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**General methods for the assessment of the ability to repair,
reuse and upgrade energy related products**

Méthodes générales pour l'évaluation de la capacité de
réparation, réutilisation et amélioration des produits liés à
l'énergie

Allgemeine Verfahren zur Bewertung der Reparatur-,
Wiederverwendbarkeit und Upgrade-Fähigkeit
energieverbrauchsrelevanter Produkte

This draft European Standard is submitted to CENELEC members for enquiry. Deadline for CENELEC: 2019-01-25.

It has been drawn up by the Technical Committee CEN/CLC/JTC 10. If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document [prEN 45554:2018] has been prepared by CEN/CLC/JTC 10 “**Energy-related products - Material Efficiency Aspects for Ecodesign**”.

This document is currently submitted to the CENELEC Enquiry.

The following dates are proposed:

- latest date by which the existence of this document has to be announced at national level (doa) dor + 6 months
- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) dor + 12 months
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) dor + 36 months (to be confirmed or modified when voting)

The dual logo CEN-CENELEC standardization deliverables, in the numerical range of 45550 – 45559, have been developed under standardization request M/543 of the European Commission and are intended to potentially apply to any product within the scope of the Directive 2009/125/EC concerning Energy-related Products (ErP).

Topics covered in the above standardization request are linked to the following material efficiency aspects:

- 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

These standards are general in nature and describe or define fundamental principles, concepts, terminology or technical characteristics. They can be cited together with other product, or product-group, standards, e.g. developed by product technical committees.

This document is intended to be used by technical committees when producing horizontal, generic, and product, or product-group, standards.

Note CEN/CENELEC/JTC 10 is a dual logo TC, and uses either CEN or CENELEC foreword templates, as appropriate. The template for the current document is correct at the time of publication.

75 Introduction

76 As ErPs can often not be completely recycled and the benefits associated with material recovery cannot fully
77 compensate the energy (and material) demand of the whole production chain, each disposed ErP also means
78 losses in energy and materials. In particular, precious and special metals are currently recycled to a very limited
79 extent and plastics are mainly used for energy recovery. Therefore, prolonging useful life by repair and re-use
80 are relevant contributions to resource efficiency of ErPs.

81 In order to ensure that measures do indeed reduce the environmental impact related to an ErP, the entire life
82 cycle needs to be considered. In the case of prolonging useful life this includes for example the evaluation of
83 trade-offs between longer lifetime and reduced environmental impacts of new products. Whilst such aspects
84 establish a relevant context for this document, they are not addressed in this document.

85 In this document, common elements for reparability, reusability and upgradeability such as an evaluation of the
86 ease of disassembly are addressed at a part and product level. Quantitative (index-related) evaluation and
87 qualitative (checklist / scoring based evaluation) options for assessment of reparability, reusability and
88 upgradability are considered.

89 The decision whether a product should be repaired, reused or upgraded or not, may be dependent on a range
90 of factors such as hazards or hygiene issues on the one hand, or economic, legal and environmental aspects
91 on the other hand. However, the question of whether a product should or should not be repaired, reused or
92 upgraded is outside of the scope of this document.

93 This document is especially linked to the generic documents on “Durability” and “Ability to re-manufacture”,
94 prEN 45552 and prEN 45553, respectively.

1 Scope

This document provides generic methods to assess the following aspects:

1. the ability to repair products
2. the ability to re-use products, or parts thereof
3. the ability to upgrade products

It includes generic criteria and methods relevant for assessing the ability to access or remove certain parts from products for the purpose of repair, re-use or upgrading.

NOTE Abilities to refurbish and re-manufacture are covered in prEN 45553:2018.

The criteria and methods in this document focus on the design of the product and related conditions when the product is placed on the market, taking into account knowledge of parts that are likely to fail, need replacing, or have re-use potential.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

prEN 45559, *Methods for providing information relating to material efficiency aspects of energy-related products*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

Note prCEN/CLC/TR 45550, which is currently under development, contains additional definitions related to Material Efficiency of ErPs.

3.1.1

part

hardware, firmware or software constituent of a product

3.1.2

disassembly

process whereby a product is taken apart in such a way that it could subsequently be reassembled and made operational

[SOURCE: IEC 62542 definition 6.1, modified by changing “an item” into “a product” and deleting the note]

3.1.3

re-use

operation by which products or parts that are not waste are used for the same purpose for which they were conceived by another user

Note 1 to Entry: the transfer of ownership is essential part of the concept of re-use

3.1.4**repair**

process of returning a faulty product to a condition where it can fulfil its intended use

3.1.5**upgrade**

process to enhance the functionality, performance, capacity or aesthetics of a product

Note 1 to entry: upgrade may involve changes to the software, firmware and/or hardware

[SOURCE: IEC 62075:2012, definition 3.23, modified by the addition of Note 1 to entry.]

3.2 Abbreviations

The following abbreviations have been used in this document:

ErP	Energy-related Product
MTBF	Mean Time Between Failures

4 How to use this document

This document provides assessment types and criteria that shall be considered when developing product-specific methods for assessing the ability to repair, reuse and upgrade of ErPs. It is general in nature and provides options allowing for the selection of assessment types and criteria as appropriate for each product group. The options, list of criteria and their classification provided in this document are not exhaustive. The user of the document can decide not to implement certain assessment types or criteria, when developing product-specific assessment methods. The relevance of each criterion and appropriateness of a classification for a specific product group shall be assessed on product-by-product basis according to the characteristics of the product group.

