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To the members of
CEN-CLC/TC 10 WG 2
"Durability"

Your reference	Our reference	☎ +49 30	Berlin
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Dear member

the Drafting Team prepared the following two documents:
- Draft "General methods for assessing the durability" (CEN-CLCTC10_WG02Sec00051DC)
- Questionnaire on draft General methods for assessing the durability (CEN-CLCTC10_WG02Sec00048Q)

Both documents are now available on the Collaboration Tool. All members are requested to review the draft standard and ***prepare comments*** by using the ***Commenting From*** (also provided on the Collaboration tool). Please also fill in the Questionnaire an upload both, your comments and the completed Questionnaire ("new response") not later than 8th September 2017. We will upload the collated comments on the 12th September as a basis for the 4th WG 2 meeting on 21st September in Seville.

Please be reminded to fill in especially the columns for the line numbers, Clause/ Subclause and Paragraph/ Figure/ Table of the Commenting Form.

Kind regards

Angelina Patel
Secretary of CEN-CLC/TC 10 WG 2

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Foreword

<CLC standard text will be inserted.>

Introduction

This standard, along with the standards of the CEN-CLC XXXXX series, has been developed under Mandate M/543 of the European Commission.

CEN, CENELEC and ETSI were requested by M/543 to develop horizontal standards and standardisation deliverables for energy-related products in support of implementation of the Ecodesign Directive (2009/125/EC) and to contribute to the transition towards a more circular economy. The standards developed under M/543 will be the baseline for future product publications covering specific energy-related products (ErP) or groups of related ErPs. The primary addressee of the standards in the CEN-CLC XXXXX series are experts preparing product specific publications on the various covered topics.

Topics covered in the CEN-CLC XXXXX series are inter alia, product durability, reparability, reusability, recyclability, recycled content, ability to remanufacture, and product lifespan. While various important topics in the context of material efficiency are covered in the standards of the CEN-CLC XXXXX series, other subjects of material efficiency, e.g. renewable resources, biodegradable plastics, light weighting and multi functionality, are not covered for the moment, despite their potential impact on material efficiency.

As ErP can often not be completely recycled and the benefits associated with material recovery cannot fully compensate the energy (and material) demand of the whole production chain, each disposed ErP also means losses in energy and materials. Especially precious and special metals are at present recycled only to a very limited extent and plastics are mainly used for energy recovery.

Therefore securing a minimum technical life time or prolonging useful life by repair, remanufacturing and reuse are relevant contributions to resource efficiency of energy-related products. Improving recyclability of ErP or use of recycled materials in product manufacturing contributes toward closing material cycles.

In order to ensure that measures indeed reduce the environmental impact related to ErPs, the entire life cycle of an ErP needs to be considered. In the case of durability this includes, for example, the evaluation of trade-offs between longer lifetime and reduced environmental impacts of new products. Considerations such as these are addressed in the preparatory studies commissioned under Directive 2009/125/EC, which include life cycle assessment and life cycle costing. Whilst such aspects establish a relevant context for this standard, they are not addressed in detail.

This standard covers a general method for the assessment of the (technical) life time of ErPs. It is especially linked to the horizontal standards on “Ability to repair, reuse and upgrade” and “Ability to re-manufacture” that have been published under CEN-CLC XXXXX series where they all shall be seen as sub-concepts to prolong the lifetime of products.

The durability calculation methods presented in this standard can be used to model wider environmental and operating conditions than those used by laboratories in ideal test situations.

1 Scope

The scope of this European standard is to define parameters and methods for the assessment of durability of energy-related products (ErP) in the scope of the Ecodesign Directive 2009/125/EC. It provides a framework for consideration of the durability of products based on generic calculation and tests of the complete product and its (critical) components such as reliability assessment, (accelerated) stress tests, etc. This European standard is not intended to be applied in the direct assessment of the durability of a specific ErP. Instead, product specific technical committees shall use this standard as method to define durability aspects, such as testing and calculation, of specific products or product groups.

As the Ecodesign Directive addresses minimum performance requirements for market access, the main focus of this standard is to propose a general method to assess durability that is able to produce enough and verifiable evidence of compliance to become part of a regulatory framework.

Maintenance (in the sense of definition 3.5) is covered by the standard, while repair considerations are addressed only to provide the link to the standard on “Ability to repair, reuse and upgrade” developed under CEN-CLC XXXXX series.

NOTE Safety aspects are not directly considered in this standard despite, much of the guidance in this standard is based on tools also used for safety assessment, e.g. failure mode analyses (e.g. FTA, AFMEA, DFMEA).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12973, Value management

EN 16271, Value management – Functional expression of the need and functional performance specification - Requirements for expressing and validating the need to be satisfied within the process of purchasing or obtaining a product

EN 60300-3-4, Dependability management – Part 3-4: Application guide – Guide to the specification of dependability requirements

IEC 60300-3-5, Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles

EN 61649, Weibull analysis

EN 61709, Electric components - Reliability - Reference conditions for failure rates and stress models for conversion

EN 62308, Equipment reliability - Reliability assessment methods

EN 62506, Methods for product accelerated testing

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
durability
ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached

3.2
limiting state
state of a product (system) or any part thereof, when required function(s)/sub-function(s) is/are no longer delivered.

Note to entry Fault or de-rated operating state reached due to a failure, a wear-out failure or a measurement accuracy out of range.

3.3
testing time to first failure
time span or number of cycles for which a product functions as required under defined testing conditions until a failure

Note to entry First failure is one example of limiting state.

3.4
first technical life time by calculation
calculated time span or number of cycles for which a product functions as required under defined conditions of use until first failure based on statistical data and models

NOTE It will be defined within the product specific standards if maintenance must be part of the defined conditions.

3.5
maintenance
technical, management and supervisory actions intended to retain an item in a state in which it can perform as required, by mitigating degradation and reducing the probability of failure and fault

Note to entry Corrective maintenance carried out after fault detection to restore a product to a state in which it can perform as required is referred to as “repair" for the purposes of this standard.

3.6
durability analysis
analysis of the equipment’s responses to the stresses imposed by operational use, maintenance, transportation, storage and other activities throughout its specified life-cycle in order to estimate its predicted reliability and expected life.

[EN 62308:2006, definition 3.1]

Note to entry In this standard durability assessment is used as synonym for durability analysis

3.7
reliability
ability to perform as required, without failure, for a given time interval, under given conditions

[IEV 192-01-24]

Note 1 to entry The time interval duration can be expressed in units appropriate to the item concerned, e.g. calendar time, operating cycles, distance run, etc., and the units should always be clearly stated.

Note 2 to entry Given conditions include aspects that affect reliability, such as: mode of operation, stress levels, environmental conditions, and maintenance.

Note 3 to entry Reliability can be quantified using measures defined in Section 192-05, Reliability related concepts: measures.

3.8
main function
first function covering the user need(s) which is highlighted by any functional analysis

3.9
main required function(s)
required functions mandatory to assure the main function for which the product is intended to be used

NOTE Due to the scope of this standard the environmental performance should be a main required function

3.10
sub-function(s)
function(s) that enables, supplements or enhances the main function and main required function(s)

3.11
functional analysis
process that describes completely the functions and their relationships, which are systematically characterised, classified and evaluated

[EN 16271 2012, §3.9]

Note 1 to entry The function structure is a part of the result of Function Analysis.

Note 2 to entry Functional Analysis covers two approaches: the Functional Need Analysis (or External Function analysis) and the Technical Function Analysis (or Internal Function analysis).

Note 3 to entry Function Analysis combines problem definition and problem solving.

3.12
normal service conditions
environmental and operating conditions for which the product is type tested and that represent as closely as possible the range of normal use.

3.13
special service conditions
service conditions not covered by normal service conditions

3.14
failure
failure <of an item>

loss of ability to perform as required

[IEV 192-03-01l]

Note 1 to entry A failure of an item is an event that results in a fault of that item: see "fault" (IEV 192-04-01).

Note 2 to entry Qualifiers, such as catastrophic, critical, major, minor, marginal and insignificant, can be used to categorize failures according to the severity of consequences, the choice and definitions of severity criteria depending upon the field of application.

Note 3 to entry Qualifiers, such as misuse, mishandling and weakness, can be used to categorize failures according to the cause of failure.

3.15
failure criterion
pre-defined condition for acceptance as conclusive evidence of failure

[IEV 192-03-03]

EXAMPLE A defined limiting state of wear, crack propagation, performance degradation, leakage, etc. beyond which it is deemed to be unsafe or uneconomic to continue operation.

Note to entry In a post-failure scenario, the conclusive evidence may be regarded as proof.

3.16
fault <of an item>
inability to perform as required, due to an internal state

[IEV 192-04-01, modified]

Note 1 to entry Qualifiers, such as specification, design, manufacture, maintenance or misuse, may be used to indicate the cause of a fault.

Note 2 to entry The type of fault may be associated with the type of associated failure, e.g. wear-out fault and wear-out failure.

Note 3 to entry The adjective “faulty” designates an item having one or more faults.

3.18
wear-out failure
failure due to cumulative deterioration caused by the stresses imposed in use

[192-03-15]

Note 1 to entry The probability of occurrence of a wear-out failure typically increases with the accumulated operating time, number of operations, and/or stress applications.

Note 2 to entry In some instances, it may be difficult to distinguish between wear-out and ageing phenomena.

3.19
wear-out part
a component or assembly, which is expected to be subject to wear-out failure

3.20
spare part
part (component, assembly or product) which can replace a faulty, failed or worn-out replaceable part covering the same operating and dependability functions

3.21
non-wearing part
a component, device, product, equipment or assembly which can replace an operating device, product, equipment or assembly after a failure assuring the same operating and dependability performance

3.22
consumable
a material, gas, fluid, component or device designed to feed the main function of a product, equipment or assembly, expected to be replaced several times along the product lifecycle

4 Durability assessment

4.1 General

The reliability of a product is directly linked to durability aspects of the parts (components, subsystems and/or assemblies) of that product.

