Working document on a Commission Regulation implementing Directive 2009/125/EC 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 Com munity 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) a re 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 improve ment of their environmental performance.

(5) This Regulation 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 XX TWh per year in 2020, which corresponds to XX Mt of C02 emissions *(to be completed once requirements are stable).*

(6) A staged entry into force of the ecodesign requirements should provide an appro priate 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 wholesale 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].

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

Subject matter and scope

This working document pursuant to Directive 2009/125/EC establishes ec odesign requirements related to small, medium and large power transformers with a minimum power rating of 1 kVA used in 50Hz electricity transmission and distribution.

This Regulation shall not apply to the following categories of transformers:

- Instrument transformers
- Traction transformers on rolling stock
- Starting transformers
- Testing transformers
- Welding transformers
- Explosion-proof and underground mining transformers
- Transformers for deep water (submerged) applications

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 following definitions shall apply.

(1) "Power transformer" means a static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternat ing 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) "General purpose 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 winding with a rated voltage higher than 1 kV, but not exceeding 36 kV.

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

(4) "Large power transformer" means a power transformer with a high voltage winding having a rated voltage exceeding 36 kV.

(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 connected by open bushings 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_m) 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" (S) 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) "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 active power absorbed 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 (any other windings, if existing, are open-circuited).

Comment [A1]: This part of the definition challenged by BE

(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.

Eco-design requirements

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

Products falling under the definitions of paragraph "Definitions" above shall meet the ecodesign requirements set out in Annex I, including:

- Minimum energy performance requirements for medium power transformers
- Peak efficiency requirements for large power transformers

- Product information requirements

Form of the Implementing measure

The Commission intends to propose a directly applicable Implementin g Regulation under Directive 2009/125/EC. The proposed Regulation is not expected to have a part icular impact on the EU acquis. There are no overlaps with other Ecodesign regulations, as far as is known.

Conformity Assessment

A conformity assessment shal l 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).

Verification procedure for m arket surveillance purposes

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.

Benchmarks

The indicative benchmarks for the best available technology currently available on the market are identified in Annex IV .

Revision

No later than six years after entry into force of this Regulation , the Commission shall review it in the light of technological progress and present the results of this review to the Consultation Forum.

Entry into for ce

The Regulation shall enter into force on the 20 th 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.

Annex I: Ecodesign requirements

a) Specific requirements for general purpose small power transformers

The minimum energy performance requirements for small power transformers consist of maximum allowed load and no -load losses given in Table I.1.

Table I.1: Maximum load and no-load losses requirements for general purpose small power transformers

Rating (S) (kVA)	Tier 1 (1 July 2014)		Tier 2 (1 July 2018)	
	Maximum no-load losses (W)*	Maximum load losses (W)*	Maximum no-load losses (W)*	Maximum load losses (W)*
1	25	100	21	85
4	55	200	45	170
16	110	400	90	340
32	165	600	135	510
64	220	800	180	680
80	285	1025	230	875
100	345	1245	280	1060

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

b) Specific requirements for medium power transformers

The minimum energy performance requirements for medium power transformers consist of maximum allowed load and no-load losses given in Tables I.2 to I.7

b.1) Specific requirements for medium power transformers with rated power <4000 kVA

