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ESWATINI NATIONAL STANDARD

Minimum Energy Performance Standards for Distribution Transformers

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Table of changes

Clause Changed	Date	Change

NATIONAL FOREWORD

This Eswatini National Working Draft Standard was prepared by Technical Committee *SWASA/TC 36 Electrical wiring and energy in* accordance with procedures of the Eswatini Standards Authority, in compliance with Annex 3 of the WTO/TBT Agreement.

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Minimum Energy Performance Standards — Distribution Transformers

1 Scope

The purpose of this document is to provide specifications for the energy losses for single-phase and three-phase liquid-immersed distribution transformers where three levels of efficiency are defined as per Section 4.1 of this document. Parties should pay special attention to the tiers of losses stipulated for transformers, their period of applicability, the marking of the rating plate in accordance with the stipulated tiers of losses and the requirement for accurate labelling according to the tiers of losses as described by Table 1 and Table 2 in Section 4.1

The maximum allowable losses stipulated in this document take precedence over the losses stipulated in any other transformer standard or specification. Purchasers must issue this standard with any enquiry for the procurement of distribution transformers.

The responsibility for enforcement of this document lies with the Energy Regulator of Eswatini and the party procuring distribution transformers. Suppliers of transformers that fail to comply with the terms of this document will face penalties in line with the capitalized cost of losses over the projected lifetime of the transformer, and risk being blacklisted as a provider of distribution transformers to Eswatini.

This standard applies to liquid-immersed distribution transformers that are manufactured in, or imported into the Eswatini, and are either sold, installed or put into service as standalone equipment or as a component of a system, and which meet the following criteria:

Distribution transformers within scope have:

- 2 windings per phase;
- a rated capacity equal to or between 5 kVA and 3150 kVA;
- a primary voltage greater than 1,1 kV, but not exceeding 36 kV; and
- are designed for use in electricity networks or industrial applications.

Distribution transformers regardless of when they were first placed on the market or put into service, shall be reassessed for conformity, and comply with this standard if they are subject to replacement operations both of the core (or part thereof) and one (or more) of the complete windings.

This standard does not apply to:

- instrument transformers, specifically designed to transmit an information signal to measuring instruments, meters, relays and other similar apparatus.
- dry type transformers;

- 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; and
- Medium Voltage (MV) to Medium Voltage (MV) interface transformers up to 5 MVA.

2 Normative references

The following standards are used as a reference:

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

IEC TS 60076-20:2017, Power transformers – Part 20: Energy efficiency

SANS780:2021, Distribution transformers

3 Terms and definitions

The definitions are as defined in IEC TS 60076-20.

3.1
efficiency
ratio of output active power to input active power.

3.2
electrical losses

electrical power consumed by the transformer at a particular value of transmitted apparent power excluding the power consumed by the cooling system

3.3
efficiency index method A
EI_A
ratio of the transmitted apparent power of a transformer minus electrical losses including the power consumed by the cooling to the transmitted apparent power of the transformer for a given load factor.

3.4
efficiency index method B
EIB

ratio of the transmitted apparent power of a transformer to the transmitted apparent power of the transformer plus electrical losses for a given load factor

3.5
peak efficiency index
PEI
highest value of efficiency index method A that can be achieved at the optimum value of load factor

Note 1 to entry: To characterize the energy performance of power transformers, it is useful to define an index that is relevant to the transformer design applicable to a wide range of uses rather than a figure that varies from second to second depending on system conditions. For this reason, a metric, the peak efficiency index, has been developed and used, which is based on active power losses and total apparent power transmitted and is independent of load phase angle, load factor and rated power.

3.6
input apparent power
S_{input}
input voltage multiplied by the input current

Note 1 to entry: This is an apparent power.

Note 2 to entry: For three phase transformers, a factor √3 shall be added.

3.7
output apparent power
S_{output}
output voltage multiplied by the output current

Note 1 to entry: This is an apparent power.

Note 2 to entry: For three phase transformers, a factor √3 shall be added.

3.8
transformer load factor
k
ratio of the actual input current to the rated current of the transformer

3.9
load factor of peak efficiency index
k_{PEI}
load factor at which the peak efficiency index (3.5) occurs

3.10
transmitted apparent power
kS_r
product of the load factor and the rated power

4 General requirements

All distribution transformers in the scope of this standard as defined in Section 1, that are manufactured in, undergo repair (as defined in the scope) in or are imported into the country/region, shall meet the minimum energy performance requirements of Section 4.1, the product and technical information requirements, and the certification and registration requirements of Section 5. The related reference test standards, compliance certification and surveillance testing requirements are as listed in Section 5.

