European CEN-CENELEC Standardization on Material Efficiency for longer lifespan within the Circular Economy

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Abstract

The European standardization organizations (CEN, CENELEC, and ETSI) agreed on the request from the European Commission to draft a series of horizontal and generic standards in the field of Material Efficiency (ME) aspects supporting the Circular Economy. This paper will describe the EU regulation context, the CEN-CENELEC (CEN-CLC) standardization structure and membership, and the organizational setup for managing the work that has already started. It will describe the objectives of the 10-standard series that will potentially be used directly by manufacturers but that are more specifically dedicated to the CEN-CLC product committees in charge of drafting product-oriented standards related to requirements from the EU Ecodesign Directive.

A summary of the expected requirements issued from these draft documents will be presented for the different topics developed for the material efficiency of energy-related products (ErPs), that will apply to equipment and systems.
These are the general topics: durability, ability to re-manufacture, ability to repair, upgrade and reuse; recyclability and recoverability; proportion of re-used components and recycled material; declaration of critical raw materials; and information on aspects of the circular economy provided to the users of ErPs. Beyond these topics that are primarily covered by the standards related to the dependability domain, a focus from functional approaches to durability assessment methods focusing on how the longer lifespan of products would be assessed will be presented inside this paper.

Based on examples, some additional information will highlight the industries and organizations to prepare the optimization inputs that could be implemented in product-oriented material efficiency standards that would be derived from the current standardization work in process.

I. Introduction

The European Commission (EC) implemented a decision on a standardization request to the European standardization organizations in regard to ecodesign requirements on material efficiency aspects of energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council. This paper aims to summarize, the standardization works in progress within the CEN-CENELEC Joint Technical Committee 10 (CEN-CLC/JTC 10), the European Commission's requests and the existing standardization framework that for several decades enabled the integration of a circular model in the economy, with the goal of a greener planet, such as the electrical distribution and industrial equipment expected to be in operation for more than 30 years.

For that purpose, the CEN-CLC/JTC 10 gathered 310 standardization experts from 18 national committees, and established some liaisons with 13 European business to customer (B2C) and business to business (B2B) professional associations. JTC 10 members are selected from the industry, the consumer organizations, NGOs Laboratories and the European Commission, including its Joint Research Centre, and ETSI in order to assemble a large panel of experts to accomplish the objectives.

All reports and standards are intended to be used and referenced by product technical committees when preparing their own of product-specific or product family standards. That standard series is not expected to be applied directly.

As the EC aims to extend products lifespan, the dedicated group CEN-CLC/JTC10 WG2 will turn a special focus to durability assessment. The standardization work is in progress and could be modified and updated before its expected publication in early 2020.

II. Prerequisite

1. Standardization

Criteria for relevance, acceptability, credibility easiness and robustness are described in the policy of several standardization bodies, while the European Commission aims for a longer product lifespan. However, a crucial capability for a standard is the verifiability, as specified with the ISO/IEC Directives part 2. The stability, reliability, or lifetime of a product shall not be specified if no testing method is available and known for use that can verify the claim within a reasonably short time. The product guarantee provided by manufacturers is not a substitute for such requirements. Guarantee conditions shall not be included inside a standard, because they are a commercial or contractual concept, not a technical one.

The European Commission asks for consistency between ecodesign implementing measures and other relevant European Union legislation. However, the standardization is usually referred for providing tools and methods on how the regulation is implemented and how any loophole or overlap between standardization and regulation must be avoided. As an example, the Waste Framework Directive, as part of circular economy, is not considered. It is implemented, based on subsidiarity, as a national competence and is not supported by CEN-CLC standards.

A non-exhaustive list, but relevant bibliography, to better understand how the circular economy concept might be controlled is based on the EN 12973[2] and EN 16271[3] for the functional approaches [1], the IEC 60300-1[4] and IEC 62347[5] for the dependability management, the IEC 62308 [6] for the durability assessment and the ISO 14044[22] and ISO 14025[23] for lifecycle assessment.

