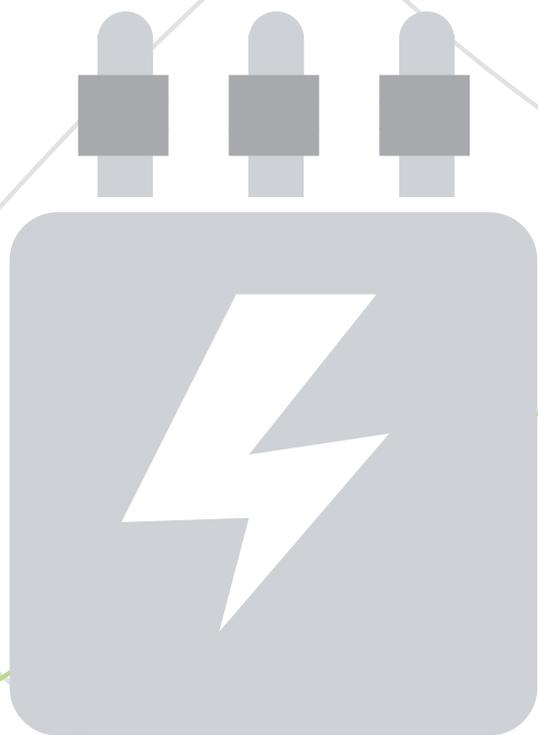


Energy Efficiency

Ecodesign for transformers

ANIE Energia Vademecum
on Regulation EU/548/2014



Erp
Eco Design
High efficiency
Low losses

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1. INTRODUCTION

On 21 May 2014, the European Commission issued Regulation EU/548/2014 (hereinafter the Regulation), with rules for the application of Council Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the development of specifications for eco-design of energy-related products.

The Regulation concerns the electric power small, medium and large transformers.

The purpose of this document is to clarify the requirements introduced by the Regulations and provide all operators sector about its applications and timing.

2. SCOPE AND TIMING OF APPLICATION OF REGULATION

The Regulation sets out the requirements (mandatory) on ecodesign requirements for electric transformers with a minimum power rating of 1 kVA used in electricity transmission and distribution networks. It indicates the maximum load and no-load losses that must be observed by various types of transformers. These values defined in Annex I of the Regulation and are shown on page 7 of this document.

2.1 Time of application

The maximum losses to be respected refer to date of placing on the market of the transformer, with two different timeframes:

- **Tier 1** from 1 July 2015
- **Tier 2** from 1 July 2021

Three years after the entry into force of the Regulation (see art. 7), subsequently tier 1, there will be an intermediate step to verify the applicability of the values now reported in tier 2 and evaluating whether or not the introduction into the regulation of products currently excluded.

By July 2017 products placed in service from 1 July 2015 will be examined; the European Commission gather and assess these data to confirm the values reported in tier 2 of 2021 or define new applicable values.

Therefore, the requirements relating to the design requirements of transformers, provided by the Regulations,

relate only to the products that are placed on the market from 1 July 2015 (tier 1) and from 1 July 2021 (tier 2).

Products placed on the market before those dates, not comply with the requirements introduced by Regulation, may continue to be lawfully marketed.

In addition, art. 1, paragraph 1 provides that the obligations are apply only to transformers purchased after the date of entry into force of the Regulation, namely after 11 June 2014.

Considering what indicated by the “recital 4 of the Regulations”, according to the interpretation of ANIE Energia, this should exclude from the scope of Regulation transformers purchased under framework contracts (for example, public supply contracts) before 11 June in 2014.

There are NOT cases of placing products on the market under 2009/125 directive and its implementing regulations:

- if the transformer is exported from the EU producer to a third country outside of Space European Economic Area;
- if the transformer is transferred from the EU producer to an exporter, who then exports it outside of the Space European Economic Area.

Finally, the mere putting in warehouse cannot be considered itself as placing on the market, unless the presence of appropriate documentation attesting the sale of the equipment.

The Directive provides that 2009/125 compliance with the Ecodesign requirements is to be attested with CE marking.

In the case of transformers, since they are not subject of other directives, the CE marking will only refer to Regulation (see paragraph 11).

¹ For “Placing on the market” Directive 2009/125 means “make available for the first time on the Community market a product in view of its distribution or use within the European Community, whether for reward or free of charge and regardless of the selling technique used”.