The document addresses the prioritization of parts and lists criteria that influence repair, re-use, upgrade. A description and classification is provided for each criterion in Annex A. References linking each repair, re-use, upgrade criterion in the main text with its description and classification in the Annex are provided in sections 6 and 7. Further ways of assessing repair, re-use, upgrade quantitatively are also provided in Annex A.

There is considerable overlap in terms of prioritization of parts and criteria among the three aspects this document addresses (repair, re-use and upgrade). Therefore, in order to facilitate their presentation, the aspect of repair is used as a basis when presenting methods and criteria, and separate subsections address specificities related to re-use and upgrade.

This document contains the following assessment types:

- Semiquantitative assessment, i.e. individual or combined classification of criteria associated with the product, and
- Quantitative assessment, i.e. numeric measuring of the degree to which a criterion is addressed in the product (e.g. indices)

Qualitative assessment is also possible, i.e. evaluating the existence of specific criterion associated with the product without classification or combination of criteria. As this can be readily derived from a semiquantitative assessment, this approach is not elaborated separately in this document. However, the criteria described in Annex A may be used as a basis for such approaches.

The user of the document shall also provide a method to verify the assessment.

5 Identification of parts to be assessed

5.1 General considerations

In order to simplify the assessment, a prioritization of parts may take place because not all parts will be equally prone to be repaired, re-used, or upgraded. Therefore, not all parts need to be assessed.

In order to identify priority parts, all parts shall be considered. If priority parts are identified, the assessment described in the Clauses 6 and 7 applies to these priority parts only.

Therefore, to assess the ability of a product to be repaired, re-used or upgraded the user of this document shall either:

1. establish a list of priority parts based on
 - a. available information or
 - b. criteria as defined in section 5.2, or;
2. establish criteria on how to define priority parts, or;
3. do a combination of both.

For the above, at least the following sources of information shall be considered (as available):

- regulations
- product manufacturers
- parts manufacturers
- repair or maintenance organizations
- re-use organizations
- consumer organizations
- scientific literature and study reports

The lists established for assessing the ability to repair, re-use and upgrade might need to be different from each other.

The relevance of having a part replaceable or upgradeable is highly dependent on the likelihood that such a replacement is needed for repairing or upgrading the product.

For the assessment of priority parts, technological differences amongst products of a product group should be considered, because different technologies that realize the same function might have completely different relevance with regard to reparability, re-usability and upgradability.

Example Electric motors that last below X hours

5.2 Assessment of the relevance of parts

5.2.1 Repair

Evaluation of parts for repair should focus on the average occurrence of failure of the part.

Relevant data shall be considered that allows assessment of the likelihood that parts fail making replacement or repair necessary. Data may be based on statistical surveys, calculations (e.g. MTBF) or experimental data. Part failure, accidental breakdowns and normal wear-out shall be considered. More details can be found in the standard dealing with durability assessment methods in prEN 45552.

5.2.2 Re-use

If deemed appropriate, the parts prioritization for the assessment of reusability of products should follow the criteria for repair. If applicable, parts potentially enabling the transfer and deletion of personal data should be classified as priority parts.

For the assessment of reusability of parts, the user of the document may follow the general considerations in 6.3. so as to develop a list of priority parts.

5.2.3 Upgrade

The evaluation of parts for upgrade is expected to focus mainly, but not exclusively, on parts subject to rapid technological changes or changes in use profiles over the use phase of the product.

In order to identify priority parts for upgrade purposes, the following should be considered from the sources listed in 5.1:

— Typical upgrade features and frequency of upgrade

— **Product replacement motivations:** The recurring motivations for replacing a still functioning product (i.e. motivated by increasing performance or functionality demands).

— **Repair to upgrade options:** The priority parts for repair are analysed for their potential to be replaced with enhanced functionality or capacity.

5.3 Ranking parts in a priority parts list

When establishing a list of priority parts, it shall be considered to rank or weight the parts according to the criteria defined under 5.2 in terms of enabling repair, reuse and upgrade respectively. The ranking of priority parts shall be used to weight the assessment results as described in Annex A.1.13.

6 Product-related criteria

6.1 Introduction

This clause gives an overview of the product criteria that shall be considered in the course of writing product-group specific standards. The criteria listed in this and the following clause may be compiled in a product-specific assessment method.

These criteria are elaborated in Annex A, also providing an example of a scoring system for the semiquantitative and quantitative assessment of repair, re-use and upgrade, which provides a basis for the development of product-specific methods.

The criteria listed for repair might also be applicable for the other two aspects. Similarly, for any of the three aspects assessed, the other two may also have an influence and may be considered.

6.2 Repair

A non-exhaustive list of criteria influencing repair is provided in this section. When defining a product-specific assessment method, the user of this document shall consider the criteria below.

- Disassembly sequence and depth (A.1.2)
- Fasteners (A.1.3)
- Tools (A.1.4)
- Working environment (A.1.5)
- Skill level (A.1.6)

A list of tools most commonly used for repair purposes in general, regardless of the specific product being repaired is provided in Table 3 of A.1.4. If the category of Basic Tools is used in the assessment of a specific product group, then the list in Table 3 shall be used.