4.1 Energy Performance Requirements

Transformers in the scope of this standard shall comply with the maximum allowed load and no-load losses values set out in the following tables. If not otherwise specified, three phase or single-phase power transformers shall be evaluated against the rated power of the individual unit. Maximum allowable losses rated powers that fall in between the given values shall be obtained by linear interpolation.

Table 1 Maximum load loss and maximum no load loss for liquid-immersed single-phase transformers with Um <= 36kV and rated frequency equal to 50 Hz

Rated power (kVA)	Tier 1			Tier 2			Tier 3		
	Maximum load losses (in W)	Maximum no-load losses (in W)	EI_{A50} %	Maximum load losses (in W)	Maximum no-load losses (in W)	EI_{A50} %	Maximum load losses (in W)	Maximum no-load losses (in W)	EI_{A50} %
5	133	37	97.17%	123	28	97.68%	112	18	98.18%
10	243	44	97.90%	224	33	98.23%	205	21	98.56%
15	331	58	98.13%	305	43	98.42%	278	27	98.71%
16	346	60	98.16%	319	44	98.45%	292	28	98.73%
25	486	83	98.36%	448	61	98.61%	410	39	98.87%
32	599	93	98.48%	552	69	98.71%	505	44	98.94%
50	889	119	98.63%	819	88	98.83%	749	56	99.03%
64	1070	145	98.71%	986	106	98.90%	901	68	99.08%
100	1535	211	98.81%	1414	155	98.98%	1293	99	99.16%

Table 2 Maximum load loss and maximum no load loss for liquid-immersed three-phase transformers with Um <= 36kV and rated frequency equal to 50 Hz

Rated power (kVA)	Tier 1			Tier 2			Tier 3		
	Maximum load losses (in W)	Maximum no-load losses (in W)	EI_{A50} %	Maximum load losses (in W)	Maximum no-load losses (in W)	EI_{A50} %	Maximum load losses (in W)	Maximum no-load losses (in W)	EI_{A50} %
25	520	70	98.40%	460	56	98.63%	400	42	98.86%
50	880	110	98.68%	782.5	92	98.85%	685	74	99.02%
100	1500	190	98.87%	1340	156	99.02%	1180	122	99.17%
160	2200	270	98.98%	1930	225	99.12%	1660	180	99.26%
250	3100	380	99.08%	2715	320	99.20%	2330	260	99.33%
315	3600	450	99.14%	3200	387	99.25%	2800	324	99.35%
400	4400	540	99.18%	3825	463.5	99.29%	3250	387	99.40%
500	5200	630	99.23%	4550	544.5	99.33%	3900	459	99.43%
630	6200	750	99.27%	5400	645	99.37%	4600	540	99.46%
800	7500	900	99.31%	6750	742.5	99.39%	6000	585	99.48%
1000	8900	1070	99.34%	8200	855	99.42%	7500	640	99.50%

1250	10500	1260	99.38%	9650	1025	99.45%	8800	790	99.52%
1600	12800	1520	99.41%	11800	1247.5	99.48%	10800	975	99.54%
2000	15100	1790	99.44%	14050	1460	99.50%	13000	1130	99.56%
2500	18000	2120	99.47%	16750	1720	99.53%	15500	1320	99.58%
3150	21500	2520	99.50%	20250	2075	99.55%	19000	1630	99.59%

The losses given in Table 1 and 2 above can be weighted by the correction factors given in Table 3 below, in order to take account of variations related to the highest voltage for equipment values.

The level of losses given in Table 1 and 2 above shall be weighted by the correction factors given in Table 4 below, in order to take account of variations related to dual voltage windings.

For distribution transformers having dual voltage on both windings for which both voltages on one winding are fully rated in combination with one of the voltages on the other winding, the levels of losses shall be based on the highest power and the values indicated in Table 1 and 2 above can be increased by 15 % for no load losses and by 10 % for load losses. The level of losses shall refer to the highest voltages of both windings. This remains valid even if further voltage combinations are available.