2. Circular Economy

Circular economy is not a new concept as reminded by the British Standard BS 8001[24]. A prerequisite of the circular economy is to use material from clean materials cycles (REACH). This concept is a dynamic socio-technical ecosystem involving many stakeholders, where the trade-off is linked to a relevant digital transformation with the Internet of Things (IoT). This concept, to transform a linear economy into a circular economy is very broad and can be relevant only if the global approach is optimized, driven by the final criterion: a reduced environmental footprint of the full lifecycle of both the product and the system in which the product belongs. The complexity of embedding both studies limits the life cycle assessment (LCA) of the product, which can be carried out separately for the upper layer of the system. The circular economy should cover the life cycles (product and system) shown in Figure 1.

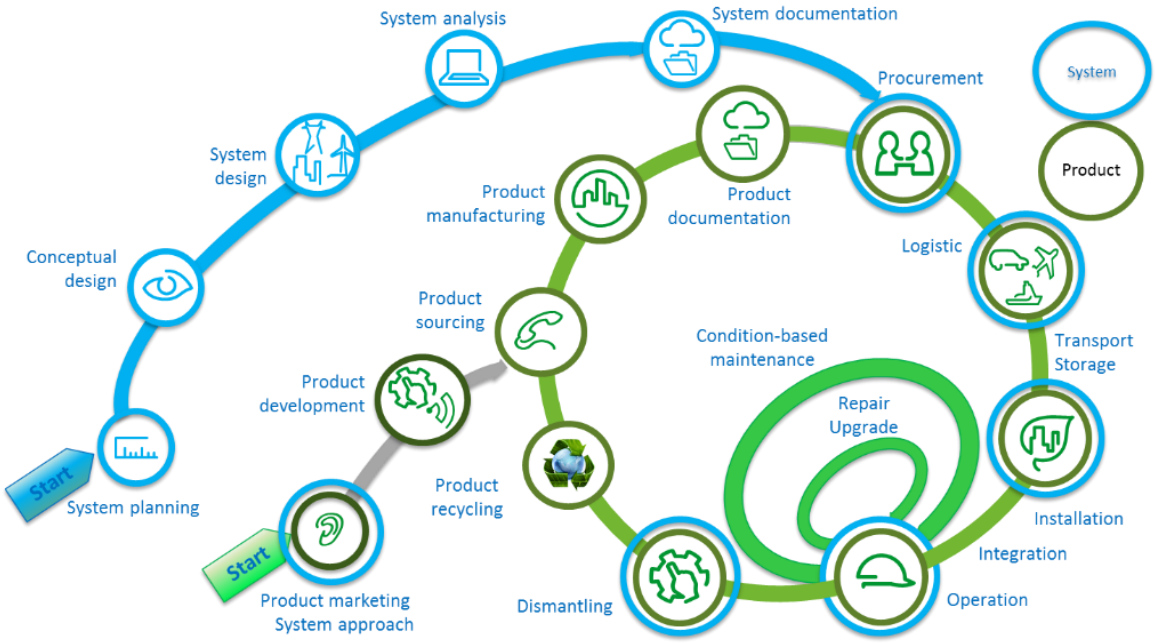

Figure 1 – Life cycles

III. Material efficiency

1. General

Through the standardization request M/543, the European Commission provided objectives to European standardization organizations in regards to ecodesign requirements the aspects of material efficiency for **energy-related products** (ErPs) in support of the implementation of Directive 2009/125/EC. The global objectives of this standardization work are described as follows:

a. Extending product lifetime.
b. Ability to re-use components or recycle materials from products at end-of-life.
c. Use of re-used components and/or recycled materials in products

The CEN-CLC/JTC 10 Committee has created six working groups that are responsible for the development of the standardization deliverables:

- WG 1 ‘Terminology’
- WG 2 ‘Durability’
- WG 3 ‘Upgradability, ability to repair, facilitate Re-Use’
- WG 4 ‘Ability to re-manufacture’
- WG 5 ‘Recyclability, recoverability, RRR index, recycling, use of recycled materials’
- WG 6 ‘Documentation and/or marking regarding information relating to material efficiency of the product’, and critical raw material (CRM) declaration

Each working group works on respective items which are summarized in Table I.