Durability refer to the ability of a part to perform its required functions under stated conditions for a specified time, (or distance, operating cycles, etc.) withstanding the effects of time-dependent mechanisms such as fatigue, wear, corrosion, electrical parameter changes. While reliability is the probability that an item will perform a required function without failure under stated conditions for a stated period of time. Durability and reliability are core attributes of the wider concept of dependability, beside availability (readiness for correct service), maintainability (the ability for a process to undergo modifications and repairs) and maintenance support. Therefore dependability standard series are an important basis for this European standard. These concepts are explained in more detail in Annex A. The product parts are “arranged” to a specific design in order to achieve desired functions with acceptable performance, durability and reliability. The types of components, their quantities, their quality and the way in which they are arranged within the product have a direct effect on the product’s dependability.

The concept of system operation, on which dependability standards like EN 62347 are based, can also be applied to energy-related products. An ErP interacts with its environment to fulfil a specific purpose respectively objectives. Each function can be perceived as an element of the system. In order to determine the functions necessary to achieve each objective, a system specification is necessary.

A first stage in a durability assessment is a functional analysis to identify the expected functions of the product (see EN 16271 & EN 12973). This will help to identify how the functions are fulfilled and how they will be checked for regulatory compliance. All information should contribute to the technical specification of the product.

For functional analysis it is necessary to think abstractly in terms of objectives and end results rather than solutions. Describing the product functions facilitates a common language and enables an objective consideration of needs compared to the product itself.

What constitutes a product can vary, and some ErPs within the scope of the Ecodesign Directive 2009/125/EC can in fact be a part of another product. For example, an electronic display is defined as a product but could be integrated as an interface within another product. Likewise for a motor which could also be part of a larger product such as a vacuum cleaner or washing machine.

The flow chart in Figure 1 provides an overview of the preliminary stages and the main information required for an assessment, calculation and test of durability and to build the verification plan. The durability assessment is one aspect of the reliability assessment as described in annex A in accordance with EN 62308 standard.

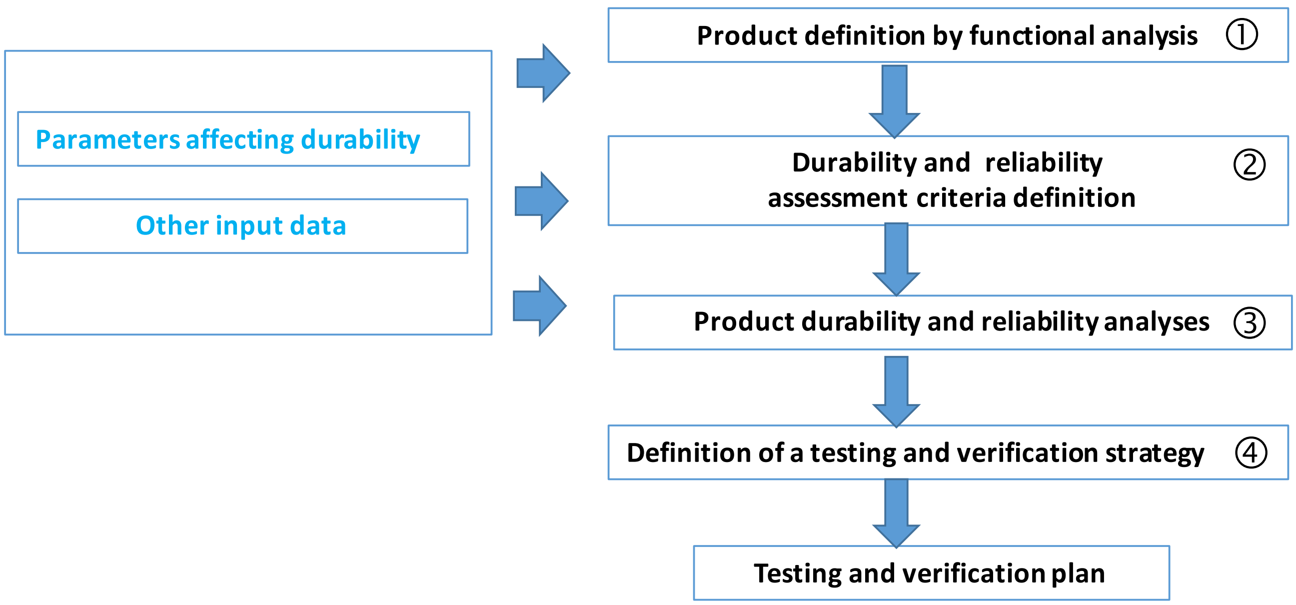


Figure 1 — General durability and reliability analysis procedure

The durability assessment provided includes the following:

a) Selection of durability parameters to be evaluated

b) Qualitative analysis based on a functional analysis and the respective failure modes of ErP

c) Quantitative analysis

d) Identification and development of test methods focussing to durability assessment

The process described in Figure 1 can be broken down to describe the applicable methodologies and standards, as summarized in Figure 2.

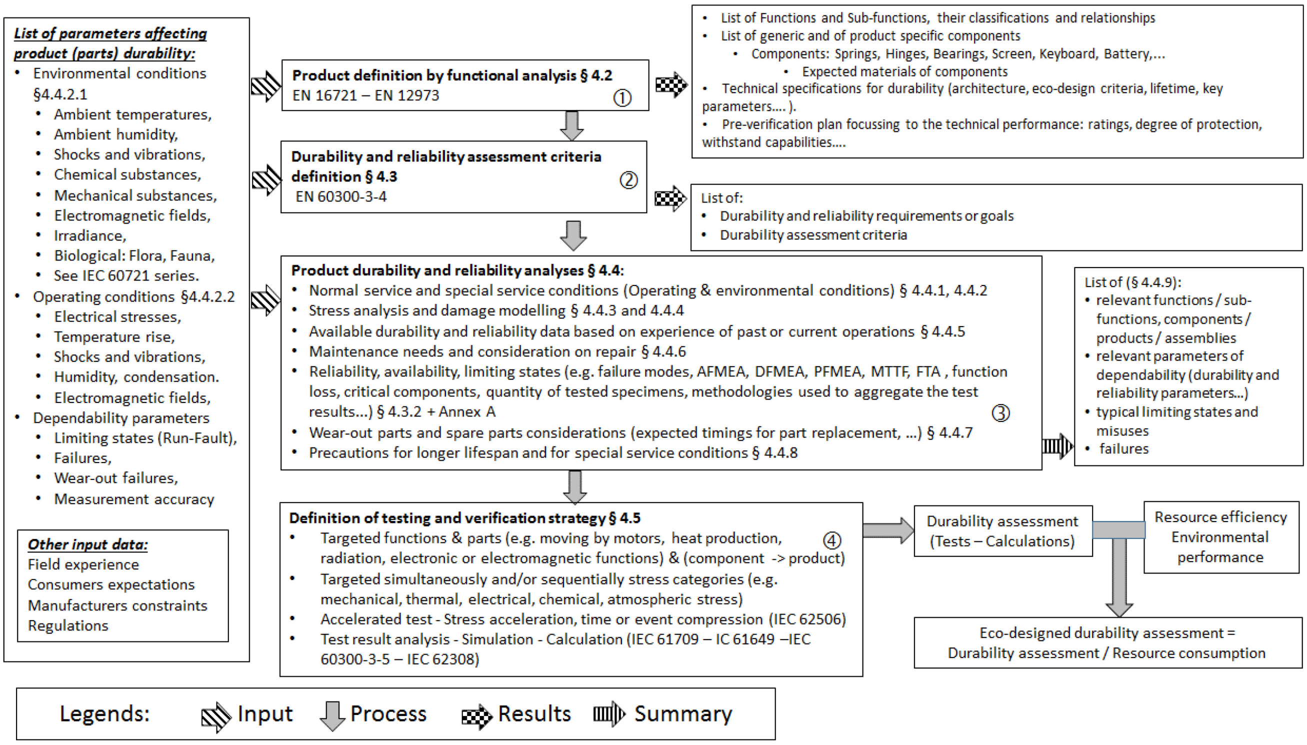


Figure 2 —Durability and reliability analysis procedure

4.2 Product definition by Functional analysis

4.2.1 Product objective and main function

A product is designed for a purpose and must have defined objectives to achieve its purpose. These product objectives shall be defined and prioritised. When a system is covered by a product standard it is considered a product.

The main function will address the key purpose of the product. The durability assessments shall be related to the main function(s).

4.2.2 Identification, classification and relationships of the functions

The starting point for a durability assessment is the functional analysis in relation to the end-user, which can then feed into the failure mode assessment. The methodologies described within the EN 12973 standard define associated durability criteria and can be used to specify main functional objectives and their respective priority. The functional analysis is the core of the technical product specification, and is described in more detail in Annex B.

In addition to the main function, a number of secondary functions will be fulfilled. The secondary functions should be ordered in accordance with their priority.

EXAMPLE: The purpose of a home theatre system is to provide cinema-like entertainment in a home environment for a defined lifespan without maintenance under safe operation. Remote control battery change is an accepted maintenance action. The functional objectives may include secondary functions such as users' perception of a clear picture vision, sound quality, connectable to internet, easy installation, upgradable and low power consumption. And also other function such as remote control could be replaced before the expected lifespan, being exposed to non-preventing event as a strong shock stress over those required by the product standard.

A selection of key functions will be necessary to perform a specific operation successfully and meet durability requirements. To properly specify product durability it is necessary to carry out an evaluation of the functions that influence durability and those which do not. This requires consideration of the influencing conditions affecting the selected durability characteristics.