6.3 Re-use

Re-use can apply to both a product and a part. The ability to re-use a product or a part is predominantly influenced by its ability to withstand wear and tear, which may be assessed according to EN 45552. The ability to re-use is also influenced by the ability to repair and the ability to upgrade.

For some products, the ability to be re-used may be determined by the ability of user data to be transferred and deleted (A.1.11), and factory settings to be restored (A.1.12).

It should also be noted that reliability and durability assessments of the part are relevant.

6.4 Upgrade

The upgradability of the product can be assessed based on the ability to add or replace one or more priority upgrade parts. For assessing the upgradability of products, the criteria referenced in Clause 6 should be followed. Specific attention however should be given to the role of software and firmware. The ability to upgrade a product might have a positive impact on the likelihood that a product is re-used.

7 Support-related criteria

7.1 Introduction

This clause provides an overview of the support-related criteria that shall be considered in the course of writing product-group specific standards. The criteria listed in this and the previous clause may be compiled in a product specific assessment method.

NOTE Manufacturer support is limited to services provided and/or authorized by the manufacturer.

These criteria are elaborated in Annex A, also providing an example of a scoring system for the semiquantitative and quantitative assessment of repair, re-use and upgrade, which provides guidelines for the development of product-specific methods.

7.2 Repair

Next to the assessment of the product-related criteria specified in Clause 6, the support provided by manufacturer for repair should be assessed based on the declaration of the manufacturer or publicly available information of the manufacturer. A non-exhaustive list of support-related criteria influencing repair is provided in this section. Some of these criteria are also relevant for re-use and upgrade. When defining a product-specific assessment method, the user of this document shall consider the criteria below:

- Diagnostic support and interfaces (A.1.7)
- Availability of spare parts (A.1.8)
- Types and availability of information (A.1.9)
- Return models (A.1.10)

7.3 Re-use

To a large extent, the ability of products to be re-used is dependent on the ability to be repaired and/or upgraded. Support-related criteria for repair and upgrade are therefore also relevant for re-use.

Specifically for re-use, all criteria of manufacturer support that enable the transfer of ownership are relevant, including information, tools and services offered by the manufacturer to facilitate identification of the product or

part, the ability of data to be deleted and/or transferred or factory settings to be restored. (A.1.9, A.1.11. and A.1.12)

7.4 Upgrade

Upgradability of the product can be assessed in terms of manufacturer support based on the availability of parts for upgrade (rather than spare parts) as well as the availability of supporting information and software and firmware support.(A.1.8 and A.1.9)

8 Reporting reparability, re-useability and upgradeability aspects

8.1 General

The user of this document shall ensure that their product-specific assessment methods include requirements for reporting material efficiency aspects as follows:

- The assessment of the product(s) / product group's <XXX> ability to be repaired, re-used and upgraded shall be documented in a report.
- The data sensitivity level of the assessment report itself, and parts thereof, shall be determined by the user of this document in accordance to prEN 45559 and the different target stakeholder.
- Special care shall be taken to demonstrate transparency and the correlation between information on the results of the assessment and the input data and assumptions used.

8.2 Elements of the assessment report

The product or product-group standard writers shall ensure that their standard(s) sufficiently cover that when reporting material efficiency aspects results, data, methods, assumptions, limitations and conclusions shall be completely and accurately reported.

The report shall follow the following structure:

A. General aspects:

1. Instigator of the assessment
2. Date of report, place, etc.
3. List of standards applicable to the assessment

B. Scope of assessment:

1. Description of product assessed
2. Description of cut-off rules applied

C. Input data and approach for the assessment of the material efficiency topic:

1. Description of data and other information used/needed for the assessment
2. Calculations or scoring when relevant
3. Methods or tools used in the assessment

D. Output of the assessment:

1. Result of the assessment covering a list of qualitative and quantitative material efficiency content that could be reported for different stakeholders
2. List of applicable references (including standards, requirements and policies)

Annex A (informative)

Assessment methods for repair, re-use and upgrade

A.1 Semiquantitative assessment

A.1.1 Introduction

A semiquantitative assessment enables the evaluation of products in relation to one or more repair, re-use, upgrade criteria of relevance. This can be performed following these steps for each of the aspects (repair, re-use, upgrade):

1. Determination of priority parts for the assessment
2. Identification of relevant criteria and applicable categories for each priority part
3. Assignment of a ranking/classification score to each criterion for each priority part based on evaluation criteria.
4. Calculation of aggregate result for the product assessed, taking into account each criterion for each priority part

When defining assessment procedures to determine the ability of a specific type of product to be repaired, reused or upgraded, the user of this document should consider all classes, specify suitable ones for each criterion, and assign numeric scores to replace the letter of each class. The higher the score the better the repair, re-use, upgrade associated with that criterion. Scores of single criteria can also be normalized, weighted and aggregated into a single rating score or thematic indices (e.g. design characteristics and service conditions). The rating can be expressed in a numerical, alphabetical or other manner.

NOTE Applicable criteria and categories can be selected and weights can be assigned if some aspects are considered to be more important, for instance to allow for the reflection of the differences between products.

Further guidance for the evaluation and rating of the criteria reported in Clauses 6 and 7 is provided in the following sub-sections.