Table I.2: Maximum load and no-load losses for **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 2014)				**Tier 2 (from 1 July 2018)**	
RATED POWER (kVA) ***Short-circuit impedance in ()***	**Maximum load losses (in Watts) ***		**Maximum no-load losses (in Watts)***		**Maximum load losses (inWatts)***	**Maximum no-load losses (in Watts)***
		Pole mounted		Pole mounted	(Pole mounted sub-category disappears)	
25 *(4%)*	Bk(725)		Ao(70)	Ao(70)	Ak(600)	Ao-20%(56)
50 *(4%)*	Bk(875)		Ao(90)	Ao(90)	Ak(750)	Ao-20%(72)
100 *(4%)*	Bk(1250)		Ao(145)	Ao(145)	Ak(1250)	Ao-20%(116)
160 *(4%)*	Bk(2000)	Ck+32%(3100)**	Ao(210)	Ao(210)	Ak(1750)	Ao-20%(168)
250 *(4%)*	Bk(2750)		Ao(300)	Co(425)**	Ak(2350)	Ao-20%(240)
315 *(4%)*	Bk(3250)		Ao(360)	Co(520)**	Ak(2800)	Ao-20%(288)
400 *(4%)*	Bk(3850)		Ao(430)		Ak(3250)	Ao-20%(344)
500 *(4%)*	Bk(4600)		Ao(510)		Ak(3900)	Ao-20%(408)
630 *(4%)*	Bk(5400)		Ao(600)		Ak(4600)	Ao-20%(480)
800 *(6%)*	Ak(6000)		Ao(650)		Ak(6000)	Ao-20%(520)
1000 *(6%)*	Ak(7600)		Ao(770)		Ak(7600)	Ao-20% (616)
1250 *(6%)*	Ak(9500)		Ao(950)		Ak(9500)	Ao-20%(760)
1600 *(6%)*	Ak(12000)		Ao(1200)		Ak(12000)	Ao-20%(960)
2000*(6%)*	Ak(15000)		Ao(1450)		Ak(15000)	Ao-20%(1160)
2500*(6%)*	Ak(18500)		Ao(1750)		Ak(18500)	Ao-20%(1400)
3150*(6%)*	Ak(23000)		Ao(2200)		Ak(23000)	Ao-20%(1760)

*Maximum losses for kVA ratings that fall in between the ratings given in Table I.2 shall be obtained by linear interpolation. Maximum losses for kVA ratings falling outside those given in this table shall be obtained by exponential extrapolation with exponent 0,75.

** These levels of load and no load losses represent concessions made bec ause of the weight limitations for mounting transformers on 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 t he work of national market surveillance authorities.

Table I.3: Maximum load and no -load losses for **dry-type** medium power tran sformers with the high-voltage winding rated • 24 kV and the other winding rated • 1,1kV

	Tier 1 (1 July 2014)		**Tier 2 (1 July 2018)**	
RATED POWER (kVA) ***Short-circuit impedance 6%***	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***
50	Ak(1500)	Ao(200)	Ak(1500)	Ao-20%(160)
100	Ak(1800)	Ao(280)	Ak(1800)	Ao-20%(224)
160	Ak(2600)	Ao(400)	Ak(2600)	Ao-20%(320)
250	Ak(3400)	Ao(520)	Ak(3400)	Ao-20%(416)
400	Ak(4500)	Ao(750)	Ak(4500)	Ao-20%(600)
630	Ak(7100)	Ao(1100)	Ak(7100)	Ao-20%(880)
800	Ak(8000)	Ao(1300)	Ak(8000)	Ao-20%(1040)
1000	Ak(9000)	Ao(1550)	Ak(9000)	Ao-20%(1240)
1250	Ak(11000)	Ao(1800)	Ak(11000)	Ao-20%(1440)
1600	Ak(13000)	Ao(2200)	Ak(13000)	Ao-20%(1760)
2000	Ak(16000)	Ao(2600)	Ak(16000)	Ao-20%(2080)
2500	Ak(19000)	Ao(3100)	Ak(19000)	Ao-20%(2480)
3150	Ak(22000)	Ao(3800)	Ak(22000)	Ao-20%(3040)

*Maximum losses for kVA ratings that fal l in between the ratings given in T able I.3 shall be obtained by linear interpolation. Maxi mum losses for kVA ratings falling outside those given in this table shall be obtained by exponential extrapolation with exponent 0,75.