For the operation of most ErP, all functions must meet both durability and reliability requirements for sustained operation. That is, all product functions during operation are needed to carry out the intended performance.

4.3 Durability and reliability requirements and assessment criteria

4.3.1 Requirements

Product reliability and durability goals, characteristics and features should be listed. The product system durability goals should be allocated to the various sub-systems, functions or components using IEC 60300-3-4 standard as guidance.

The influence of the installation environment, although outside the responsibility of the manufacturer should also be assessed for its impact on reliability and durability.

4.3.2 Reliability, availability, limiting states

The limiting states of the product or parts thereof (fault or states due to failure modes, de-rated modes…) shall be determined, as well as their mechanisms, causes, effects and consequences. This will enable identification of the degradation mechanism (failures) that may cause limiting states and facilitate analysis of fault paths. The relation of reliability to the useful lifetime and examples of limiting states are described in more detail in Annex A.2. The standard dealing with the procedure for failure mode and effects analysis (FMEA) is the EN 60812.

These analyses are useful to identify, classify and mitigate risk regarding the defined limiting state(s) and to identify failure modes of the ErP, on which durability assessment should focus.

When an FMEA analysis targets the application of the product (misuse, functional need…) it is termed an Application FMEA (AFMEA), when the analysis focuses the design stage it is termed a Design FMEA (DFMEA), and when the analysis is manufacturing oriented it is termed a Production FMEA (PFMEA).

The reasons for undertaking Failure Mode Effects Analysis (FMEA) or Failure Mode Effects include:

a) to identify those failures which have unwanted effects on system operation, e.g. preclude or significantly degrade operation or affect the safety of the user;

b) to satisfy functional requirements;

c) to allow improvements to the reliability or safety (e.g. by design modifications or quality assurance actions);

d) to allow improvement to the maintainability (by highlighting areas of risk or nonconformity for maintainability).

In view of the above reasons for undertaking a FMEA effort, the objectives of an FMEA may include the following:

a) a comprehensive identification and evaluation of effects, which could cause a failure within the defined boundaries of the system being analysed, and identification of the sequences of events brought about by each identified item failure mode, from whatever cause, at various levels of the system's functional hierarchy;

b) the determination of the criticality or priority for addressing/mitigation of each failure mode with respect to the correct function or performance of the system and the impact on the process concerned;

c) a classification of identified failure modes according to relevant aspects, including their ease of detection, capability to be diagnosed, testability, compensating and operating provisions (repair, maintenance, logistics, etc.);

d) identification of product-system functional failures and estimation of measures of the severity and probability of failure;

e) analysis of the possibility of fault avoidance and development of design improvement plan for mitigation of failure modes;

f) support for the development of an effective maintenance plan to mitigate or reduce likelihood of failure (see EN 60300-3-11).

4.3.3 Environmental impact

The assessment of durability has to be integrated with the assessment of the environmental impacts over the entire life cycle of an ErP (Life Cycle Assessment — LCA according to the ISO 14040 series). On the one hand the extension of the technical lifetime can reduce impacts due to the manufacturing and disposal of the product. On the other hand decreasing efficiency of worn-out products as well as technological progress embodied in new products can cause increase of environmental impacts with increased technical lifetime. Determining the optimal lifetime is therefore a crucial step for setting durability requirements. This step needs to be part of the scientific preparation process (preparatory studies) under the Ecodesign Directive.

4.4 Product durability and reliability analyses

Parameters affecting the durability include the stresses, the time and the capability of the component, assembly or product to withstand these constraints to function up to a defined limiting state. The stresses can come from various origins when any function is performed. The reference conditions for a component, product or assembly (See EN 62347) must be known in order to carry out a durability assessment.

Some parts can be tested under several conditions and with several samples in order to obtain reliability data as input for the durability analysis. Many electronic components can be found within available reliability handbooks (See IEC TR 62380).

When such data are not available for the entire product, additional testing and calculations should be carried out to better assess the durability parameters and gaining a better understanding of damage modelling through stress analysis.

Based on dependability analysis, durability and reliability analysis process could be summarized as follows:

1) Qualitative analysis

   i) Analyse the functional system structure (§ 4.2);

   ii) Determine system and part fault modes, failure mechanisms, causes, effects and consequences of failures (§ 4.3.2);

   iii) Determine degradation mechanism that may cause failures (§ 4.3.2);

   iv) Analyse maintainability with respect to time, problem isolation method, and repair method (§ 4.4.6 and for repair see standard xx *(WG3));*

   v) Determine the adequacy of the diagnostics provided to detect faults (§ 4.3.2);

   vi) Analyse possibility for fault avoidance (§ 4.3.2);

   vii) Determine possible maintenance and repair strategies, etc. (§ 4.4.6).

2) Quantitative analysis

   i) Develop reliability and/or availability models (§ 4.4.3);

   ii) Define numerical reference data to be used (§ 4.4.4);

   iii) Perform numerical dependability evaluations (§ 4.4 4 and Annex B).

Modelling of durability is ultimately an abstraction of reality. It is not possible to fully represent real life usage, and therefore it is important that this is made clear in communications around durability.

4.4.1 Define service conditions

The service conditions can be divided into two categories; normal service conditions and special service conditions. Both shall be defined in accordance with information on staying within the operating and environmental conditions. A profile of the operating and environmental conditions is required to assess the durability. It is defined by the extreme and average values and their associated duration for each life phase of the product.

4.4.1.1 Normal service conditions

Unless otherwise specified, products are intended to be used in accordance with their rated characteristics and in the defined normal service conditions. Operation under normal service conditions of a product should be covered by the tests detailed in the relevant product standard.

4.4.1.2 Special service conditions

When a product is expected to be used under conditions different from the normal service conditions (usually stronger conditions), the user requirements should be defined using information obtained from the relevant operating or environmental conditions if not provided by the product standards.

NOTE 1 Appropriate action should also be taken to ensure proper operation under such conditions of parts of the product such as components.

NOTE 2 Detailed information concerning classification of environmental conditions is given in EN 60721-3-3 (indoor) and EN 60721-3-4 (outdoor).

4.4.2 Define environmental and operating conditions

It is necessary to determine the operational and environmental loads that a product will experience throughout its life cycle including transportation, handling, storage, operation and maintenance (see EN 62308).

The influencing factors affecting each function should be identified to assess their impact on product durability. Using Annex A.3.3 as guidance, key influencing factors can be identified from the matrix relationships affecting the functions needed by the system.

It may not be possible to quantify all the necessary information regarding operational and environmental conditions. In these cases, engineering judgment may be required. If a condition is known, or strongly suspected to exist, it is usually better to estimate it than to ignore it.

Many of the relevant conditions may occur only in certain phases of the equipment’s expected life, such as storage, transportation (road with various infrastructure, shipping, air freight, etc.). It is important to determine or arrive at a credible estimate of the duration of such conditions.

4.4.2.1 Environmental conditions

The environmental stresses depend on the macro and micro locations of the studied component, assembly or product (geographical area, operating site, layout within a system, compartment of device, etc.) and are linked to the application of the use.

Any environmental conditions shall consider the following information, as relevant:

1) ambient temperature;
2) cycles of temperature (variations, time, expected total duration along life time);
3) variations of supplies such as frequency, voltage, as well capability such as power and cooling;
4) ambient humidity;
5) cycles of humidity (variations, time, expected total duration along life time);
6) ambient chemical contaminants, particles and deposit (NaCl deposit, SO2, NOx, O3, PM2.5, PM10,...);
7) electromagnetic field;
8) mechanical vibration due to transportation, earthquake, machines (acceleration, amplitude, frequency range, spectrum…);
9) any other environmental conditions that may cause failures (biological, fauna, etc.).

4.4.2.2 Operating conditions

Any operating conditions shall consider the following information, as relevant:

1) electrical stresses due to the operation of the equipment;
2) steady-state temperature due to self-heating;
3) temperature variations due to turning the equipment on and off;
4) shocks: vibration, drop, mechanical impacts;

5) moisture conditions due to humidity and condensation;

6) failure induced due to (lack of) maintenance;

7) any other stresses that may cause failures.

4.4.3 Stress analysis

4.4.3.1 Description and purpose

The stress-strength analysis is a method to determine capability of an item to withstand electrical, mechanical, environmental, or other stresses that might be a cause of their failure. These analyses determine the physical effect of stresses on an item, as well as its mechanical or physical ability. Probability of failure is directly proportional to the applied stresses. The specific relationship of stresses versus strength of an item determines the reliability of an item (component, assembly).

4.4.3.2 Application

Stress-strength analysis is primarily used in determination of reliability or equivalent failure rate of mechanical components. It is also used in physics of failure to determine likelihood of occurrence of a specific failure mode due to a specific individual cause in a component.

Component structural reliability, i.e. its capability to withstand electrical or other stresses, depends on its strength or load-carrying capability, where reliability is the probabilistic measure of assurance of the component performance. Determination of this load-carrying capability involves uncertainty; therefore, this capability is modelled as a random variable, as opposed to the applied stress which, for the same reason of uncertainty, is modelled as another random variable. The overlap of these random variables, when represented by a distribution, represents the degree of probability that the stress will exceed the strength, that is, the area of overlap of the respective probability density functions represents the probability of failure occurrence.

Evaluation of stress against strength and resultant reliability of parts depends upon evaluation of the second moments, the mean values and variances of the expected stress and strength random variables. This evaluation is often simplified to one stress variable compared to strength of the component In general terms, the strength and stress shall be represented by the performance function or the state function, which is a representative of a multitude of design variables including capabilities and stresses. Positive value of this function represents the safe state while negative value represents the failure state.