For a distribution transformer having an insulation level according to Table 3 below and having dual voltage according to Table 4 below the loss level shall take into account both corrections.

Table 3 correction of load loss and no-load loss applicable to other insulation levels.

Ref	Highest voltage for equipment values	Correction of load loss and no-load loss
1	One winding with 1,1 kV < Um ≤ 24 kV andtheotherwith1,1kV<Um ≤24kV	The maximum losses indicated in Table 1 and 2 can be increased by 10 % for no load loss and by 10 % for load loss.
2	One winding with 24 kV < Um ≤ 36 kV and the other with Um ≤ 1,1 kV	The maximum losses indicated in Table 1 and 2 can be increased by 15 % for no load loss and by 10 % for load loss and short circuit impedance unless otherwise specified should be increased by adding a value of 0,5 %.
3	One winding with 24 kV < Um ≤ 36 kV and the other with Um > 1,1 kV	The maximum levels of losses indicated in Table 1 and 2 can be increased by 20 % for no load loss and by 15 % for load loss and short circuit impedance unless otherwise specified should be increased by adding a value of 0,5 %.

Table 4 Correction of load loss and no-load loss applicable to dual voltage.

Ref	Dual voltage	Correction of load loss and no-load loss
A	One winding	In the case of power transformers with one high-voltage winding and two voltages available from tapped low-voltage winding, losses shall be calculated based on the higher low-voltage and shall comply with the levels indicated in Table 1 and 2. The maximum available power on the lower low voltage on such power transformers shall be no more than 0,85 times its rated power. In the case of power transformers with one high-voltage winding with two voltages available from a tap, the maximum available power on the lower high-voltage on such power transformer shall be limited to 0,85 of its nominal rated power. In the case where the full rated power is available regardless of the combination of voltages, the levels of losses indicated in Table 1

		and 2 can be increased by 15 % for no load loss and by 10 % for load loss. Such levels of losses shall refer to the highest voltage.
B	Both windings	The maximum allowable losses indicated in Table 1 and 2 can be increased by 20 % for no load losses and by 20 % for load losses for power transformers with dual voltage on both windings if the rated power is the same regardless of the combination of voltages. The level of losses shall refer to the highest voltages of both windings. This remains valid even if further voltage combinations are available

5 Marking requirements

5.1 Product Information Requirements

The following product information requirements for distribution transformers included within the scope of this standard shall be included in any related product documentation, including free access websites of manufacturers:

a) information on rated power
b) load loss and no-load loss
c) the tier of losses according to Tables 1 and 2.
d) the electrical power of any cooling system required
e) information on the weight of all the main components of a power transformer (including at least the conductor, the nature of the conductor and the core material)
f) manufacturer/repairer name
g) year of manufacturing/repairing
h) serial number

The above-mentioned information shall also be durably marked on the rating plate of the distribution transformer. The transformer's loss category as per the tier level described in Table 1 and 2 of this document shall be clearly displayed immediately below the manufacturers logo/name.

5.2 Technical Documentation Requirements

The following information shall be included in the technical documentation of distribution transformers:

a) manufacturer's/repairer's name and address
b) model identifier, the alphanumeric code to distinguish one model from other models of the same manufacturer
c) the information required under Section 5.1 above.

5.3 Compliance Certification and Registration Requirements

The transformer's energy performance must be tested in accordance with the requirements set by IEC 60076-1.

TEST CERTIFICATES

Test certificates from the following laboratories are accepted:

a) Manufacturers' in-house test laboratories.
b) Third party test laboratories that have been accredited by their respective national accreditation bodies or by an internationally accreditation body for a measurement expanded uncertainty, as defined in IEC 60076-19 and referring to a coverage factor k = 2 (i.e. to a confidence level of about 95 % assuming a normal distribution), not exceeding 5 %.

REGISTRATION

Importers and manufacturers/repairers of transformers covered by this standard must register themselves with the designated authority, following the prescribed procedure, accompanied by the required documents and information and the applicable fees.

Transformer designs covered by this standard must be registered with the designated authority through the submission of the full product and technical information as required under Sections 5.1 and 5.2, together with the test certificates as required by the Test Certificates clause above.

[Optional clause: Transformer designs that are already registered with other countries that are members of a recognised official "Regional Energy Efficiency Certificate Mutual Recognition Agreement" or equivalent may be registered by providing the registration certificate of the respective country. Purchasers should however, verify that the losses of the transformers comply with the requirements of this standard.]