² Article 7 - Review: “No later than three years after the entry into force, the Commission shall review this Regulation in the light of technological progress and present the results of this review to the Consultation Forum”.

3. WHEN THE REGULATION DOESN'T APPLY

This Regulation shall not apply to transformers specifically designed and used for the following applications:

- 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 this Regulation;

- 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.

4. PLATE AND ACCOMPANYING DOCUMENTATIONS

Before 15 July 2015 transformers manufactured in accordance with EN 60076-1 had to have a plat compliant to chapter 7.1.

Information to be given in all cases:

- a)** Kind of transformer (for example transformer, auto-transformer, booster transformer, etc.);
- b)** Number of standard;
- c)** Manufacturer's name;
- d)** Manufacturer's serial number;
- e)** Year of manufacture;
- f)** Number of phases;
- g)** Rated power (in kVA or MVA). For multi-winding transformers, the rated power of each winding should be given. The loading combinations should also be indicated unless the rated power of one of the windings is the sum of the rated powers of the other windings;
- h)** Rated frequency (Hz);
- i)** Rated voltages (in V or kV) and tapping range.

For transformers putted on the market after 15 July 2015, transformers' plat should contain:

- CE marking (with the indication of conformity to the Regulation);
- Information on rated power, on load losses and no-load losses and on electric power of any cooling system required at no-load;
- For medium power transformers (power > 3150 kVA) and for large power transformers, the value of peak efficiency index and the power at which it occurs;
- For dual voltage transformers, the maximum rated power at the lower voltage, according to table I.3 of the Regulation;
- Information on the weight of all main components (including at least the conductor, the nature of the conductor and the core material).

For a more full information, to the mandatory items listed above, it is appropriate to add in the plat also the items indicated in the standard EN 60076-1, at points: a), c), d), e), f), h), i). In addition the information related to the conformity to the standard, point b), it is useful in particular for the definition of the operating conditions and test not included in the Regulation.

The Regulation says that all the documentation related to product, included public pages of manufacturer website, include:

- Manufacturer's name and address;
- Model identifier, the alphanumeric code to distinguish one model from other models of the same manufacturer;
- Plat's items: mandatory that indicated on point 2, 3 and 4 of the preview paragraph;
- Value of the peak efficiency index and the power at which it occurs, for medium power transformers with power > 3150 kVA e for large power transformers;
- For medium pole mounted transformers, a visible plat with the wording <<intended exclusively for on pole mounting>>.

If the technical documentation is based upon (part of) the technical documentation of another model, the model identifier of that model shall be provided. The technical documentation shall provide the details of how the information is derived from the technical documentation of the other model, e.g. on calculations or extrapolations, including the tests undertaken by the manufacturer for the verification.

5. HOW THE REGULATION APPLIES TO TRANSFORMERS

5.1. Medium power transformers

The classification "medium power transformers" is not in common use. The Regulation gives the following definition:

"medium power transformer: a power transformer with a highest voltage for equipment higher than 1,1 kV, but not exceeding 36 kV and a rated power equal to or higher than 5 kVA but lower than 40 MVA".

Medium power transformers are divided in two categories according to the rated power:

- a) potenza \leq 3150 kVA
- b) potenza > 3150 kVA, ma < 40 MVA

In this chapter we deal with transformers of type a). Already following standards gave an energy classification of transformers through tables with different levels of losses either no-load or load. Within said tables e.g. Authority had decided a premium on investment for utilities who bought transformers with losses \leq Ak, B0 compliant with EN 50464-1.

Below lists the standards of distribution transformers, dry type and oil immersed:

Dry type transformers

- EN 50541-1:2011-04, Three phase dry type distribution transformers 50 Hz, from 100 to 3150 kVA, with highest voltage for equipment not exceeding 36 kV. Part 1: General requirement³

Oil immersed transformers

- EN 50464-1; 2007-08, Three phase oil immersed distribution transformers 50 Hz, from 50 kVA to 2500 kVA with highest voltage for equipment not exceeding 36 kV. Part 1: General requirements⁴

Will soon be issued new European standards prepared in response to a mandate of the EC to CENELEC (European standard committee) and replace those mentioned above, currently in force.

For medium power transformers:

- EN 50588-1: Medium voltage transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV, it regards three phase transformers from 25 kVA to 40 MVA with two windings and a maximum voltage for component of 36 kV.