Table I.4: Maximum load and no -load losses for other combinations of winding voltages **(**rated power < 4000kVA)

One winding with Um • 24 kV and the other with Um > 1,1 kV	The levels of losses indicated in Tables I.2 and I.3 can be increase d 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 levels of losses indicated in Tables I.2 and I. 3 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 levels of losses indicated in Tables I.2 and I. 3 can be increased by 20% for no load losses and by 15 % for load losses
Case of dual voltage on the same winding	The levels of losses indicated in Tables I.2 a nd I.3 can be increased by 15% for no load losses and by 10% for l oad losses in case of one dual voltage on one winding
Case of dual voltage on both windings	The levels of losses indicated in Tables I.2 and I.3 can be increased by 25% for no load losses a nd by 25% for load losses in case of dual voltage on both windings (the level of losses for this kind of transformer is given on higher voltage)

b.2) Specific requirements for medium power tra nsformers with rated power • 4000kVA

Table I.5: Maximum load an d no-load losses for **liquid immersed** medium power transformers with the high-voltage winding rated • 24 kV and the other winding rated • 1,1 kV

		Tier 1 (1 July 2014)		Tier 2 (1 July 2018)	
RATED POWER (kVA)	**Short-circuit impedance (%)**	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***
4000	8-10	Ak(30000)	Ao(2800)	Ak(30000)	Ao-20%(2240)
5000	8-10	Ak(33000)	Ao(3300)	Ak(33000)	Ao-20%(2640)
6300	8-10	Ak(37000)	Ao(4000)	Ak(37000)	Ao-20%(3200)
8000	8-10	Ak(42000)	Ao(4800)	Ak(42000)	Ao-20%(3840)
10000	8-10	Ak(48000)	Ao(5800)	Ak(48000)	Ao-20%(4640)
12500	9-11	Ak(55000)	Ao(7000)	Ak(55000)	Ao-20%(5600)
16000	9-11	Ak(66000)	Ao(8500)	Ak(66000)	Ao-20%(6800)
20000	9-11	Ak(78000)	Ao(10500)	Ak(78000)	Ao-20%(8400)
25000	9-12	Ak(92000)	Ao(13000)	Ak(92000)	Ao-20%(10400)
31500	9-12	Ak(112000)	Ao(16000)	Ak(112000)	Ao-20%(12800)
36000	9-12	Ak(125000)	Ao(18000)	Ak(125000)	Ao-20%(14400)
40000	9-12	Ak(136000)	Ao(20000)	Ak(136000)	Ao-20%(16000)

*Maximum losses for kVA ratings that fal l in between the ratings given in T able I.5 shall be obtained by linear interpolation. Maximum losses for kVA ratings falling outside those given in this table shall be obtained by exponential extrapolation with exponent 0,75.

Table I.6: Maximum load and no -load losses for **dry type** medium power transformers with the high-voltage winding rated above 1,1 kV but below 24 kV and the other winding rated • 1,1kV

		Tier 1 (1 July 2014)		Tier 2 (1 July 2018)	
RATED POWER (kVA)	**Short-circuit impedance (%)**	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***	**Maximum load losses (in Watts)***	**Maximum no-load losses (in Watts)***
4000	7	Ak(28000)	Ao(5000)	Ak(28000)	Ao-20%(4000)
5000	8	Ak(35000)	Ao(6000)	Ak(35000)	Ao-20%(4800)
6300	8	Ak(44000)	Ao(7500)	Ak(44000)	Ao-20%(6000)
8000	8	Ak(55000)	Ao(9500)	Ak(55000)	Ao-20%(7600)
10000	8	Ak(68000)	Ao(12000)	Ak(68000)	Ao-20%(9600)

*Maximum losses for kVA ratings that fal l in between the ratings given in T able I.6 shall be obtained by linear interpolation. Maxi mum losses for kVA ratings falling outside those given in this table shall be obtained by exponential extrapolation with exponent 0,75.

Table I.7: Maximum load and no-load losses for medium power transformers with other combinations of winding voltages (rated power > 4000kVA)

One winding with Um = 36 kV and the other one with 1,1 kV < Um • 24 kV	The levels of losses indicated in Tables I.5 and I.6 can be increased by 15% for no load losses and by 10% for load losses
Both windings with 24 kV < Um • 36 kV	The levels of losses indicated in Tables I.5 and I.6 can be increased by 25% for no load losses and by 15% for load losses

b.3) Specific requirements for medium power transformers with other characteristics

b.3.1) Load and no load losses for transformers equipped with tapping +/ -5%

When transformers are equipped with tap changers, the levels of load and no load losses in the relevant table of this Annex I, can be increased by 10%.

c) Specific requirements for large power transformers (>36kV)

The minimum peak energy efficiency requirements for large power transformers are set out in Table I.8. The methodology for calculating the peak energy efficiency is available in Annex II.