Stress analysis is performed for example by classical mathematical techniques, analytic mathematical modelling or computational simulation. Often it is conducted with some type of computer-aided analytical process, such as finite element or finite difference analysis, which are combined with investigation or field tests when possible. Investigation tests are some monitored tests carried out to assess a stress met by a product during a life phase or to investigate a product withstand. Certified laboratory is not required to conduct these assessments. Computational methods enable simulation of the behaviour of a component, assembly or product with combined variable input stresses covering wider stress cases than those met by typical testing and field conditions.

The results of this type of analysis are usually reported graphically, with the areas of greatest stress being highlighted in some easily detectable way.

4.4.3.3 Key elements

The key elements include a detailed knowledge of the component materials and construction, as well as other properties of interest as well as proper modelling of expected stresses.

4.4.3.4 Benefits

Stress-strength analysis can provide accurate representation of component reliability as a function of the expected failure mechanisms. It includes variability of design as well as variability of expected applied stresses, and their mutual correlation. In this sense, the technique provides a more realistic insight into effects of multiple stresses and is more representative of physics of component failure, as many factors – environmental and mechanical – can be considered, including their mutual interaction.

4.4.3.5 Limitations

In the case of multiple stresses, and especially when there is an interaction or correlation between two or more stresses present, the mathematics of problem solving can become very involved, requiring professional mathematical computer tools. Another disadvantage is possible wrong assumption on distribution of one or more random variables, which, in turn, can lead to erroneous conclusions.

4.4.4 Damage modelling

After the types, locations and magnitudes of the stresses are identified, their effect in causing wear-out failures is determined. This is done using damage models. Damage models are mathematical equations that predict how long a given item can withstand a given stress before failure due to wear-out.

Damage models also may be used in accelerated testing to estimate the behaviour of an item over a longer time at a lower stress level, based on its behaviour in a shorter time at a higher stress level.

As the name implies, damage models are useful for predicting wear-out failures due to the accumulation of damage caused by operating or environmental stresses. They are not applicable to failures due to overstress.

The main damage models (Arrhenius, Inverse power law, Eyring…) can be found in EN 62308 standard (Annex B - Durability analysis), EN 61709 standard (Reference conditions for failure rates and stress models for conversions) and EN 62506 standard (Methods for product accelerated testing) standards.

Damage models are, by nature, inexact. The most effective models will usually represent a compromise between the extremes of:

a) attempting to describe the situation so completely that they become so complex and data hungry that they are unusable, and

b) being so simple that they are inaccurate.

4.4.5 Available durability and reliability data based on experience

The number of systems in use may influence the choice of methods and tools used to implement dependability. If the number of the identical systems in use is high, the experience data feedback will be relevant and test data are often available. A low number of systems in use may result in a lack of data on failure of those systems. The choice of methods and tools to implement dependability may be limited. The need for a dependability demonstration may be necessary for verification. In this case probabilistic methods and tools for modelling and system simulation may be used.

Generally, data for calculation should be based on recognized sources of data, results obtained from operational experience on similar systems in the field, laboratory tests or from software/hardware integration.

The failure rate prediction can use similarity analysis, which includes the use of fielded (in-service) equipment performance data, as mentioned within EN 60300-3-1 standard.

The data should be collected according to the EN 60300-3-2 standard.

The analysis of data should use statistical and reliability methods. EN 60300-3-5 standard provides guidance on reliability test conditions and statistical test principles.

The assessment of durability could require an assessment of availability, in accordance with EN 61703 standard. Several availabilities definitions are existing being well defined by the standards. It is easier to assess any availability especially when field data are available, compared to a durability assessment.

4.4.6 Maintenance needs and considerations on repair

Maintenance and repair in general increase product reliability respectively durability performance. However, there might also be trade-offs between durability and reparability, as a design feature which supports durability and reliability could hinder easy repair.

The type and nature of a product will affect the durability specifications, and products can have varying degrees of reparability. For example, some may include maintenance action and planned exchange of ware-out parts as a normal part of use cycle and can usually be repaired, e.g. large technical systems. Others such as small household and ICT devices for example, may be harder to repair due to their size. Also, for such products, due to technological progress the cost of repair at a certain point in time might be higher than the residual value of the product and thus the option of repair may be rendered economically unattractive. The performance of a reparable product is greatly influenced by the product maintainability as well as the repair or maintenance strategies employed. When long-term provision of function is the critical requirement for a product, the performance measure of “availability” is the appropriate measure to evaluate the influence of maintenance and repair on product dependability. When continuous provision of function is the critical requirement, reliability is the appropriate performance measure.

Maintainability should be analysed with respect to time (duration, cycle & distance), problem isolation method and repair method in order to determine the possible maintenance and repair strategy. The adequacy of the diagnostics provided to detect faults should also be considered.

The standards on “Ability to repair, reuse and upgrade” and “Ability to re-manufacture” that have been published under CEN-CLC XXXXX series provide further guidance on the assessment of the reparability of ErPs. In the other way round, the durability and reliability analysis according to this standard can provide relevant information for the assessment process describes in the standard on “Ability to repair, reuse and upgrade”.

Modelling of durability is an abstraction of reality, because it is not possible to fully represent real life usage. Therefore the ability of a product to be repaired is important to secure reaching durability expectations beyond time to first failure.

4.4.7 Wear out parts and spare parts considerations

The showed examples could be different depending of the design architecture linked to the product specific standard and the manufacturer.

<For examples please check CEN-CLCTC10_WG02Sec00050DC (document limiting states v5-xls, sheet “ex consumables & wearing parts”), could be included as examples here?>

4.4.8 Precautions for longer lifespan and special service conditions

The durability of ErP is mainly linked to environmental and operating conditions. To achieve a longer lifespan optimization of these conditions is required expecting the damage modelling is linked to the technologies and product design and would not be changed. The optimization of the operating conditions is more linked to the behaviour of the user or the optimization of its application, and it can be difficult to influence them. However, the environmental conditions can be improved for longer lifespan when normal service conditions are met. Some precautions to reduce the effects from atmospheric conditions to any ErP can be applied as well as during the installation phase but also during the design phase. Examples are given in Table 1. Privilege to the passive precautions will be given avoiding any consumption of energy. The same precautions are applicable when special service conditions are met to recover at least the normal service conditions, which can always be improved.

Several phenomena could be met on ErP when no precaution are applied as follows and as non-exhaustive examples:

- Early ageing of synthetic materials,
- Early corrosion,
- Accelerated battery ageing,
- Over consumption of active ErPs….

Table 1 — Example of information linked to product durability and reliability analyses

	To reduce			
Precautions for any enclosure embedding electrical components, products, assemblies.	Pollution	Condensation	Temperature variation	Humidity
Draining system (Electrical room, substation…)		x		x
Air filtering (Filter adapted to the main pollutant…)	x			
Air conditioning (Moisture & temperature)		x	x	x
Sealing of cable entrances (Cellar, cable vault…)	x	x		x
Thermal insulation		x	x	
Absence of air flow through the electrical device	x			
Clearance between equipment and walls		x	x	
Thermal waste in separate compartment (transformers, engine…)	x		x	
Absence of fans	x			
Double layers air insulated enclosure (Canopy, ceiling + roof…)		x	x	
Optimization of the openings required for any cooling (forced or natural)	x		x	x
Optimization of the openings in polluted area (salty, industrial…)	x			
Improvement of the degree of protection (EN 60529)	x			
Orientation of the openings in relation to the pollution source	x			
Air flow		x	x	
Heating to maintain a stable temperature (Technical room)		x	x	

4.4.9 Summary of data and results of the durability and reliability assessment

After the functional analysis and the durability and reliability assessment the following results shall be available:

List of:

1) Relevant functions, subfunctions & components, products, assemblies;

   Any specific product standard shall classify their priority of functions which are different for each lot of ErP. As example as soon as the main function(s) is (are) fulfilled a function of the environmental performance should appeared targeting an eco-designed product.

a. Main functions of the product under safe operation, for an expected durability

b. Other functions should be sub-functions

2) Relevant parameters of dependability (durability parameters, reliability parameters);

a. Environmental and operating conditions

b. Durability (cycle, distance, duration)

c. Failure modes (see §4)

d. Failure rates: λ, MTTF, MTTFF, MTBUF, …

3) Typical limiting states, failures, and misuses;
   a. Limiting states:
      i. Any state reached from a required state after a failure (§3.2)
         1. Fault,
         2. No information about the product itself if the product is assumed to inform the user about its state

   b. Failures:
      i. Any event reaching a limiting state (§3.15)
         1. Broken component
         2. Welded electrical wire
         3. Flash over through electrical insulation material
         4. Any signal out of expected tolerance
            a. (measurement, consumption, LED brightness, LCD readability, environmental disturbance (noise, EMF,..))

   c. Misuses:
      i. Any use of ErP to carry a non-expected load
      ii. Any use or ErP out of its scope or its normal service conditions
      iii. Reasonably foreseeable misuse: use of a product, process or service in a way not intended by the manufacturer, but which may result from readily predictable human behaviour
         1. Use of hair dryer to dry clothes

4) Reporting durability analysis results

Typically, durability analysis results are reported as a list of likely failures, arranged chronologically from the shortest to the longest time to failure. From a reliability prediction point of view, only the shortest times to failure are of interest. This is because durability analysis predicts wear-out failures, which by definition are common cause; thus all the items will fail by the short time wear-out mechanisms (competing risks).

The type of information reported for durability analysis is not well established. At a minimum, the following information should be included for each failure.

i) **Time to failure.** This is usually a point estimate; however, the distributions of some failures may be known. It may be specified using a Weibull model. Often, suppliers state the time for a given percentage of failures as for example B10 (10 % failed) and B50 (average lifetime).

ii) **Failure site.** It is desirable to know which element of the design will fail. In addition to being useful as an input to safety analysis, this information could be useful to the designer in improving the design.

iii) **Failure mechanism.** This information also is useful for safety analysis and for design improvement

iv) **Failure-causing stress.** This information can be used to evaluate changes in the operating and environmental conditions to increase time to failure.