5.4 Referenced Test Standards, Compliance Certification and Surveillance Testing

The metrics, referenced standards, compliance certification, and surveillance testing criteria are set out in this section.

Main Reference
• IEC 60076-1 ed3.0 (2011-04) Power transformers - Part 1: General

Supplementary References

IEC 60076-2 ed3.0 (2011-02) Power transformers - Part 2: Temperature rise for liquid-immersed transformers

IEC 60076-3 ed3.0 (2013-07) Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air

IEC 60076-4 ed1.0 (2002-06) Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing- Power transformers and reactors

IEC 60076-5 ed3.0 (2006-02) Power transformers - Part 5: Ability to withstand short circuit

IEC 60076-6 (2007) Power transformers - Part 6: Reactors

IEC 60076-7 ed1.0 (2005-12) Power transformers - Part 7: Loading guide for oil-immersed power transformers

IEC 60076-8 ed1.0 (1997-10) Power transformers - Part 8: Application guide

IEC 60076-10 ed1.0 (2001-05) Power transformers - Part 10: Determination of sound levels

IEC 60076-10-1 ed1.0 (2005-10) Power transformers - Part 10-1: Determination of sound levels - Application guide

IEC 60076-11 ed2.0 (2018-11) Power transformers - Part 11: Dry-type transformers

IEC 60076-13 ed1.0 (2006-05) Power transformers - Part 13: Self-protected liquid-filled transformers

EC 60076-14 (2013-09) Power transformers - Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials

IEC/TS 60076-19 ed1.0 Power transformers - Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors

IEC/TS 60076-20 ed1.0 Power transformers - Energy efficiency

IEC 60137 (2008) Insulated bushings for alternating voltages above 1000 V

IEC 60296 (2003) Fluids for electro technical applications – Unused mineral insulating oils for transformers and switchgear

EN 50329 Railway applications – Fixed installations – Traction transformers

IEC 61378-1 Converter transformers - Part 1: Transformers for industrial applications

IEC 61869-1:2007 Instrument transformers - Part 1: General requirements

SANS-780:2021 (Ed. 5.01) South African National Standard: Distribution Transformers

6 Entry into Force

The energy performance requirements set out in Section 4 shall take effect as follows:

- Tier 1 - one (1) year after adoption of MEPS or 1 July 2023, whichever is sooner
- Tier 2 - four (4) years after adoption of MEPS or 1 July 2026, whichever is sooner
- Tier 3 - seven (7) years after adoption of MEPS or 1 July 2029, whichever is sooner

All other requirements set out in Sections 4 and 5 shall take effect from one (1) year after adoption of MEPS.