The standard, which will replace both EN 50464-1 and EN 50541-1 actually applicable, introduces the following significant technical changes:

- In the same document there are both dry type transformer and oil immersed;
- The scope of application is extended from 3150 kVA to 40 MVA;
- In the losses table there are new lower values;
- For transformers with power > 3150 kVA it is introduced the concept of Peak Efficiency Index;
- Tolerances on load losses and no load losses are reduced respect of EN 60076-1.

³ Standard developed by CENELEC, effective as European standard and so effective also in Italy, from 01-12-2011

⁴ Standard developed by CENELEC, effective as European standard and so effective also in Italy, from 01-12-2011

Regulation has adopted in Annex I, at point 1.1, the requirements for three phase medium power transformers with rated power ≤ 3150 kVA, losses values taken from tables inside relevant standards cited above.

Differently from the tables of standards that contain also values of impedance of short circuit and rumor level, the Regulation gives only the maximum values of losses.

Generally for any discrepancy between standards and the Regulation, latter should prevail.

A particular attention should be paid to the inclusion of tolerances to loss values shown in the tables contained in Annex I, section 1.1.

On this topic the Regulation gives indications on table of Annex III – Verification procedure.

Carrying out the market surveillance (left to Member States) the authorities of the Member States shall apply the following verification procedure of the losses values shown in the tables contained in Annex I, section 1.1. Member States testing the transformer make measurements using a procedure reliable, accurate and reproducible, taking into account the most advanced methods and generally recognized.

Tolerances set out (+5% for load losses and no load losses) in this Annex relate only to the verification of the measured parameters by Member States authorities and shall not be used by the manufacturers or importer as an allowed tolerance to establish the values in the technical documentation.

Therefore, for the manufacturer or the importer the losses values shown in the tables and reported in the technical documentation are to be considered maximum values.

5.2. Large power transformers

Minimum peak efficiency index (PEI) indicated in table I.7 regard liquid immersed large power transformers, instead those in table I.8 regard dry type large power transformers.

PEI values lower than that indicated in the tables are not acceptable, so the values are the minimum applicable for the typologies of transformers.

The tolerances specified in the standards usually applicable in the field of transformers (CEI, IEC, IEEE, etc...) can still be used for the values of losses (no load, load), but they must not affect the minimum value of PEI measured; in practice, already in the design phase, it must take account of this information in order to be able to keep the margin of safety between the calculated values and those measured subsequently in final testing.

6. MARKET SURVEILLANCE

Annex III – Verification procedure: “When performing the market surveillance check referred to in Article 3, paragraph 2, off Directive 2009/125/EC, the authorities of the Member States shall apply the following verification procedure for the requirements set out in Annex I.

Directive 2009/125/CE – Article 3 – Placing on the market and/or putting into service – Paragraph 1: “Members States shall take all appropriate measures to ensure that products covered by implementing measures may be placed on the market and/or put into service only if they comply with those measures and bear the CE marking in accordance with article 5”.

Directive 2009/125/CE – Article 3 – Placing on the market and/or putting into service – Paragraph 2: “Members States shall designate the authorities responsible for market surveillance. They shall arrange for such authorities to have and use the necessary powers to take the appropriate measures incumbent upon them under this Directive...”.

The Regulation provides that each Member State take steps to appoint some local authorities of the activities of surveillance of the market. In Italy, the institution responsible for this task is ENEA – Italian National Agency for New Technologies, Energy and Sustainable Economic Development - which, with its instrumentation or external collaborations or alternatively at the laboratories of the manufacturers, is called to verify compliance to the regulation of products placed on the market. Taking into account the limitations of weight and size in the transport of medium and large power transformers, the authorities of the Member States may decide to initiate the verification procedure in the premises of manufacturers, before the equipment is put into service at their place of final destination.

The method of calculation used to determine the peak efficiency index (PEI) for medium and large power transformers (> 3150 kVA) is based on the relationship between the apparent power transferred to a transformer less electrical losses and the apparent power transferred; while for transformers medium / small (≤ 3150 kVA) measurements only take into account the levels of no-load and load losses.

In the table of Annex III of the Regulation, are incorrectly reported the values defined “tolerances applicable to the verification”; these values are simply measurement uncertainty that the responsible institution (ENEA) shall find in the comparison with the values declared from the manufacturer.