4.4.10 Durability and reliability assessment process improvement

As a process, a continuous improvement especially when integrated within a circular economy, is required.

Previous durability or reliability assessment results could be used to improve the later durability or reliability assessment processes, and are a source of information for improvement of the equipment throughout the equipment life cycle, however validations are required as follows to avoid misunderstanding of root cause of the limited states:

a) comparing calculated results from reliability assessments, e.g. expected lifespan, MTTFF (Mean Time to First Failure), MTTF (Mean Time to Failure), MTBUR (Mean Time Between Unit Repair), confidence intervals, time to failure, etc., with field data;

NOTE: mean operating time to first failure MTTFF is the calculation of the operating time to first failure, see also operating time to first failure (192-05-02). For non-repairable items, the MTTFF is also the MTTF.

b) comparing failure sites, modes, and mechanisms predicted by reliability assessments with those obtained from in-service data;

c) checking to ensure that all failures recorded are what might be termed ‘legitimate’; and

d) comparing in-service environmental, operating, and maintenance conditions with those assumed in reliability assessments.

With regard to a), it might be that a sudden surge in voltage on a power supply line (a primary failure) arising from the failure of a single component, might lead to many other failures (secondary failures). Unless there was some special reason to record secondary failures, such failures would normally be discounted. Other types of failure might also need to be discounted. For example, if the ambient temperature of a piece of equipment rises or falls well beyond design limits, and this in turn gives rise to failure of the equipment, such a failure might well need to be discounted.

With regard to b), care should be taken when comparing predictions with observed results. It is almost certain that predictions and observations will never agree exactly or even approximately in spite of the fact that the results of the prediction might be close to reality. This is because predictions are based mainly on mean values whereas observations seldom are.

4.5 Verification and test strategy

To verify if the durability and reliability goals will be met, the product functionality and product component tests or calculations shall be identified.

Results from analysis are likely to be less accurate predictions than the results obtained from testing in defined testing condition. However results from analysis are likely to be more accurate predictions than the results obtained from testing when a broad set of environmental and operations conditions must be verified, because any simulation covers wider combinations of constraints compared to the capability of testing conditions met in a laboratory. However testing results feed any analysis like the damage modelling, especially when they come from endurance tests. Therefore, ISO/IEC Directive 2 2016 §5.5, specifies stability, reliability or lifetime of a product shall not be specified if no test method is known which can verify the claim in a reasonably short time. If this condition is satisfied testing should be the preferred strategy.

When the duration of the test of the ErP is not practicable, the necessary information may be obtained by testing major subassemblies or components. Testing of components not yet built in in an ErP has the advantage to reduce test cycles, as a tested component may be used in several product models. However thereby the specific build in situation is not considered, which can have an effect on durability.

Tests shall be identified according to the following priorities:

1) test of the performance of the ErP

2) test of the performance of selected functions, subassemblies or components integrated in the ErP

3) test of assemblies or components performed, if not yet integrated in the ErP

In addition, the environment and operating conditions as well as use patterns of the product have to be taken into account when the tests are selected respectively developed. Thereby test conditions and test cycles shall as much as possible match with the real operation conditions. In cases where the test is performed close to the in-service conditions, the test will give a good estimate of the durability, but the test might last a very long time, require a large number of test items and the low number of failures will result in a large uncertainty in the durability estimates. If the test is accelerated, the sample size and the test time can be reduced. The larger number of failures will reduce the statistical uncertainty, but the technical uncertainty will be higher, since the accelerated test conditions can cause failure modes that are not relevant in the field. If accelerating factors are used, they should be chosen so as to avoid the introduction of failure mechanism which differ from those occurring in service, transportation and storage.

The test should be selected respectively designed to provide information on the following properties of ErP:

1) the ability to operate within specified environmental and operating conditions

2) if appropriate the ability to withstand conditions of transport, storage and installation

Tests shall especially address critical failure mechanisms and main failure modes. Durability testing within this standard shall primarily demonstrate a minimum failure free operation time respectively number of failure free cycles. In some cases this might only be possible with some degree of assurance. In such cases the confidence interval need to be stated.

In a first step it should be assessed, if appropriate tests are already available, e.g. reliability test, or if existing tests, e.g. environmental or safety test procedures can be adapted to the need of durability tests. If necessary, new tests shall be developed.

The tests shall be specified in terms of test parameters and if applicable test apparatus respectively arrangement and dimension of test equipment and a description how to conduct the test. Thereby the description shall be performance related rather than apparatus-dependent. The test shall be accompanied by a suitable sampling plan. The principles of dealing with uncertainties of the product life cycle and effects which cannot be simulated with the test shall be stated.

4.5.1 Accelerated tests

When accelerated tests can be carried out the EN 62506 standard should be applied, which provides guidance on the application of various accelerated test techniques for measurement or improvement of product reliability. Identification of potential failure modes that could be experienced in the use of a product/item and their mitigation is instrumental to ensure dependability of an item.

The object of the methods presented within the EN 62506 standard, is to either identify potential design weakness or provide information on item dependability, or to achieve necessary reliability/availability improvement, all within a compressed or accelerated period of time.

EN 62506 standard addresses accelerated testing of non-repairable and repairable systems. It can be used for probability ratio sequential tests, fixed duration tests and reliability improvement/growth tests, where the measure of reliability may differ from the standard probability of failure occurrence. This standard also extends to present accelerated testing or production screening methods that would identify weakness introduced into the product by manufacturing error, which could compromise product dependability.

The Figure 3 from the EN 62506 standard which has been modified to show the most appropriate accelerated testing methods type B and type C focussing to the useful lifetime under precaution as mentioned by the standard, could be applied.

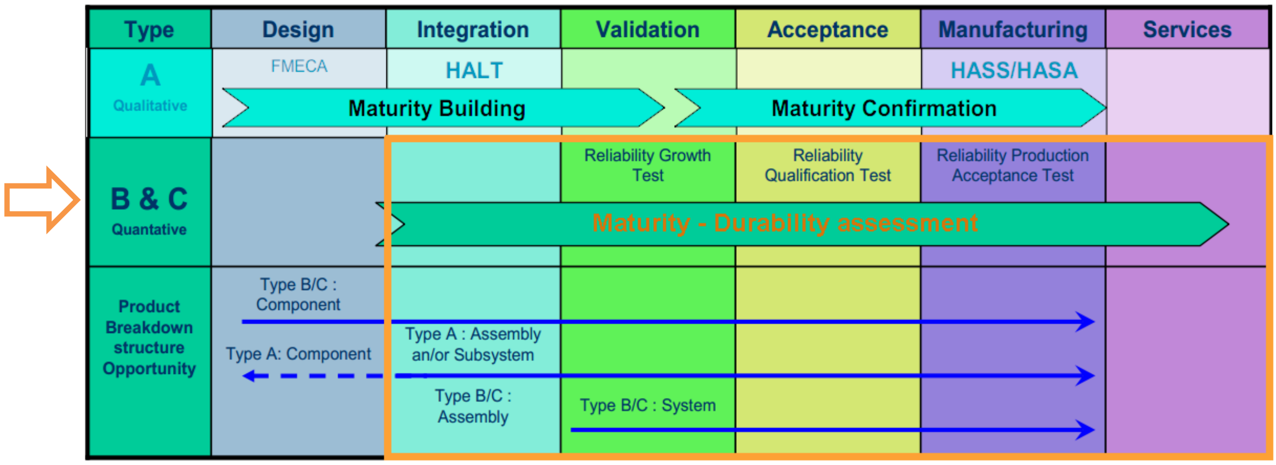


Figure 3 — xxx

There are two distinctly different approaches to reliability activities:

a) Type A: qualitative accelerated tests: for detection of failure mode and/or phenomenon;

It verifies, through analysis and testing, that there are no potential failure modes in the product that are likely to be activated during the expected life time of the product under the expected operating conditions;

b) Type B: quantitative accelerated tests: for prediction of failure distribution in normal use;

It estimates how many failures can be expected after a given time under the expected operating conditions.

Type B tests use cumulative damage methods to determine product reliability projected to the end of the expected product life. The necessary margin between the expected cumulative damage and the requirement produces a reliability measure. It is necessary to have a thorough understanding of the potential failure mechanisms and the operational and environmental stresses of the product or system. FMEA (See EN 60812) can be used.

The extent of acceleration, usually termed the acceleration factor (AF or A), is defined as the ratio of the life under use conditions to that under the accelerated test conditions.

Reliability growth testing

Verifying in-service reliability

c) Type C: quantitative time and event compression tests: for prediction of failure distribution in normal use.

Type C tests are mostly used for estimation of the life time of components where wear out in active use is the dominating failure mode; for example switches, keyboards, relays, connectors or bearings. The data from these tests are often analysed using the Weibull distribution, and often in the form of the so-called “sudden death test” (see EN 61649)

Time compression

Time compression is achieved by eliminating “OFF-time” (e.g. non-operating time) by compressing the duty cycle through addressing just the ON time.

With a relatively short test duration at nominal stresses, there is no reason to increase the stresses, and therefore, there is no need to determine stress acceleration factors; otherwise there is a risk of overstressing the units under test. Testing only under operational conditions would disregard the influence of non-operating environments which could be avoided (synthetic material ageing, corrosion, fatigue …)

Event compression

This tests can be combined with the compression tests and with the stress acceleration tests, however in both cases as the time compressions may influence the stress acceleration without material relaxation as example.