A.1.2 Disassembly depth

The disassembly depth is the number of steps required to remove a part from a product. The analysis of disassembly depth is fundamental to assess the effort required to access and/or replace priority parts as relevant. When defining product-specific assessment methods, the user of this document can specify what constitutes a step.

If fasteners are not visible, the disassembly sequence may require further steps to locate the fasteners such as removing stickers or finding disassembly instructions.

The disassembly sequence is necessary to assess the disassembly depth. It is the order of steps needed to remove a part from a product (which might include getting access to fasteners). The disassembly sequence to access priority parts is provided preferably by the manufacturer.

A score according to the number of steps could be assigned to this criterion for each priority part according to the following formula:

$$S_{depth,i} = 1 - \frac{DD_i}{DD_{ref}}$$

where

— $S_{depth,i}$ is the disassembly depth score for the priority part i

— DD_i is the depth for the part i

— DD_{ref} is the reference depth for the product group specified at product-specific level

A.1.3 Fasteners

Fasteners and connectors play an important role in the disassembly of a product. Fasteners are closely interlinked to the assessment of necessary tools and skills for repair, re-use or, upgrade. The number of fasteners and their visibility may be used as a proxy for the time needed to repair or upgrade a product. For the assessment of fasteners, important criteria are the reversibility and the re-usability of fasteners.

The type of fasteners could be assessed as follows: the assessment is done for each priority part and the results should be summed up to an overall score. The following types should be considered for the classification of fasteners:

Table A.1 Classification of fastener types

Category Description	Class
Reusable	A
Removable	B
Neither removable nor reusable	C

The various classes of fasteners are described below:

- **Reusable (class A):** An original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process.
- **Removable (class B):** An original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly (in case of repair or upgrade) or re-use of the removed part (in case of re-use) for a repair, re-use or upgrade process.
- **Neither removable nor reusable (class C):** An original fastening system which is not removable and non-reusable, as defined above, for a repair, re-use or upgrade process.

A.1.4 Tools

Tools necessary for repair are determined by the product design and are therefore an objective characteristic of the product. Repair, re-use or upgrade processes can, therefore, be classified according to the tools necessary to carry them out. Table A.2 gives an overview of process classification by necessary tools.

Processes corresponding to class A entail less constraints with regard to the variety of feasible repair scenarios than processes corresponding to class B, etc. Not all classes may apply to every type of product.

Table A.2 — Process classification by necessary tools

Category Description	Class
Feasible with basic tools	A
Feasible with product group specific tools	B
Feasible with other commercially available tools	C
Feasible with proprietary tools	D
Not feasible with any existing tool	E

The various classes of necessary tools are described below.

Basic tools (class A): A repair, re-use or upgrade process, which can be carried out:

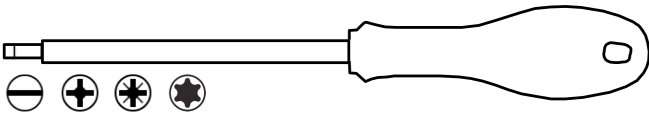
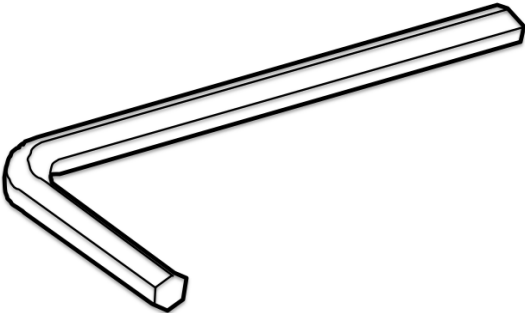

- without the use of any tools, or
- using a tool or set of tools that is supplied with the product, or
- using only basic tools as listed Table A.3 below.

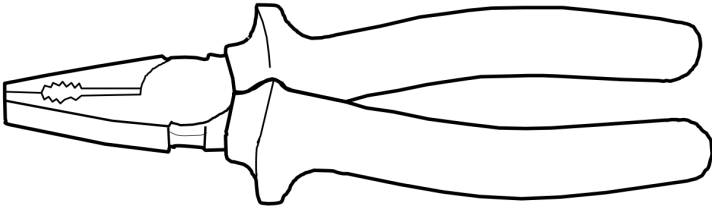
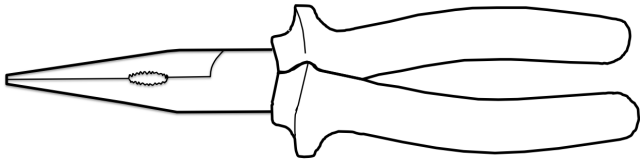
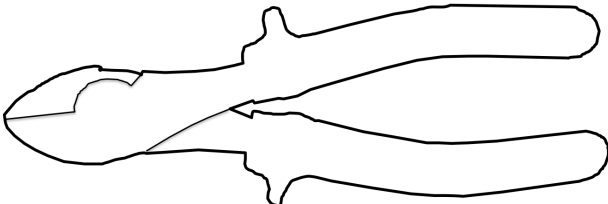
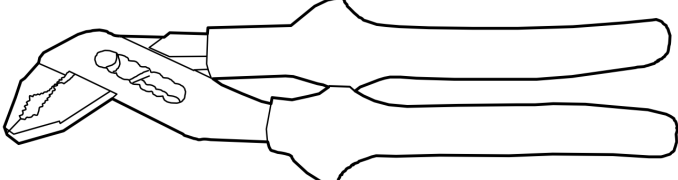
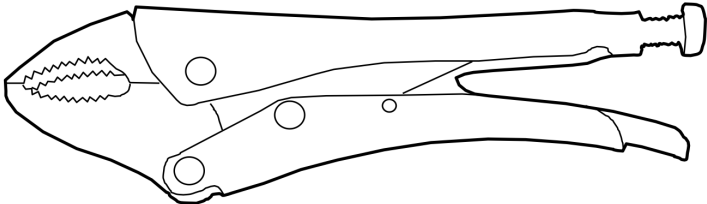
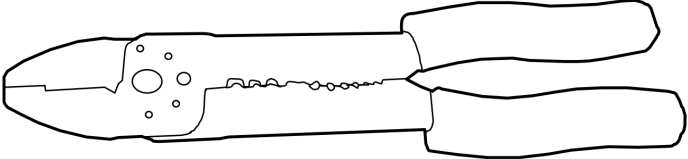