7. ECODESIGN REQUIREMENTS

Requirements applicable (losses value) to three phase liquid immersed medium power transformers with rated power ≤ 3150 kVA with one winding with $U_m \leq 24$ kV and the other one with $U_m \leq 1,1$ kV (table I.1).

Rated power (kVA)	Tier 1 (from 1 July 2015)		Tier 2 (from 1 July 2021)	
	Maximum load losses P_k (W)	Maximum no load losses P_0 (W)	Maximum load losses P_k (W)	Maximum no load losses P_0 (W)
≤ 25	C_k (900)	A_0 (70)	A_k (600)	$A_0 - 10\%$ (63)
50	C_k (1100)	A_0 (90)	A_k (750)	$A_0 - 10\%$ (81)
100	C_k (1750)	A_0 (145)	A_k (1250)	$A_0 - 10\%$ (130)
160	C_k (2350)	A_0 (210)	A_k (1750)	$A_0 - 10\%$ (189)
250	C_k (3250)	A_0 (300)	A_k (2350)	$A_0 - 10\%$ (270)
315	C_k (3900)	A_0 (360)	A_k (2800)	$A_0 - 10\%$ (324)
400	C_k (4600)	A_0 (430)	A_k (3250)	$A_0 - 10\%$ (387)
500	C_k (5500)	A_0 (510)	A_k (3900)	$A_0 - 10\%$ (459)
630	C_k (6500)	A_0 (600)	A_k (4600)	$A_0 - 10\%$ (540)
800	C_k (8400)	A_0 (650)	A_k (6000)	$A_0 - 10\%$ (585)
1000	C_k (10500)	A_0 (770)	A_k (7600)	$A_0 - 10\%$ (693)
1250	B_k (11000)	A_0 (950)	A_k (9500)	$A_0 - 10\%$ (855)
1600	B_k (14000)	A_0 (1200)	A_k (12000)	$A_0 - 10\%$ (1080)
2000	B_k (18000)	A_0 (1450)	A_k (15000)	$A_0 - 10\%$ (1305)
2500	B_k (22000)	A_0 (1750)	A_k (18500)	$A_0 - 10\%$ (1575)
3150	B_k (27500)	A_0 (2200)	A_k (23000)	$A_0 - 10\%$ (1980)

Requirements applicable (losses value) to three phase dry type transformers with rated power ≤ 3150 kVA with one winding with $U_m \leq 24$ kV and the other one with $U_m \leq 1,1$ kV.

Rated power (kVA)	Tier 1 (from 1 July 2015)		Tier 2 (from 1 July 2021)	
	Maximum load losses P_k (W)	Maximum no load losses P_0 (W)	Maximum load losses P_k (W)	Maximum no load losses P_0 (W)
≤ 50	B_k (1700)	A_0 (200)	A_k (1500)	$A_0 - 10\%$ (180)
100	B_k (2050)	A_0 (280)	A_k (1800)	$A_0 - 10\%$ (252)
160	B_k (2900)	A_0 (400)	A_k (2600)	$A_0 - 10\%$ (360)
250	B_k (3800)	A_0 (520)	A_k (3400)	$A_0 - 10\%$ (468)
400	B_k (5500)	A_0 (750)	A_k (4500)	$A_0 - 10\%$ (675)
630	B_k (7600)	A_0 (1100)	A_k (7100)	$A_0 - 10\%$ (990)
800	A_k (8000)	A_0 (1300)	A_k (8000)	$A_0 - 10\%$ (1170)
1000	A_k (9000)	A_0 (1550)	A_k (9000)	$A_0 - 10\%$ (1395)
1250	A_k (11000)	A_0 (1800)	A_k (11000)	$A_0 - 10\%$ (1620)
1600	A_k (13000)	A_0 (2200)	A_k (13000)	$A_0 - 10\%$ (1980)
2000	A_k (16000)	A_0 (2600)	A_k (16000)	$A_0 - 10\%$ (2340)
2500	A_k (19000)	A_0 (3100)	A_k (19000)	$A_0 - 10\%$ (2790)
3150	A_k (22000)	A_0 (3800)	A_k (22000)	$A_0 - 10\%$ (3420)

Correction of load and no load losses in case of other combinations of windings voltage (rated power ≤ 3150 kVA⁵) (table I.3):