To summarize the purpose of quantitative accelerated tests type B and C, is to estimate one or more measures of reliability, e.g. failure rate, probability of failure or survival, or time to failure (TTF). Often the purpose of quantitative accelerated testing is to determine the life time of components with a limited life (wear out), or to determine (quantify) and improve the reliability of systems and components. For this, Weibull analysis is very useful (see EN 61649).

For a quantitative accelerated test (Type B and C test) the number of items are mainly determined by whether the purpose of the test is to estimate the average constant risk (exponential failure distribution assumed) or the purpose is to estimate the time to failure (life time) for the items.

For quantitative accelerated tests (Type B and C) the acceleration factor has to be estimated (see example in Annex A) to link the test time with the equivalent time in the field. Each failure mode has to be analysed separately. Therefore a failure analysis is required for all failures. Once an estimate has been made for each failure mode observed, the failure probability and time to failure can be added to estimate the failure probability of the product as a function of time. Statistical tools that can be used for analysis include the following standards: EN 61123, EN 61124, EN 60605-6, EN 61649, EN 62506 and EN 62429.

4.5.1.1 Determination of stress levels, profiles and combinations in use and test – stress modelling in a step by step procedure

The following procedure should be applied:

a) identify the relevant stress factors from the field, including storage and transportation (see the EN 60721 series);
b) determine which stress types have to be accelerated, which will be nominal and which can be omitted, e.g. because they are covered by other tests;
c) determine if the stresses can be applied simultaneously to include stress interactions or whether they will have to be applied sequentially, e.g. in a test cycle (see EN 60605-2);
d) determine if the acceleration factor (A) can be estimated from the test or estimate the acceleration factors based on relevant acceleration equations and relevant empirical factors;
e) determine the sample size (see EN 61649, EN 61123 and EN 61124);
f) perform the test (see EN 60300-3-5);
g) perform failure analysis;
h) analyse the test – each failure mode separately (see EN 61649, EN 61710 and EN 61124);
i) report test result (see EN 60300-3-5).

EN 62506 standard should be used for more detail about the quantitative test methodologies, using multiple stresses accelerations and life test (§5.7.2).

Annex A
(informative)

Dependability – Reliability – Durability

A.1 General

Any durability assessment is complex and requires a perfect knowledge of the studied part. There are several defined methodologies where the prediction for a part of its capability to withstand when facing to one or several stresses for a defined time, cycle, distance. These methodologies are the merging of the experience, physical and statistical aspects especially from domain where the risk must be mastered such as Aerospace, Civil engineering, Defense, Nuclear activities and where any controlling system must be secured.

These domains are covered by their own standardization and regulatory frameworks, where reference to IEC publications can be found. IEC publishes standards, technical reports and guides about “Dependability” through the technical committee TC56.

This clause has been built to introduce and explain the topic of dependability based from IEC/EN publications focussing to durability and reliability assessments of an ErP, and when possible using general examples.

A.2 Dependability

Dependability can be expressed in terms of the core attributes of availability, reliability, durability, maintainability and maintenance support that are tailored to application-specific functional and service attributes. This requires methodologies taking a functional approach to describe all functions intended to be covered by the product under certain environmental and operating conditions along its life cycle.

The dependability of an item is the ability to perform as and when required, and beyond this the IEC definition of dependability is used as collective term for the time-related quality characteristics of an item.

Dependability (192-01-22) includes availability (192-01-23), reliability (192-01-24), recoverability (192-01-25), maintainability (192-01-27), and maintenance support performance (192-01-29), and, in some cases, other characteristics such as durability (192-01-21), safety and security.

For the purpose of this document dependability will be the general domain taken as reference of standardisation to describe the reliability assessment embedding the durability assessment.

A.3 Reliability

The reliability of an item is different compared with the reliability of a measure as follows:

- The reliability of an item is the ability to perform as required, without failure, for a given time interval (time, cycles, distance run, etc.), under given conditions such as the mode of operating, stress levels, environmental conditions, and maintenance.

- The reliability of a measure is the probability of performing as required for the time interval (*t1*, *t2*), under given conditions such as the mode of operating, stress levels, environmental conditions, and maintenance.

The reliability is defined further based on data of failures under certain conditions. However, the reliability can be defined by assessing the failure modes, operating and storage conditions, and environmental conditions.

The ECEN 61709 defines the reference conditions for failure rates and stress models for the reliability of electric components.

A.3.1 Assessment criteria

Before introduction of the different schemas and examples of the limiting states, a shared understanding of states (Run – Fault) and events-transitions (Repair - Failure) is necessary.

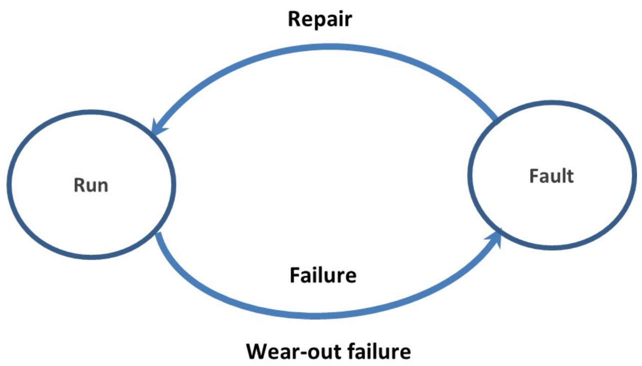


Figure 4 — xxx

The Figure 4 shows reliability limitations and Figure 5 several examples of limiting states for which a durability of a single item could be limited. Only two kind of limiting states have been used as example, respectively showing digital and analog signals, but sometime they could not be expressed as a signal such as example the pitting corrosion. The clause 4.3.3 explains how to identify the limiting state.

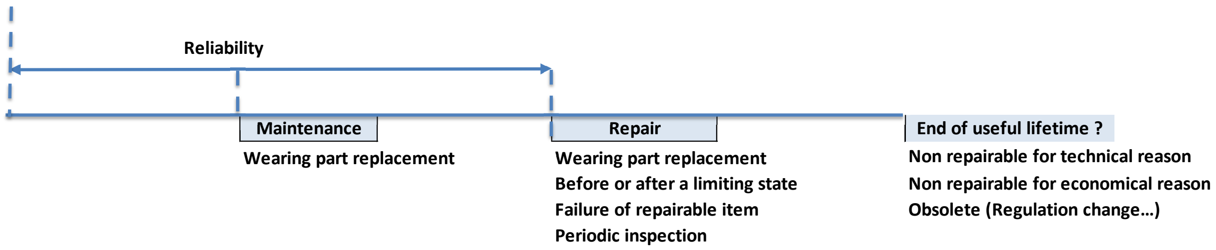


Figure 5 — Limitation of reliability

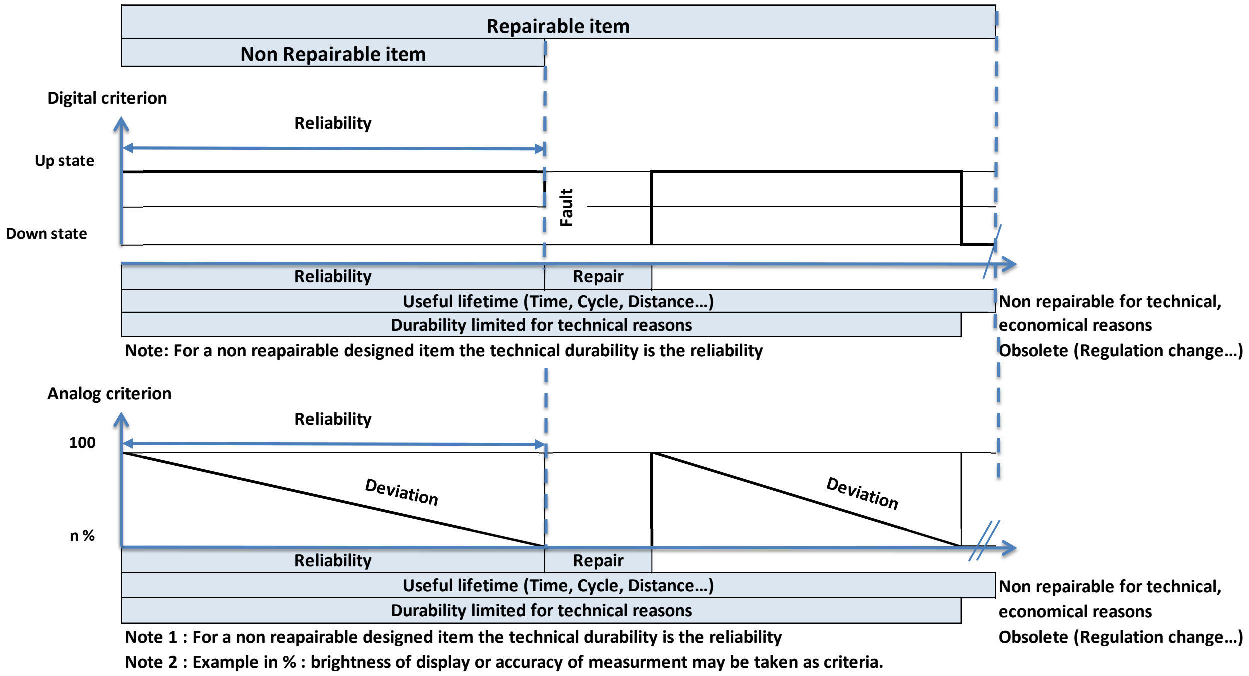


Figure 6 — Examples of limiting states

The Figure 6 shows an example which could be met for an ErP or for a function where the assessment criteria of the technical durability which avoid social and economic aspects, could be considered as equivalent of operating availability. The operating availability could be shorted by the lifespan of a component when facing to a stress in accordance with normal service conditions and ageing due to its failure modes.