This list of Table A.3 identifies a fixed set of ‘basic tools’ as referenced in Table A.2. It contains a selection of hand-operated tools that can be used for repairing various ErPs.


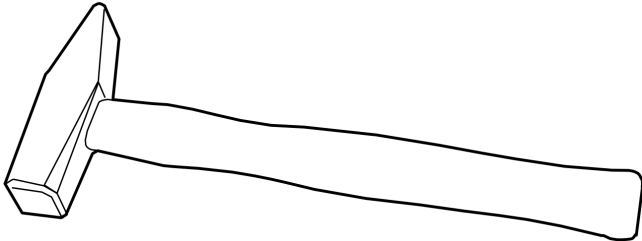
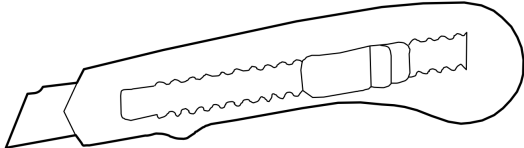
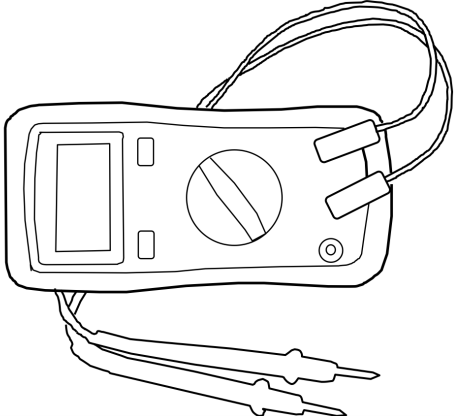
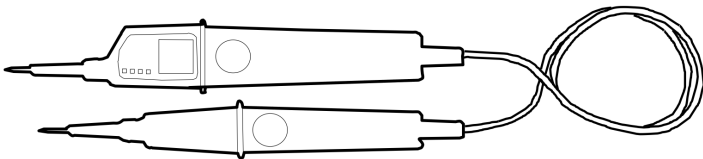
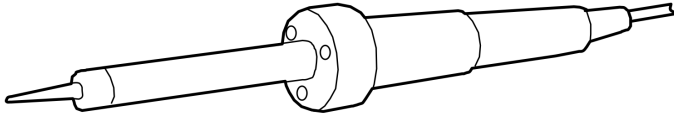
As opposed to repair operations that can be completed without the use of any tools, the need for any type of tool may in certain cases present a barrier for the repair. However, since a person who regularly undertakes repair of various ErPs is highly likely to have the tools referenced in Table A.3 at their disposal, the need for these tools for a given repair operation is unlikely to constitute a significant barrier to that repair operation even across a variety of different repair scenarios.

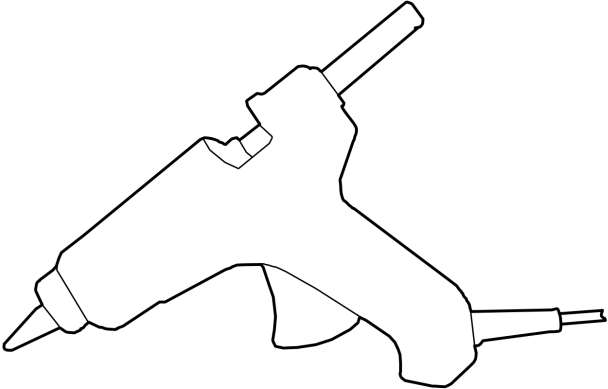
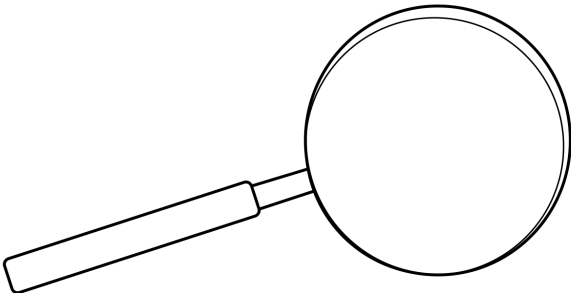
NOTE 1 Most tools come in different sizes. This list only refers to the tool type. Although some sizes are more common than others, for practical purposes, any size of the listed tools is considered to be a basic tool.