Table I.8 Minimum peak energy efficiency requirements for large power transformers

RATED POWER (kVA)	**Tier 1 (1 July 2014)**	**Tier 2 (1 July 2018)**
	η_{max} (%) *	η_{max} (%) *
4000		
5000		
10000		
25000		
40000		
50000		
80000		
100000		
150000		
250000		
350000		

*Minimum peak efficiency levels for kVA ratings that fall in between the ratings given in this table shall be obtained by linear interpolation. Minimum peak efficiency levels for kVA ratings falling outside those given in this table shall be obtained by exponential extrapolation with exponent 0,75.

The Technical Subgroup on Large Power Transformers will present to the Ecodesign Consultation Forum options to be considered for setting out mandatory minimum peak efficiency requirements.

d) Product information requirements

From 01.07.2014 the following product information requirements apply:

(1) Information on rated power, load loss[2] and no-load loss[3] 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 large power transformers, the peak efficiency and the power at which it occurs shall be 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) Special small power purpose transformers with well defined target applications shall have their application identified in any related product documentation and shall include the ISO caution mark to read the product documentation.

(5) Pole mounted distribution transformers as defined in this Regulation 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.

[2] [2] Corrected to reference temperature

Annex II: Measurement methods

1. For the purpose of compliance with the requirements of th is Regulation, measurements shall be made using a reliable, accurate and rep roducible measurement procedure , which takes into account the generally recognised state of the art measurement methods, including methods set out in documents the reference number s of which have been published for that purpose in the Official Journal of the European Union.

A European Standard EN xxxx for "Three -phase medium voltage transformers 50Hz, with highest voltage for equipment not exceeding 36 kV" is likely to be voted by CENELEC in the next six months. This European Standard should then become a harmonized standard) in support of this Ecodesign Regulation (through the publication of its reference in the OJEU) by the time it has been adopted.

2. Calculation method for the energy efficiency η_{max} of large power transformers .

The methodology for calculating the energy efficiency of a specific transformer is based on the load and no load losses that occur at the operation point of maximum efficiency. The formula includes the apparent power at which the losses are measured.

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

where

Po is the no load losses (*)
Pco is the electrical power required by the cooling system for no load operation
Pk is the load losses(*) corrected to reference temperature (**)
Sr is the (apparent) rated power of the transformer at which Pk is measured.

(*) measured at rated voltage and rated frequency, on the rated (nominal?) tap
(**) as defined in EN IEC 60076 -1:2011

Annex III: Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Article 3(2) of Directive 2009/125/EC, the authorities of the Member States shal apply the following verification procedure for the requierements set out in Annex I.

1. The authorities of the Member State shall test one single unit

2. The model shall be considered to comply with the povisions set out in this Regulation if the measured parameters meet the values declared by the supplier within the ranges set out in Table 1

3. If the result referred to in point 2 is not achieved:

   - For models that are produced in lower quantities than x per year, the model shall be considered not to comply with this Regulation
   - For models that are produced in quantities of x or more per year , the market surveillace auth ority shall randomly test x additional units

4. The model shall be considered to comply with the provisions se t out in this Regulation if the averages of all the measured parameters referred to in Table 1 do not vary from the values set out in Annex I by more than 5%

5. If the results referred to in point 4 are not achieved, the model shall be considered not to comply with this Regulation .

For the pruposes of checking conformity with the requierements of this Regulation, Member States authori ties shall use reliable, accurate and reproducible measurement procedures, which take 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.

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 b e greater than the declared value by more than 5 %.

Annex IV: Indicative benchmarks

At the time of adoption of this Regulation, the best available technology widely available in the EU market for the products concerned has been identified as follows:

- Liquid-immersed medium power transformer: No -load losses Ao-20%, load losses Ak-20%
- Dry-type medium power transformer: No -load losses Ao-20%, load losses Ak-20%

The Commission seeks confirmation from stakeholders as to whether the above benchmarks identified in the preparatory study and the impact assessment study are adequate.