7 Declaration of Conformity

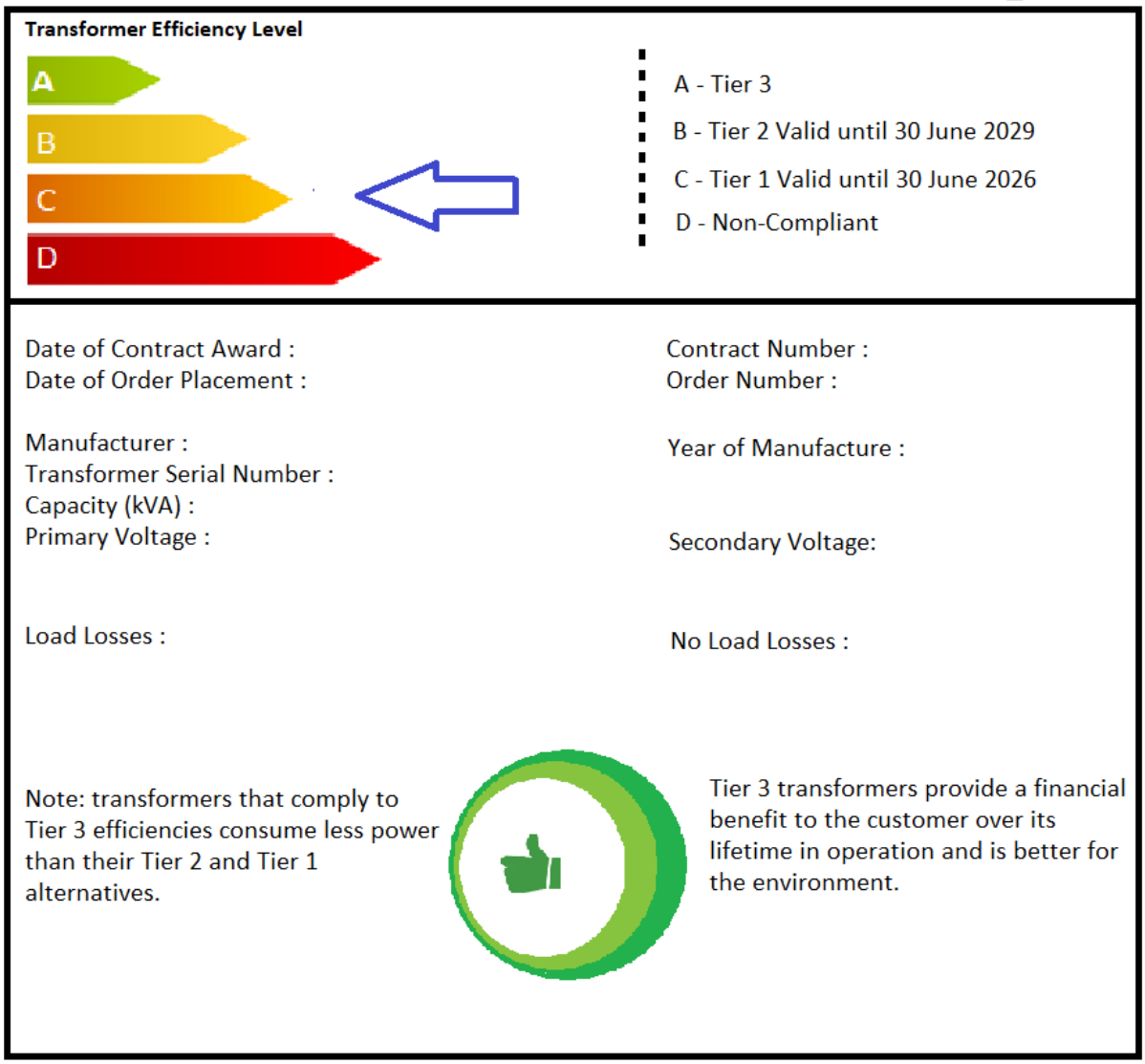
Compliance with the requirements of this standard shall be demonstrated in accordance with the provisions of Sections 4 and 5. Suppliers (i.e. importers and manufacturers/repairers) shall provide the information and technical documentation necessary for the market surveillance authority to assess conformity and verify compliance and any additional optional claims. This information and technical documentation can be provided by the supplier as a Conformity Assessment Report (CAR) and/or entered into the relevant product registration database or supplied in any other format as reasonably determined by the market surveillance authority. The conformity assessment information and documentation should:

a) demonstrate that the product model fulfils the requirements of this Standard;
b) provide any other information required to be present in the technical documentation file;
c) specify the reference settings and conditions in which the product complies with this Standard.

The information shall be submitted to the designated authority by the supplier for review prior to placing the product on the market. If the CAR or application for registration for the designated model is approved, which is confirmed by written correspondence from the designated authority and/or listing of the product on the relevant product registration system, the model may be placed on the market. If a CAR or application for registration is rejected, a written explanation shall be provided to the submitter. All aspects identified in the written explanation must be addressed in any revised CAR or application for registration. Until the CAR or application for registration is approved, the product is ineligible for placement on the market. The duration of product CAR or registration validity shall be as reasonably determined by the market surveillance authority. The supplier is obliged to check and update product conformity information, including informing the market surveillance authority of pertinent information as defined by the authority related to product compliance without undue delay.

8 Labelling requirements

All distribution transformers manufactured for use in Eswatini should be clearly labelled to indicate the tier of losses that the transformer complies to, in accordance with the requirements of Table 1 and Table 2 in Section 4.1 of this document. This requirement is in addition to the requirements stipulated in Section 5. The labels will assist Port Authorities in preventing non-compliant transformers from entering Eswatini.



The Ports Authority will correlate the losses stipulated on the transformer's rating plate and energy label to the tiers of losses stipulated in Table 1 and Table 2 of Section 4.1 of this document. Non-compliant transformers will not be allowed entry into Eswatini.

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