Table A.3 —Fixed set of basic tools and their reference standards

Tool type	Illustration (informative example)	Reference
Screwdriver for slotted heads, cross recess or for hexalobular recess heads		ISO2380, ISO8764, ISO10664
Hexagon socket key		ISO2936
Combination wrench		ISO7738

Tool type	Illustration (informative example)	Reference
Combination pliers		ISO5746
Half round nose pliers		ISO5745
Diagonal cutters		ISO5749
Multigrip pliers (multiple slip joint pliers)		ISO8976
Locking pliers		
Combination pliers for wire stripping and terminal crimping		
Prying lever		

Tool type	Illustration (informative example)	Reference
Tweezers		
Hammer, steel head		ISO15601
Utility knife (cutter) with snap-off blades		
Multimeter		
Voltage tester		
Soldering iron		

Tool type	Illustration (informative example)	Reference
Hot glue gun		
Magnifying glass		

NOTE 2 Many processes, such as the removal of fasteners for instance, can be completed with several different types of tools. In order to assess the applicable tool category, only the simplest tool that is required for a given process is taken into account, regardless of the type of tool that can be used in practice by actual repair operators. For instance, if a process is feasible with both class A and class B tools, class A takes precedence for the purpose of the assessment even if class B tools can be more frequently used for the actual repair.

Product group specific tools (class B): A repair, re-use or upgrade process, which cannot be carried out with tools as defined above (class A), but can be carried out with a tool or set of tools as defined in an applicable product-specific method for assessing the ability to repair, re-use or upgrade:

- either by way of a finite list of tools, or
 - by way of criteria for identifying product group specific tools and verifiably distinguishing them from other commercially available tools, or
 - by a combination of both,
- insofar as the tools defined in the product specific method are:
- not proprietary, and
 - necessary for repairing, preparing for re-use or upgrading products produced by at least two different manufacturers.

NOTE 3 In the absence of a product-specific method defining product group specific tool lists or criteria as described above, this category is void.

Other commercially available tools (class C): A repair, re-use or upgrade process, which cannot be carried out with basic or product-group specific tools as defined above (classes A and B), but can be carried out without the use of any proprietary tools.

Proprietary tools (class D): A repair, re-use or upgrade process, which can be carried out only with one or more proprietary tools. These are tools that are not available for purchase by the general public or for which any applicable patents are not available to license under fair, reasonable, and non-discriminatory terms.

Not feasible with any existing tool (class E): A repair, re-use or upgrade process, which cannot be carried out with any existing tool.

A.1.5 Working environment

Working environment requirements refer to the degree of specialization of the environment required to perform the repair, re-use, upgrade process; which can take place for example at home, in a professional workshop or in a production environment. Safety provisions and equipment are some of the factors influencing where the repair, re-use, upgrade process can be performed.

The environment can be categorized according to the table below.

Table A.4 — Classification of working environment

Category Description	Class
Use environment	A
Intermediate environment	B
Production-equivalent environment	C

The various classes of working environment are described below:

- **Use environment (Class A):** If a repair, re-use or upgrade process can be carried out in the environment where the product is in use without any working environment requirements it is categorized as requiring no specific environment.
- **Intermediate environment (Class B):** If a repair, re-use or upgrade process cannot be carried out in the environment where the product is in use (class A) but does not require a production site environment (class C) it is categorized as requiring a workshop environment.
- **Production-equivalent environment (Class C):** If a repair, re-use or upgrade process can only be carried out in an environment that is comparable with the environment in which the product was manufactured, that process is categorized as requiring a production site environment.

A.1.6 Skill level

Repairing a faulty product requires a certain technical skill of the person who performs the repair. This comprises the ability to identify and localize the fault, to access the faulty part within the product, handle the tools safely and manage any risk to the product, the environment and the operator. As a consequence, certain repair operations may only be feasible for certain target groups.

The skill level for a given process can be classified as shown in Table A.5 below.

Table A.5 — Classification of skill level

Category Description	Class
Layman	A
Generalist	B
Expert	C
Authorized expert	D
Manufacturer	E
Not feasible with any existing skill	F

The various classes of skills are described below.

- **Layman (Class A):** If a repair, re-use, upgrade process can be carried out by a person without any specific repair, re-use, upgrade experience or related qualifications, the process is categorized as feasible for a layman.
- **Generalist (Class B):** If a repair, re-use, upgrade process cannot be carried out by Layman (class A) but can be carried out by a person with a general knowledge of basic repair, re-use, upgrade techniques and safety precautions, the process is categorized as feasible for a generalist.
- **Expert (Class C):** If a repair, re-use, upgrade process cannot be carried out by the previous categories but can be carried out by a person with specific training and/or experience related to the product category concerned, the process is categorized as feasible for an expert.
- **Authorized expert (Class D):** If a repair, re-use, upgrade process cannot be carried out by the previous categories but can be carried out by a person who is directly trained and audited by the manufacturer, the process is categorized as feasible for an authorized expert.
- **Manufacturer (Class E):** If a repair, re-use, upgrade process cannot be carried out by the previous categories but only by the manufacturer.
- **Not feasible with any existing skill (Class F):** If a repair, re-use, upgrade process cannot be carried out by the previous categories the process is categorized as Not feasible with any existing skill.