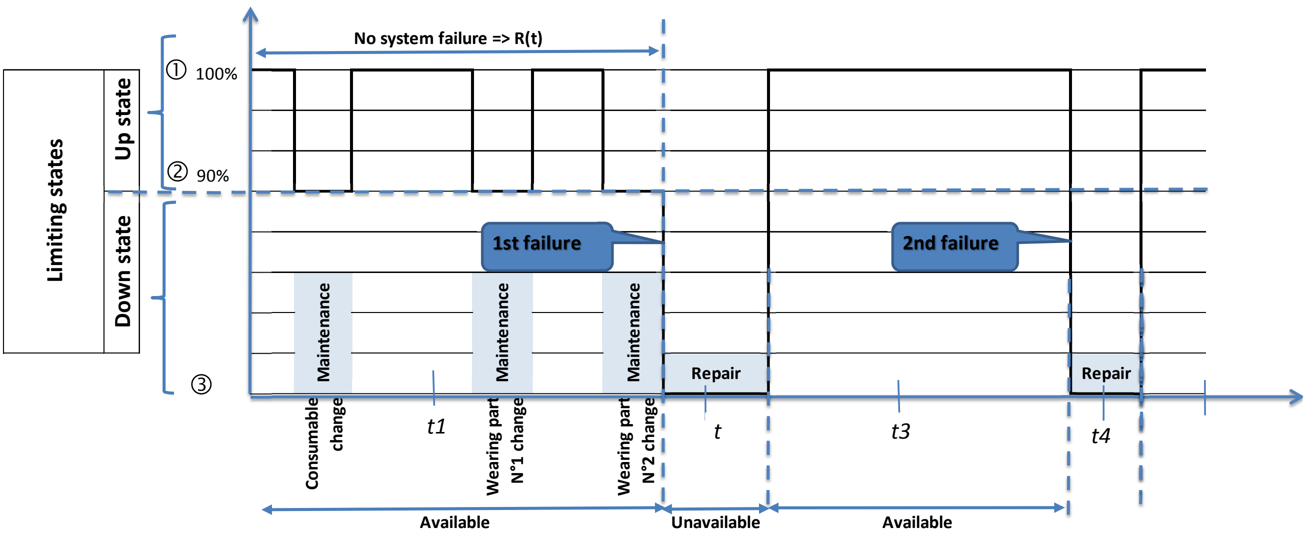


Figure 7 — Operating availability

To assess the operating availability the EN 61703 standard shall be used. The EN 61703 standard defines mathematical expressions dealing with reliability, availability, maintainability and maintenance support terms.

A.4 Durability

Durability is an aspect of reliability, related to the ability of an item to withstand the effects of time (or of distance travelled, operating cycles, etc.) dependent mechanisms such as fatigue, wear, corrosion, electrical parameter change, and so on.

The most appropriate definition of the durability of an item is its ability to function as required, under defined conditions of use, and maintenance and repair, until a limiting state is reached.

Being an ability, a demonstration of the durability should be required. This demonstration should identify if the technical criteria associated with a maintenance program will be able to fulfil the product functionalities and if the whole product will match with the expected lifespan. Non-technical criteria related to economic, regulatory framework, or aesthetic influences cannot be considered as it is not possible to evaluate these aspects (as defined by the IEC directive).

Clause 4.1.2 defines a procedure using a flow chart which is based on existing and applicable tools used for dependability studies, aiming to assess the robustness of a product over an expected duration.

Durability is usually expressed as a minimum time before the occurrence of wear-out failures. In repairable systems, it is often characterized as the ability of the product to function after repairs. Prerequisite definitions product parts should be shared to assume later different kind of limiting states of a product.

A.4.1 Durability analysis

A durability analysis is an analysis of the equipment's responses to the stresses imposed by operational use, maintenance, shipping, storage and other activities throughout its specified life-cycle to estimate its predicted reliability and expected life.

As the definition indicates, the results of a durability analysis are stated in expected time to meet a limiting state such as fault (which could become a failure when non-reparable), rather than as a failure rate or MTTF which is standard expression when defining a reliability.

Durability analysis is described within the EN 62308 standard. Before assessing the durability of a product a good knowledge of the functions it is intended to cover and its failure modes are required.

A.4.2 Functions

For this functional analysis techniques, can be used to optimize the choices during the design phases of a product or a sub-system. The functional analysis is used to identify the function of the product, to quantify the performance to be reached where the technical performance should be well balanced to respect a conscious design regarding the impact to the environment.

The main prerequisite of any functional analysis impacting a durability analysis shall be to define the profile of the operating and environmental conditions. The normal service conditions usually are a list of defined constraints within a product specific standard reflecting standardized values surrounding the product for an expected application and operation. When these conditions are not normal, the constraints could be specified as special service conditions. The service conditions are usually checked when a product is designed for an application and should be used for others. As example of application we can find home, building, industrial, marine...

To initiate a functional approach the EN 62347 standard specifies influencing factors for evaluation of system functions applicable to ErP, as shown in Table 2.

Table 2 — Influencing factors for evaluation of system functions

	Influencing conditions								
	Task requirements	**Human interaction**	**Process**	**Environment**	**Environmental**	**Support services**	**Utilities**	**Interacting system**	**Other factors**
Influencing factors	Nature of tasks	Command authorized	Input / output	Temperature	WEEE	Maintenance	Power	Boundary	Economic constraints
	Scope	Unauthorized Interaction	Modes	Humidity	RoHS	Documentation	Fuel	Protocol	Regulatory constrains
	Duration	Job-defined interaction	Stages	Vibration	REACH	Technical support	Energy	Interference	Technical novelty
	Sequence	training	Cycles	Shock	Footprint	Spare parts	Public utilities	Dependency	Novelty of operation
	Mode of Operation	skills	Failure modes	Pressure	Circularity	Special tools	Private utilities	Interoperability	Complexity
	Start-up	Interfaces		Radiation (EMC)	Energy efficiency	Maintenance access	Communications	Cyber-security	Number of systems
	Normal operation			Contaminations	Decarbonization	Levels of support			Degree of redundancy
	Emergency operation			Storage	EMF - Radio (RED)				
	Shut-down			Transports	Noise				

A.4.3 Service conditions

The IEC/GUIDE 106 specifies environmental conditions for equipment rating. Basic environments for stationary use at weather protected locations, as defined and in accordance with the EN 61709, is insensitive to the weather outdoors and humidity is controlled within defined limits. This is typical of telecommunications and computer equipment placed in buildings. This includes office situations.

A.4.3.1 Example:

The classification E1 in accordance with the IEC 61709 2011 mentions environmental conditions by several parameters and severities such as 3K3 for classification of a climatic conditions 3M3 for the mechanical conditions, in accordance with IEC 60721-3-3 2002, which could be specified as normal service conditions:

Low air temperature: +5°C
High air temperature: +40°C
Low relative humidity: 5%
High relative humidity: 85%
Rate of change of temperature: 0.5°C/min
Condensation: No
Solar radiation: 700W/m²

If a specific product standard is expected to refer to the normal service conditions as defined by 3K3, and if the product is intended to be used for a climatic condition 3K4, the services conditions becomes special.

Low air temperature: +5°C
High air temperature: +40°C
Low relative humidity: 5%
High relative humidity: 95%
Rate of change of temperature: 0.5°C/min
Condensation: No
Solar radiation: 700W/m²

As example a product could refer to the classification 3K3 when it is on loaded and used. A same product could refer to 1K2 according to IEC 60721-3-1 if stored on same normal conditions or stronger conditions being off loaded when stored. In any case the storage conditions shall be specified.

The used product could be designed to an environmental condition at 3K4 or stronger classification.

The operating conditions are defined by the conditions coming from the environmental conditions combined with the additional stress brought by the components of the product and its application during operation life phase.

If the product is asked to be used under special service conditions some precautions shall be applied to recover the normal service conditions

A.4.4 Stress analysis

The stress analysis is explained in the main part of this document, however the informative annex will highlight the importance of this phase continuing examples, as follows:

Low air temperature: +5°C with a tolerance of 0 °C +2 °C: 10 days / year
Average air temperature +20°C: 345 days / year
High air temperature: +40°C with a tolerance of -2 °C 0 °C: 10 days / year

This kind of definition could not be enough accurate to assess a durability based on damage modelling even if in Europe mainly temperate climates are met according to IEC 60721-2-1.

As example the Figure 8 shows two curves of temperature distribution lower than 20 °C as yearly average of two temperate climates met in Europe such as Stockholm (Sweden) and Malaga (Spain), which will be influenced by the building construction, internal waste and all device influencing the temperatures surrounding the ErP.