TABLE I -

N°	Doc	Title of deliverable	WG	Ref	CEN-CENELEC
1	TR	Definitions related to material efficiency (NWI65684)	1	Pr TR 45550	CENELEC
2	TR	Guide on how to use generic material efficiency standards when writing energy-related product specific standardization deliverables	1	Pr TR 45551	CENELEC
3	EN	General method for the assessment of the durability of energy-related products (JT010003)	2	Pr EN 45552	CEN
4	EN	General method for the assessment of the ability to repair, reuse and upgrade energy-related products (NWI 65685).	3	Pr EN 45554	CENELEC
5	EN	General method for the assessment of the ability to re-manufacture energy-related products (NWI 65686).	4	Pr EN 45553	CENELEC
6	EN	Methods for assessing the recyclability and recoverability of energy-related products (JT010001).	5	Pr EN 45555	CEN
7	EN	General method for assessing the proportion of re-used components in an energy-related product. (NWI 65709).	4	Pr EN 45556	CENELEC
8	EN	General method for assessing the proportion of recycled material content in an energy-related product. (JT010002).	5	Pr EN 45557	CEN
9	EN	General method to declare the use of critical raw materials in energy-related products. (NWI 65687).	6	Pr EN 45558	CENELEC
10	EN	Methods for providing information relating to material efficiency aspects of energy-related products. (NWI 65688).	6	Pr EN 45559	CENELEC
11	TR	Environmental Engineering (EE); Circular Economy (CE) in Information and Communication Technology (ICT); Definition of approaches, concepts and metrics (Published)		TR 103 476 V.1.1.2	ETSI
12	ES or EN	Specific metrics, methods and parameters for assessment of material and resource efficiency aspects of ICT network infrastructure goods in the context of circular economy			ETSI

The aim of these standards is to provide methodologies and tools as well as criteria for assessing existing ErP products, but not to provide requirements for being circular by design optimization as the European Environment Agency highlights [25]. An additional complexity of these tasks is the merging of the B2C and B2B specificities and experiences combined with the objective of the European Commission, which is to publish the regulations using these standards as support. It is the reason why the standards should not anticipate the regulations and should focus on descriptions of assessment methods for existing ErP products as a toolbox and not to include any requirements that will come from the regulatory framework.

While CEN-CLC JTC10 standards simplified some assessments to be accessible in terms of communication for the users, other existing standards contributing to ecodesign and optimizing the design stages should be specified to help the product TC dealing with the standards for new products.

The following clause will remind us of the objective of each of the CEN-CLC/JTC10 deliverables completed by respective added value from existing standards and by examples if any.

2. Technical topics

This clause aims to describe the objectives of each document followed by the stakes, which will be completed by identified improvable approaches related to new products, as expressed below:

- pr **EN 45550** [10] aims to harmonize the definitions used by the different standards. While many definitions exist in the IEC 60050-192 [8] standard, it might be beneficial to modify a few existing definitions when they are too close to definitions already used or expected to be used in a regulatory framework. As an example, "normal service conditions" is missing from the IEC database (Electropedia), and has been replaced by "environmental and operating conditions for normal or intended use" to clarify respective scopes.
- pr **EN 45551** [11] is frozen, because an attempt is being made to include the guidance inside each respective document.
- pr **EN 45552** [12] aims to describe methods for assessing the durability of ErPs. The durability is mainly covered by existing standards such as the IEC 62308 [6] clause 9.3. However, a reminder of the influencing parameters on product aging and on how, on how to conduct a functional analysis seemed useful. In addition, the European Commission targeted reliability through durability, which are two different concepts, and targeted validation with tests that are only valid under the test conditions and not under the normal use conditions. The user of the pr EN 45552 shall differentiate when durability focusses only on aging, fatigue, and wear-out due to environmental and operating conditions, or when the durability assessment also considers maintenance and repair actions, until end of product life. For example, it has been identified that oil-immersed and dry type power transformers' aging is mostly affected by thermal conditions . The loading guide for oil immersed power transformers has existed since 1984, enabling the assessment of the power transformers' expected lifespan related to the use temperature and load factor. In addition to using this fatigue to identify the limit before a failure, energy efficiency as a requirement of the M548/2014 directive might be a criterion related to the durability. A loading guide that has existed since 1984 enables the assessment of the expected lifespan of the power transformers under a defined use temperature, load factor, oil and windings temperature rise.
- pr **EN 45553** [13] covers the assessment of the ability to re-manufacture energy-related products on a generic level, reminding that neither safety nor performance of the product or part to be remanufactured will be impaired during the remanufacturing process, requiring qualified persons, traceability of re-manufactured products and used or expected-to-be-used parts. For example, for power transformers, the amendment of the eco-design directive forecast to deal with material efficiency for circular economy considering the level of the efficiency after the repair, reuse or upgrade (pr EN 45554) and after remanufacturing or refurbishment (pr EN 45553) [26]. In all cases, the legal status and the warrantee of the product after remanufacturing is outside the scope of the standard.
- pr **EN 45554** [14] aims to assess reparability and reusability to extend the lifetime of already designed products. For the CEN-CLC/JTC 10 Committee, corrective maintenance is classified as so-called repair, while the term "maintenance" is reserved for preventive and condition-based maintenances. The reparability of the product or parts thereof is a benefit enabling longer lifespans, and an optimization process is described with existing guides such as IEC 60300-3-10, -11, -12, -14 whereas the IEC 60300-3-11[9] describes the relation for reliability centred maintenance (RCM), and shows six different failure patterns that would be useful for the pr EN 45552. The failure identification process and RCM analysis enables the identification of the whole range

of expected maintenance tasks, and therefore permits the initiation of support planning. The identified maintenance tasks will produce the information needed to analyze support activities such as the provisioning of spare parts, level of repair analysis (LORA), requirements for tools and test equipment, manpower skill levels, and the requirement for the facilities necessary to support the derived maintenance concept. Further reliability study, some non-repairable part could have a longer lifespan and higher reliability, integrating cell coin battery when soldered instead of being withdrawable, especially those targeted lifespans over 10 years required for industrial products. This is why only a robust design based on a functional analysis would be able to confirm if the ecodesign perspectives have been achieved.