A.1.7 Diagnostic support and interfaces

This step of the assessment of product service support is about the provision of information facilitating the identification of the problem or faulty part. Further it relates to the type of interface available for a repair, re-use or upgrade process, including operations such as adjustment or resetting of parameters or settings. A design that allows a more accessible diagnostic and reset interface, will enable for a broader range for repair, re-use, upgrade scenarios.

Depending on the product group, this information might be made available through self-diagnostic capabilities of the product or it might be made otherwise available by the manufacturer.

Product specific methods for assessing the ability to repair, re-use or upgrade should establish for their product group a categorization of tools for diagnostic support and interfaces.

Interfaces for diagnostic support, failure detection, software and firmware updates, resetting of failure modes and factory settings can be categorized as follows:

Table A.6 — Process classification by necessary interface

Category Description	Class
Intuitive interface	A
Coded interface with public reference table	B
Publicly available hardware / software interface	C
Proprietary interface	D
Not possible with any type of interface	E

The various classes of diagnostic interfaces include:

- **Intuitive interface (Class A):** If the fault can be diagnosed by a signal that can be intuitively understood without the need for any supporting documentation or software, that process is categorized as having a visually intuitive interface.
- **Coded interface with public reference table (Class B):** If the fault can be diagnosed with supporting documentation or software, through consulting a fault-finding tree or through reading and/or entering codes,

supplied with the product and / or publicly available, that process is categorized as having a coded interface with public reference table.

- **Publicly available hardware / software interface (Class C):** If a repair, upgrade or re-use process can only be carried out through the use of hardware and software which is publicly available, that process is categorized as having a publicly available hardware / software interface.

This can include hardware functionality testing software tools developed by a third party, provided the software tools are publicly available and the manufacturer provides information on their accessibility and applicable updates. The product can be equipped with an appropriate interface for hardware and software to do fault diagnosis and reading, adjustment or resetting of parameters or settings (e.g. external memory device, data cable connection, or from a remote source using a network connection). The port, slot, or connector that is used for the hardware and software interface is accessible without tools.

- **Proprietary interface (Class D):** If a repair, upgrade or re-use process can only be carried out using proprietary tools for diagnosis, change of settings or transfer of software, which are not included with the product, that process is categorized as needing a proprietary interface.

- **Not possible with any type of interface (Class E):** If a repair, upgrade or re-use process cannot be carried out with any type of interface, that process is categorized as not possible with any type of interface.

A.1.8 Availability of spare parts

The availability of spare parts is a prerequisite for a successful repair. For many product groups, the availability of upgrade parts, software and firmware, is comparably relevant.

Spare parts availability refers to both the availability to various target groups and the availability over a specific period of time. These two perspectives are assessed in sequence. The availability of software and firmware may be assessed in the same way as for hardware parts.

The availability of spare parts to given target groups is assessed according to Table A.7.

Table A.7 — Classification of spare parts availability by target group

Category Description	Class
Publicly available	A
Available to independent repair service providers	B
Available to manufacturer-authorized repair service providers	C
Available to the manufacturer only	D
No spare parts available	E

The various classes of spare part availability by target group are described below.

- **Publicly available (class A):** A repair, re-use or upgrade process, for which the necessary spare part(s) is/are available to all interested parties.

- **Available to independent repair service providers (class B):** A repair, re-use or upgrade process, for which the necessary spare part(s) is/are not publicly available as described above (class A), but is/are available to any self-employed professional as well as any legally established organization providing repair services.

- **Available to manufacturer-authorized repair service providers (class C):** A repair, re-use or upgrade process, for which the necessary spare part(s) is/are not available to the general public or to independent repair service providers as described above (classes A and B), but is/are available to service providers authorized by the product manufacturer to offer repair services.

- **Available to the manufacturer only (class D):** A repair, re-use or upgrade process, for which the necessary spare part(s) is/are not available to the general public or to independent or authorized repair service providers as described above (classes A, B and C), but is/are available to the product manufacturer.

- **No spare parts available (class E):** A repair, re-use or upgrade process, for which the necessary spare part(s) is/are not available for any of the target groups described above (classes A, B, C and D).

Spare parts are considered to be available to target group classes A, B, C and/or D respectively, if the following information is publicly available from the manufacturer:

- Unequivocal identification of the product and of the parts of the product for which spare parts are available, based on the commercial product name and the type designation;
- The procedure by which target groups A, B and / or C respectively can obtain the necessary part;
- The procedure by which target groups A, B and / or C respectively can have the part replaced by the manufacturer.

NOTE 1 The availability of a specific spare part to relevant target groups can be assessed based on product and part identification combined with general statements from the manufacturer about the availability of spare parts for a given product or product portfolio.

If the information mentioned above is not publicly available from the manufacturer, the spare parts availability is considered to correspond to class E.

The likelihood of repair, re-use or upgrade can also be influenced by spare part interfaces. A classification is provided below:

Table A.8 — Classification of spare part interface

Category Description	Class
Standard part	A
Proprietary part with standard interface	B
Proprietary part with non-standard interface	C

The various classes of spare part interfaces are described below.

- **Standard part (Class A):** A part that is non-proprietary and has a standard interface.
- **Proprietary part with standard interface (Class B):** A part that is proprietary and has a standard interface.
- **Proprietary part with non-standard interface (Class C):** A part that is proprietary and has no standard interface.

Example1: An example of a standard interface is an USB-connector.