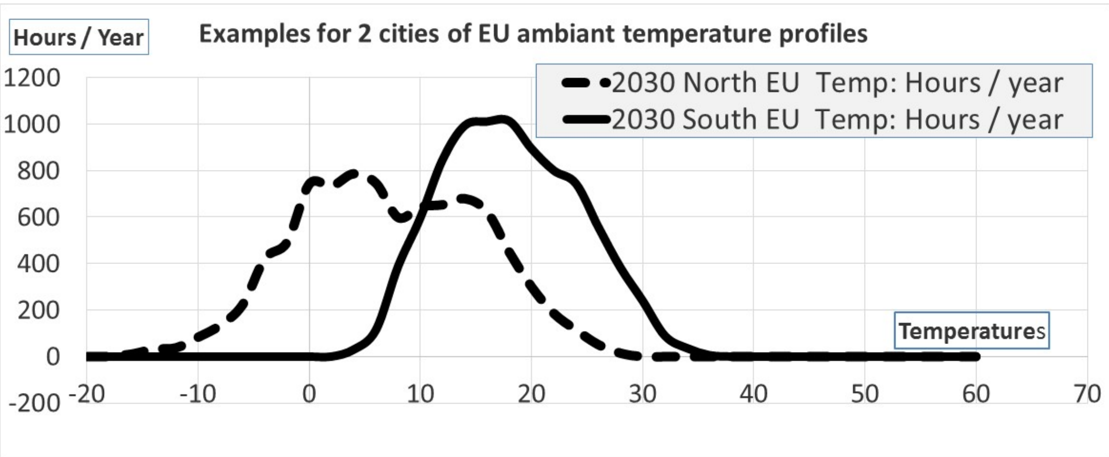


Figure 8 — xxx

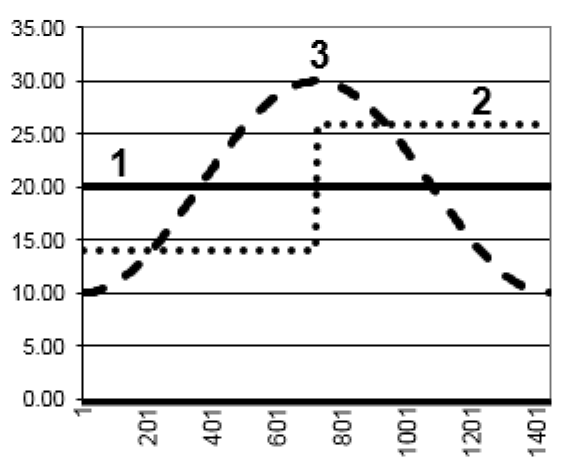
The installation of the device shall be carried out in accordance with the manufacturer installation guide.

A.4.5 Damage modelling

As mentioned above the ageing is influenced by a lot of parameters, and any product and technology should be analysed to define the energy of activation. The energy of activation is required by a lot of damage models as mentioned within EN 62506, EN 62308 and EN 61709 standards.

As a basic example Figure 9 highlights the importance of accuracy of the input data. The case is 3 temperatures as examples of environmental conditions and it shows the effects to the failure rate factor if Arrhenius model is applied in accordance with following conditions: Energy of activation Ea is assumed at 0.9, the verification test is 40°C when the material is assumed to be used at 20°C as average, for a same period. The result would be the same for different periods (Days, week, year, lifetime…)

Temperatures (° C) / day (min)			Failure rates factor: 1 / Af		
Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
20.00	20.00	19.99	0.10	0.13	0.14
Ambiant air fixed value 20°C	Ambiant air 2 thresholds 14°C & 26°C	Ambiant air daily variation	$\frac{\lambda(\text{Test})}{\text{Af}}=\lambda(\text{Use})$ MTTF (use)= Af * MTTF (test) Arrhenius: Ea* = 0.9 ev & θ (Test) = 40 °C 1 / Af =		



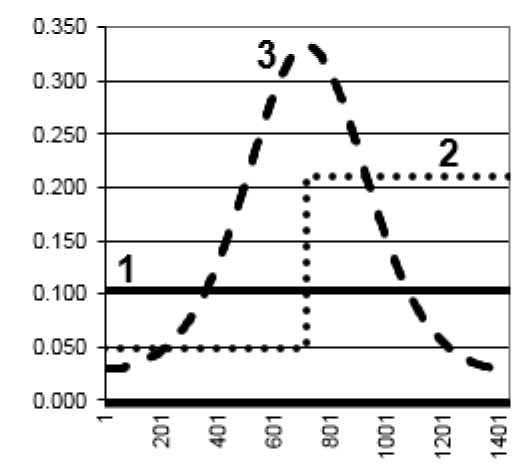


Figure 9 — xxx

Annex B
(informative)

Functional analysis

B.1 Functional analysis approach

Function Analysis involves identifying functions, validating them with the help of clear logical elements and characterizing them. This approach enhances communication to obtain a common understanding between the team members as to the project fundamentals

Functional analysis is used to:

- identify the functions of a product;
- quantify the performances to be reached;
- act as a means of improved communication between those involved in the definition, the durability analysis.

The term user shall not be limited to the end user alone, even if the latter is often the principal user of the product. Functional analysis shall identify and consider as users all those who, for each of the phases of the product's life cycle, have particular requirements or expectations with regard to the product.

Function Analysis is a process that results in a comprehensive description of the functions and their relationships, which may be systematically characterized, classified and evaluated. The function model is the result of Function Analysis. It may be represented by diagrams which provide a common understanding by the working group of the functional performance.

The function model may be represented by diagrams which provide a common understanding by the working group of the functional performances. Functional analysis implies working through multidisciplinary team.

There are two types of functions:

1. User related function: that the product does during its whole life cycle (it is the **what for?**) or expected to be satisfied. (it can be met as service function or external function)
2. Product related function: that describes the internal actions of the product to work out the answer to the need (it is the **How**?) (it can be met as technical function or internal function)

General process:

- Identifying and listing all the functions to complete the purposes for all life phases of the product, using verb specifying the nature of the action and the noun of the element for which the verb is applicable.
  - Method of interaction with the product surrounding as defined within EN 12973 standards helps the function definition. Figure 10 gives a non-exhaustive example for an operational phase of a product.
  - Some interactions could be linked through the product
- Organizing the functions (Table, tree….)
- Characterising the function by their performance and limitation
  - Define the risks
  - Define durability objective
  - Define limiting states (up or down states or continuous state which is over an acceptable limit)
  - Define maintenance and repair strategy
- Setting the function in a hierarchical order by importance of the users
  - This phase is more relevant for design phase which is part of the product specific standard, compared to its added value for durability assessment.
  - The main function …"for the expected lifetime" should be the highest priority

- The whole environmental performance and its lowest priority compared to the secondary functions should be specified by the specific product standard.
  - Manufacturers could make the choice to classify environmental performance at the main priority.
- This classification helps to identify the functions for which the priority of the reliability and durability analysis should focus.

B.2 Usual FA techniques

Different methods are used for the various phases of the overall process of FA, from the listing to the evaluation of functions. We examine below the methods which are most frequently used:

B.2.1 Natural or intuitive search;

This method is more appropriate when there is an existing product without new technology.

B.2.2 Method of interaction with the external environment;

This method is interesting to define the main and secondary functions by life phase.

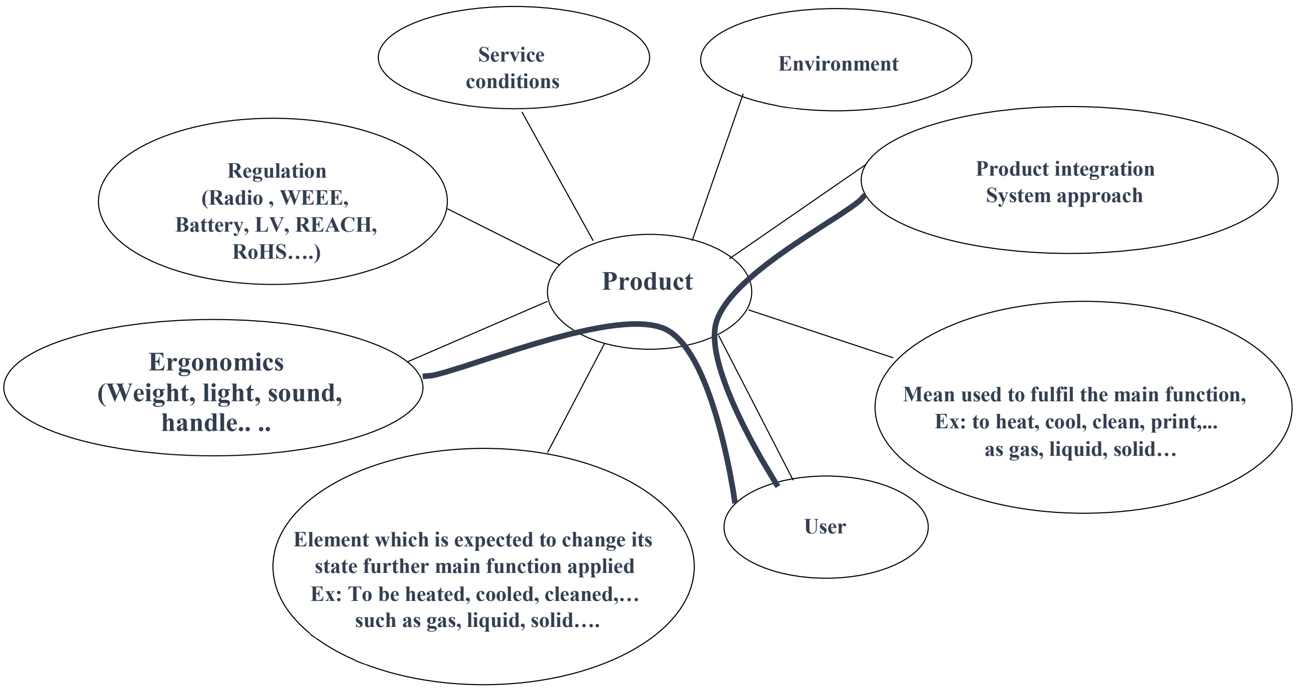


Figure 10 — xxx

B.2.3 Function Analysis Systems Technique (FAST);

The technical FAST as described within the EN 12973 standard is a common structured methodology which could be used to fulfil the functions during the design phase of the product and will be useful to identify how these functions should be verified.

B.2.4 Other FA techniques such as the Structured Analysis methods.

B.2.5 Technical specification

This phase is achieved when durability assessment is carried out. It is a document required before the design phase within the life cycle.

Any complete functional analysis enables to share a common understanding about the product performance, how those performances can be achieved and how they can be verified, embedding constraints coming from regulatory framework.

In addition functional analysis enables to built or complete the product technical specification and associated verification and validation testing program.

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