- pr **EN 45555** [15] provides a general methodology for assessing the recyclability and recoverability of energy-related products and the recyclability of critical raw materials from energy-related products. In addition, this document considers the ability to access or remove certain components, assemblies, materials or substances from products to facilitate their extraction at the end of life to optimize ease of treatment, recycling, and other recovery operations. It includes a description of horizontal criteria and clarifies the quantitative measurement of recyclability using a full or simplified process. It makes the link with environmental benefits and considers the end-of-life treatment scenario, considering the representativeness and the different sources of relevant data. For example, the power transformers are reparable and recyclable, enabling the valorization of the materials even if power transformers are excluded from the WEEE directive,
- pr **EN 45556** [16] provides a general method for assessing the proportion of re-used components in energy-related products. Two calculation methods based on the mass of re-used components and the number of re-used components are presented. While writing product-specific standards on assessing the proportion of re-used components product-specific technical committees should apply the most suitable methods for their product group.
- pr **EN 45557** [17] provides a general method for assessing the proportion of recycled material content in energy-related products. This standard describes the “pre-consumer material”. It distinguish new scrap, it provides the way to calculate the recyclability and recoverability of ErPs and presents the principle for the mass-balanced recycled material. It gives specific guidelines for material consideration and deals with the traceability.
- pr **EN 45558** [18] provides a general method for declaring the use of critical raw materials in energy-related products to enable information exchange between stakeholders along the supply chain in a well-known formalized format issued from the IEC 62474 standard [21]. The pr EN 45558 defines critical raw material (CRM) as the CRM listed in the annex 1 of the EU Commission document COM(2017)490 final [x].
- pr **EN 45559** [19] provides methods for providing information relating to material efficiency aspects of energy-related products. All documents previously mentioned describes different methods of assessment. The result of the assessment methods will be communicated to the user. In addition, the conditions for which the assessments are valid shall also be communicated. Example: A power transformer is expected to be operated by a user under defined conditions for 20 years. If one condition is that the yearly average temperature is at 20°C with a load factor near 1, while a second user would like to use the same power transformer in a warmer area such as 25°C with a different load factor. The Figure 2 shows how a user is informed and how he can verify the influence of temperature of use and the load factor changes, keeping the same aging rate. The second user shall limit its load factor at 0.95 for a same aging rate.

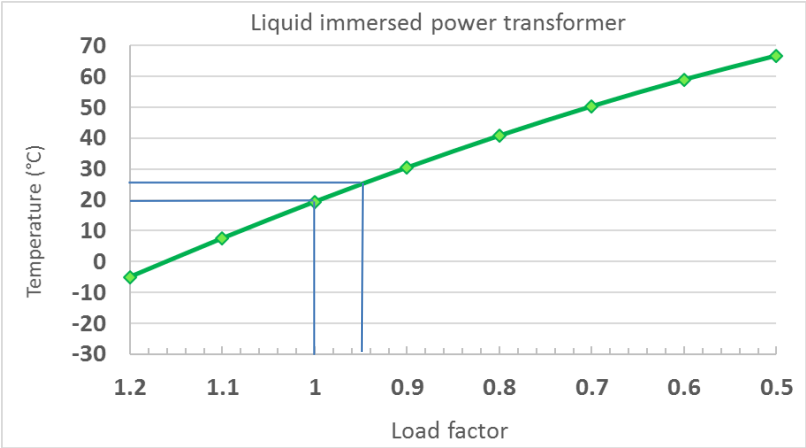

Figure 2 – Example for liquid immersed power transformer for a constant aging rate.

- **ETSI TR 103 476** [20]: This technical report aims to provide an overview of the most important existing aspects, parameters, indicators, metrics, results, and business models used for estimating the resource efficiency and circular economy characteristics of information communication technologies (ICT) infrastructure goods as input for further standardization. All topics mentioned in Table 1, requiring metrics, are covered by the ETSI 103 476 report, mentioning the respective trade-off based on a wide bibliographical analysis. For example, in a durability analysis, a trade-off is required between OPEX and CAPEX while the innovations are expected to bring energy savings. Therefore, optimization is the heart of any durability analysis, where functional durability shall complete the technical durability [25].

3. Durability concept

Durability is the ability to function as required, under defined conditions of use, maintenance and repair, until a final limiting state is reached. The limiting state is reached after an event limiting a function. This event could be a failure or a wear-out failure or a fatigue when a digital or an analog function is no longer delivered, as shown Figure 3. Each function should be classified by importance, to identify where the function associated with ecodesign should be identifiable. The maintenance and repair strategies influence the functional durability when the technical durability encounter a limitation. A durability assessment should differentiate when durability only focuses on aging, fatigue, and wear-out due to environmental and operating conditions, or when the durability assessment also considers maintenance and repair actions, until the end of product life.

In accordance with the IEC, the durability corresponds with the end of the useful life, which means a unit associated with a duration (time, cycle, distance, etc.) from the first use until user requirements are no longer met, due to economics of operation and maintenance, or obsolescence. The CEN-CLC/JTC 10 could not integrate predictive limitation(s) inside the proposed methods to assess the durability, due to the economic and obsolescence reasons.