One winding with $U_m \leq 24$ kV and the other with $U_m > 1,1$ kV	The maximum allowable losses in preview tables shall be increased by 10% for no load losses and by 10% for load losses
One winding with $U_m = 36$ kV and other with $U_m \leq 1,1$ kV	The maximum allowable losses in preview tables shall be increased by 15% for no load losses and by 10% for load losses ⁶
One winding with $U_m = 36$ kV and the other with $U_m > 1,1$ kV	The maximum allowable losses indicated in preview tables shall be increased by 20% for no load losses and by 15% for load losses

Requirements applicable (PEI index) to liquid immersed medium power transformers with rated power >3150 kVA (table I.4):

Rated power (kVA)	Tier 1 (from 1 July 2015)	Tier 2 (from 1 July 2021)
	Minimum Peak Efficiency Index (%)	
3150 < S_r ≤ 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

Requirements applicable (PEI index) to dry type medium power transformers with rated power >3150 kVA (table I.5):

Rated power (kVA)	Tier 1 (from 1 July 2015)	Tier 2 (from 1 July 2021)
	Minimum Peak Efficiency Index (%)	
3150 < S_r ≤ 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

⁵ In the Italian translation there is an editorial error: it is indicated that the table is applicable for power transformers > 3150 kVA rather than ≤ 3150 kVA.

⁶ In the Italian translation there is an editorial error: it is indicated the value of 15% for no load and load losses, while in the English version it is indicated 15% for no load losses and 10% for load losses.

Requirements applicable (PEI index) to liquid immersed large power transformers (table I.7):

Rated power (MVA)	Tier 1 (from 1 July 2015)	Tier 2 (from 1 July 2021)
	Minimum 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

Requirements applicable (PEI index) to dry type large power transformers (table I.8):

Rated power (MVA)	Tier 1 (from 1 July 2015)	Tier 2 (from 1 July 2021)
	Minimum Peak Efficiency Index (%)	
≤ 4	99,158	99,225
5	99,200	99,265
6,3	99,242	99,303
8	99,298	99,356
10	99,330	99,385
12,5	99,370	99,422
16	99,416	99,464
20	99,468	99,513
25	99,521	99,564
31,5	99,551	99,592
40	99,567	99,607
50	99,585	99,623
≥ 63	99,590	99,626

For all the tables, maximum allowable losses for kVA ratings (or PEI values) that fall in between the rating given shall be obtained by linear interpolation.

For example, if it is necessary to obtain the load losses for a liquid immersed medium power transformer with rated power of 2300 kVA, you should refer to table I.1 as follows:

$$2000 \text{ kVA transformers} \longrightarrow P_k = 18000 \text{ W} \quad 2500 \text{ kVA transformers} \longrightarrow P_k = 22000 \text{ W}$$

By computing the straight line passing through the two points, whereas the x-axis the power transformer and the y-axis the value of the loss to be borne, we obtain a mathematical equation of the type: $y=8x+2000$.

So for the 2300 kVA transformer, load losses value is: $P_k = 20400 \text{ W}$.

8. ATTENTION POINTS

In the following table are better clarify the cases that may arise in the application of the Regulation or less depending on the date of signature of the contract and placing on the market.

Situation before 11/06/2014

Any contract signed before that date does not fall under the application of Regulation (not existing until 6/11/2014 the Regulation itself), even though the goods will be “placed on the market” or “putted into service” after the 01/07/2015. In practice for contracts signed before 06/11/2014 transformers do not have to meet the requirements specified in the regulation.

Situation from 11/06/2014 to 01/07/2015

Contracts signed (or races outputs) after 11/06/2014 must be taken into account, although not explicit in the terms and conditions between the buyer and supplier, the existence of the Regulation. In practical transformers “placed on the market” or “putted into service” from 01/07/2015 will be fully conformed with the values of the “tier 1” contained in Annex I of the Regulation, while those related to contracts after 11/06/2014 but “placed on the market” or “putted into service” before the 01/07/2015 will still be exempt from the Regulation.

Situation from 01/07/2015 to 30/06/2021

Contracts signed (or races outputs) after 01/07/2015 must be taken into account, although not explicit in the terms and conditions between the buyer and supplier, the existence of the Regulation. In practice transformers “purchased”, “placed on the market” or “putted into service” from 01/07/2015 to 30/06/2021 shall be fully compliant to the values indicated in “tier 1” reported in Annex I of the Regulation.

