1620)
1600	Ak (13000)	Ao(2200)	Ak(13000)	Ao-10%(1980)
2000	Ak (16000)	Ao(2600)	Ak(16000)	Ao-10%(2340)
2500	Ak (19000)	Ao(3100)	Ak(19000)	Ao-10%(2790)
3150	Ak (22000)	Ao(3800)	Ak(22000)	Ao-10%(3420)

*Maximum losses for kVA ratings that fall in between the ratings given in Table I.2 shall be obtained by linear interpolation.

Table I.3: Correction of load and no load losses in case of other combinations of winding voltages or dual voltage in one or both windings (rated power ≤ 3150kVA)

One winding with Um ≤ 24 kV and the other with Um > 1,1 kV	The maximum allowable losses in Tables I.1 and I.2 can be increased by 10% for no load losses and by 10% for load losses
One winding with Um = 36 kV and the other with Um ≤ 1,1 kV	The maximum allowable losses in Tables I.1 and I.2 can be increased by 15% for no load losses and by 10% for load losses
One winding with Um = 36 kV and the other with Um > 1,1 kV	The maximum allowable losses indicated in Tables I.1 and I.2 can be increased by 20% for no load losses and by 15% for load losses
Case of dual voltage on one winding	In case of transformers with one MV (Medium Voltage) winding and two voltages available from a tapped LV (Low Voltage) winding, losses shall be calculated based on the higher LV voltage and shall be in compliance with the maximum allowable losses in Tables I.1 and 1.2. The maximum available power on the lower LV winding on such transformers shall be limited to 0.85 of its nominal rated power.
	In case the full nominal power is available regardless of the combination of voltages, the levels of losses indicated in Tables I.1 and I.2 can be increased by 15% for no load losses and by 10% for load losses.
Case of dual voltage on both windings	The maximum allowable losses in Tables I.1 and I.2 can be increased by 20% for no load losses and by 20% for load losses for transformers with dual voltage on both windings. The level of losses is given on the basis that the rated power is the same regardless of the combination of voltages.

a.2) Specific requirements for medium power transformers with rated power >3150kVA

Table I.4: Minimum Peak Efficiency (PEI) values for **liquid immersed** medium power transformers

RATED POWER (kVA)	Tier 1 (01.07.2015)	Tier 2 (01.07.2021)
	Peak Efficiency Index (%)	
4000	99.465	99.532
5000	99.483	99.548
6300	99.510	99.571
8000	99.535	99.593
10000	99.560	99.615
12500	99.588	99.640
16000	99.615	99.663
20000	99.639	99.684
25000	99.657	99.700
31500	99.671	99.712
40000	99.684	99.724

PEI values for kVA ratings that fall in between the ratings given in Table I.4 shall be calculated by linear interpolation

Table I.5: Minimum Peak Efficiency Index (PEI) values for **dry type** medium power transformers

RATED POWER (kVA)	Tier 1 (01.07.2015)	Tier 2 (01.07.2021)
	Peak Efficiency Index (%)	
4000	99.348	99.382
5000	99.354	99.387
6300	99.356	99.389
8000	99.357	99.390
10000	99.357	99.390

PEI values for kVA ratings that fall in between the ratings given in Table I.5 shall be calculated by linear interpolation

a.3) Specific requirements for medium power transformers with rated power ≤ 3150kVA equipped with tapping connections

When medium power transformers with rated power ≤ 3150 kVA are equipped with tapping connections suitable for operation while being energised or on-load for voltage adaptation purposes, the maximum allowable levels of load and no load losses in Tables I.1 and I.2 of this Annex I can be increased by 10%.

a.4) Specific requirements for medium power pole-mounted transformers

These levels of load and no load losses indicated in Tables I.1 and I.2 are not applicable to pole-mounted transformers with power ratings between 160 kVA and 315 kVA. For these specific models of medium power pole-mounted transformers, the maximum levels of allowable losses are set out in Table I.6.

This regulatory concession is granted because of the weight limitations for mounting transformers on utility poles. In order to avoid misuse of transformers specifically manufactured for pole-mounted operation, they should include a visible display "For pole-mounted operation only", so as to facilitate the work of national market surveillance authorities.