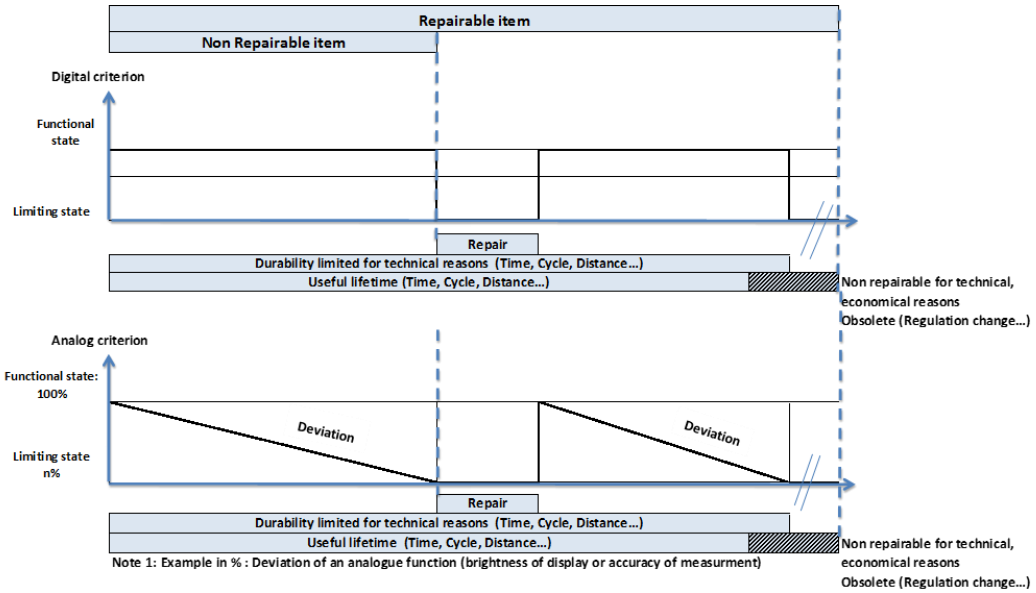

Figure 3 – Durability limitations and actions to recover a use phase.

When a repair intends to recover a rating assessed by an analog criterion, it could be necessary to identify an acceptable threshold defining a tolerance. However, the critical functions, such as those linked to health and safety, must reach 100% after repair.

The durability analysis should be carried out in accordance with to IEC 62308:2006 [6], subclause 9.3, as follows:

1) identify applicable environmental and operating conditions (see IEC 60721 series of standards and the product standard) being part of the mission profile.
2) identify stresses related to the conditions previously defined (see IEC 62308 [6])
3) identify transfer functions (EN 12973 [2])
4) identify magnitude and locations of stresses combining conditions and simulation tool such as finite element (FE) or other.
5) identify likely failure sites, mechanisms and modes (FE tool or other)
6) identify the most appropriate damage model (Experience, accelerated test (see IEC 62506 [7])
7) identify the durability using appropriate damage model(s) and acceleration factors

The durability of any ErP product is a crucial information used in any life cycle assessment or a reliability analysis, however the durability is not a reliability of an ErP.

IV. Conclusion

As a first step the assessed criteria and deliverables to be issued in 2019/2020 by the CEN-CLC/JTC 10 will be a relevant methodology to assess different topics of the material efficiency for circular economy, while the IEC should engage the whole approach, aiming to optimize the circular economy through a design approach balancing the lowest environmental footprint and the functional analysis of the products and systems.

In a second step, the presumption of conformity with particular material efficiency requirements from the EU Regulation will be possible by using dedicated product-oriented CEN-CLC standards. These standards should be derived from the horizontal deliverables issued from the JTC 10 Committee but drafted by TCs in charge of particular ErPs.

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