Situation after 01/07/2021

Contracts signed (or races outputs) after 01/07/2021 must be taken into account, although not explicit in the terms and conditions between the buyer and supplier, the existence of the Regulation. Transformers “purchased”, “placed on the market” or “putted into service” after 01/07/2021 shall be fully compliant to the values indicated in “tier 2” reported in Annex I of the Regulation.

8.1. CE marking

An innovation introduced by the Regulation, due to the fact that it is mentioned the Directive 2009/125, regards on the CE marking of the transformer. Until now, this marking was excluded because on the transformers was not applicable as indicated in the table below:

Classification	Title	Motivation
2006/95/CE	Low Voltage Directive	Art.1 “For the purposes of this Directive, <<electrical equipment>> means any equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current, other than the equipment and phenomena listed in Annex II”.
2004/108/CE	Electromagnetic compatibility Directive (EMC)	The directive is not applicable due to the fact that technical standard IEC 60076-1 (ed. 3.0 2011/04) in paragraph 12 provides that: “power transformers shall be considered as passive elements in respect to emission of and immunity to electromagnetic disturbance”. (passive elements are that elements not liable to produce electromagnetic disturbance and their behaviour is not liable to be influenced from this disturbances)
2006/42/CE	Machine Directive	Static component that has no moving parts.
2008/768/CE	Directive for CE marking	Transformers are not subject to CE marking, because the directives 2006/95/CE, 2004/108/CE and 2006/42/CE, that regulate the marking itself, are not applicable.

8.2 Transformers performance

In paragraph c) of Annex IV of the Regulation, about performance of transformers with amorphous steel core, there is an error related to the indicated value Ak-50%⁷.

This type of transformers has a considerable advantage in the use for the construction of the core of amorphous steel which greatly reduces the value of the no load losses for which the objective of the no-load losses A0-50% appears definitely reached. Load losses of transformer, related to ohmic losses and additional losses of copper and aluminium, are not influenced by the use of this technology so the parameter Ak-50% seems to be not coherent for these type of transformers.

9. PARTICULAR ISSUES

An argument to be evaluated because it is not clearly explained in the Regulation is that of Framework Contracts with any “unities in option”, that additional quantities of equipment whose purchase is only a possibility, being subject to option solved by the purchaser, at its decision, within a certain period after the conclusion of the Framework Agreement. Consider, for example, in a tender of 2013 for 50 MV / LV transformers, providing for 20 additional units in “option.”

In this case, if the first 50 transformers are definitely excluded from the scope of the Regulations, as an object of a framework agreement before 11 June 2014, the date of entry into force of the Regulations, the following 20 instead, according to the interpretation of ANIE Energia, could not be considered excluded from the applicability of the Regulations, if the purchase option was solved after 11 June 2014, as having been the agreement on the supply of such products completed after the entry into force of the Regulations, would not apply the exclusion provided for by article 1, paragraph 1.

10. DEFINITIONS

POWER TRANSFORMER

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.

SMALL POWER TRANSFORMER

A power transformer with a highest voltage for equipment not exceeding 1,1 kV.

MEDIUM POWER TRANSFORMER

A power transformer with a highest voltage for equipment higher than 1,1 kV, but not exceeding 36 kV and a rated power equal to or higher than 5 kVA but lower than 40 MVA.

LARGE POWER TRANSFORMER

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

LIQUID IMMERSED TRANSFORMER

A power transformer in which the magnetic circuit and windings are immersed in liquid.

DRY TYPE TRANSFORMER

A power transformer in which the magnetic circuit and windings are not immersed in an insulating liquid.

RATED POWER (S_r)

Conventional value of apparent power assigned to a winding

LOAD LOSSES (P_k)

The absorbed active power at rated frequency and reference temperature associated with a pair of windings when the rated current is flowing through the line terminal of one of the windings and the terminals of other windings are in short-circuit with any winding fitted with tapplings connected to its principal tapping, while further windings, if existing, are open-circuited.

NO LOAD LOSSES (P₀)

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.

PEAK EFFICIENCY INDEX (PEI)

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.

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

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

⁷ ANIE has already mentioned this error to the officer of the European Commission