Table I.6 Maximum load and no-load losses for medium power pole-mounted transformers

	Tier 1 (1 July 2015)		**Tier 2 (1 July 2021)**	
Um (kVA)	**Maximum load losses (in Watts) ***	**Maximum no-load losses (in Watts)***	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***
50	Ck (1100)	Ao (90)	Bk (875)	Ao (90)
100	Ck (1750)	Ao (145)	Bk (1250)	Ao (145)
160	Ck+32% (3100)	Co(300)	Ck+32% (3100)	Co-10% (270)

*Maximum allowable losses for kVA ratings that fall in between the ratings given in Table I.6 shall be obtained by linear interpolation

b) Specific requirements for large power transformers

The minimum efficiency requirements for large power transformers are set out in Table I.7

Table I.7 Minimum Peak Efficiency Index requirements for large power transformers

RATED POWER (MVA)	Tier 1 (01.07.2015)	Tier 2 (01.07.2021)
	Peak Efficiency Index (%)	
≤ 4	99.465	99.532
5	99.483	99.548
6,3	99.510	99.571
8	99.535	99.593
10	99.560	99.615
12,5	99.588	99.640
16	99.615	99.663
20	99.639	99.684
25	99.657	99.700

31,5	99.671	99.712
40	99.684	99.724
50	99.696	99.734
63	99.709	99.745
80	99.723	99.758
≥100	99.737	99.770

c) Product information requirements

From 1 July 2015, the following product information requirements shall apply:

(1) Information on rated power, load loss and no-load loss and the electrical power of any cooling system required at no load shall be mandatory in any related product documentation, as well as on the transformer's rating plate.

(2) For medium power (where applicable) and large power transformers, the value of the Peak Efficiency Index and the power at which it occurs shall be included in the product documentation and marked on the rating plate.

(3) Information on the weight of all the main components of a transformer (including the conductor, the nature of the conductor and the core material) shall be mandatory in any related product documentation.

(4) Pole mounted distribution transformers as defined in this Working Document shall have their application mentioned in any related product documentation and shall include the ISO caution mark to read their documentation. In order to avoid misuse of transformers specifically manufactured for pole-mounted operation, they should also include a visible display "For pole-mounted operation only", so as to facilitate the work of national market surveillance authorities.

Annex II: Measurement and calculation methods

Measurement method

For the purpose of compliance with the requirements of this Working Document, measurements shall be made using a reliable, accurate and reproducible measurement procedure, which takes into account the generally recognised state of the art measurement methods, including methods set out in documents the reference numbers of which have been published for that purpose in the Official Journal of the European Union.

[A European Standard EN for "Three-phase medium voltage transformers 50Hz, with highest voltage for equipment not exceeding 36 kV" is under preparation and it's likely to be voted by CENELEC before the end of 2013. The standard lays down requirements related to electrical characteristics and design of three-phase medium power transformers. This European Standard should become a harmonized standard in support of this Ecodesign Working Document through the publication of its reference in the OJEU.]

[A European Standard EN for large power transformers is also under preparation by CENELEC TC 14 WG 29. This standard includes a detailed calculation method for the peak efficiency index (PEI). Once this standard has been voted, it should become a harmonized standard in support of this Ecodesign Working Document through the publication of its reference in the OJEU.]

Calculation methods

The methodology for calculating the Peak Efficiency Index (PEI) for medium and large power transformers is based on the ratio of the transmitted apparent power of a transformer minus the electrical losses to the transmitted apparent power of the transformer.

$$PEI = 1 - \frac{2(P_0 + P_{c0})}{S_r \sqrt{\frac{P_0 + P_{c0}}{P_k}}}$$

Where:

P_0 is the no load losses measure at rated voltage and rated frequency, on the rated tap

P_{c0} is the electrical power required by the cooling system for no load operation

P_k is the measured losses at rated current and rated frequency on the rated tap corrected to reference temperature according to EN 60076-2

S_r is the rated power of the transformer or autotransformer on which P_k is based

Annex III: Verification procedure

For the purposes of checking conformity with the requirements laid down in Annex I, Member States authorities shall use the measurement and calculation procedure set out in Annex II.

Given the weight and size limitations in the transprotation of medium and large power transformers, Member States authorities may decide to undertake the verification procedure at the premises of manufacturers, before models are put into service in their final destination.

The model shall be considered to comply with the provisions set out in this Working Document, if the measured parameters meet the requirements set out in Annex I within the verification tolerances indicated in Table 1 of this Annex.

Table 1.

Measured parameter	Verification tolerances
Load losses	The measured value shall not be greater than the declared value by more than 5 %.
No load losses	The measured value shall not be greater than the declared value by more than 5 %.
Peak Efficiency Index (PEI)	The measured values of the load (Pk) and no-load losses (Po) for the calculation of the PEI shall not be greater than the declared value by more than 5%.