Example 2: An example of a proprietary part with a non-standard interface (Class C) is a Laptop Battery Pack.

Finally, for spare parts available to target group classes A, B, C and D, the continued availability over time may be assessed according to Table A.9.

When specifying product-specific assessment methods, the user of this document should select relevant duration classes, specify the precise duration that is to be considered as short, mid or long term based on the expected useful life of the product, and assign relevant scores to each class of duration.

NOTE 2 The duration could, for example, refer to the following periods during which spare parts will be available:

— a specified minimum number of years after the placement of the product on the market,

— a specified minimum number of years after the sale of the product,

— a specified minimum number of years after the end of production of the product.

Table A.9 — Classification of spare parts availability by duration of availability

Category Description	Class
Long-term availability	A
Mid-term availability	B
Short-term availability	C
No information on duration of availability	D

The various classes of spare part availability by duration are described below.

- **Long-term availability (class A):** A repair, re-use or upgrade process, for which the required spare part(s) is/are available for a duration of time that reflects the expected maximum useful life of the product.
- **Mid-term availability (class B):** A repair, re-use or upgrade process, for which the required spare part(s) is/are not available for the duration as described above (class A), but is/are available for a duration of time that reflects the expected average useful life of the product.
- **Short-term availability (class C):** A repair, re-use or upgrade process, for which the required spare part(s) is/are not available for the duration as described above (classes A and B), but is/are available during a period of two years after the time of sale of the product.
- **No information on duration of availability (class D):** A repair, re-use or upgrade process, for which the required spare part(s) is/are available at the time of sale, but for which the duration of availability cannot be determined.

Spare parts are considered to be available for duration classes A, B or C respectively, if the following information is publicly available from the manufacturer:

- The period during which the necessary part is available to target groups A, B, C and/or D respectively.

NOTE 3 The duration of availability of a specific spare part can be assessed based on general statements from the manufacturer about the availability of spare parts for a given product or product portfolio.

When aggregating results (see section A.1.13.), availability by target group, spare part interface and duration are combined into a single criterion. If the duration of availability differs by target group, each target group class may be combined with the corresponding duration class and the best outcome may be selected to take into account for the general assessment, without however combining any duration class with a target group class to which it does not apply. Finally, the user of this document should decide to aggregate or not the availability of spare parts to different target groups by summing up their respective spare part availability scores. It may be the availability of spare parts to different target groups varies.

A.1.9 Types and availability of information

Types and availability of information refers to both the comprehensiveness of the information and the availability to various target groups. These two perspectives are assessed in sequence.

When defining a product-specific assessment method, the user of this document should select relevant target group classes and specify appropriate communication channels for each target group.

The comprehensiveness of available information is assessed according to Table A.10. The precise type and format of information that is to be considered as comprehensive, basic or no information available should be specified when the user of this document defines a product-specific assessment method.

Table A.10 — Classification of information availability by comprehensiveness

Category	Class
Comprehensive information available	A
Basic information available	B
No information available	C

The various classes of information availability by comprehensiveness are described below.

- **Comprehensive information available (class A):** A repair, re-use or upgrade process, for which all relevant information is available.

EXAMPLE 1. Complete information concerning priority parts may include circuit board schematics of electronic parts, functional specification of parts (e.g. resistance value of resistors, viscosity grade of lubricants) and information on compatibility of parts with other products, step-by-step disassembly instructions with identification of tools needed, recommended torque for fasteners, diagnostic and error resetting codes, testing procedures, reference values for measurements, and training materials for repair, re-use and upgrade.

EXAMPLE 2. Appropriate formats for reporting comprehensive information may include IEEE1874 (*IEEE Standard for Documentation Schema for Repair and Assembly of Electronic Devices*).

- **Basic information available (class B):** A repair, re-use or upgrade process, for which comprehensive information is not available as described above (class A), but for which some information is available.

EXAMPLE. Basic information may include product identification, instructions for regular maintenance, an overview of repair or upgrade services offered by the manufacturer, troubleshooting charts, a list of available updates, an exploded view and spare parts list.

- **No information available (class C):** A repair, re-use or upgrade process, for which no relevant information (classes A, and B) is available.

For those repair, re-use or upgrade processes, for which basic, comprehensive or complete information is available (classes A and B), the availability to target group classes is assessed according to Table A.11.

Table A.11 — Classification of information availability by target groups

Category	Class
Publicly available	A
Available to independent repair service providers	B
Available to manufacturer-authorized repair service providers	C
Available to the manufacturer only	D

The various classes of information availability by target group are described below.

- **Publicly available (class A):** A repair, re-use or upgrade process, for which the relevant information is available to all interested parties.

- **Available to independent repair service providers (class B):** A repair, re-use or upgrade process, for which the relevant information is not publicly available as described above (class A), but is available to any self-employed professional, as well as any legally established organization, providing repair services.

NOTE 1 Channels for communicating information to independent service providers may include printed manuals, password-protected websites and digital information carriers such as DVD's or flash drives.

- Available to manufacturer-authorized repair service providers (class C):** A repair, re-use or upgrade process, for which the relevant information is not available to the general public or to independent repair service providers as described above (classes A and B), but is available to service providers authorized by the product manufacturer to offer repair services.
 - Available to the manufacturer only (class D):** A repair, re-use or upgrade process, for which the relevant information is not available to the general public or to independent or authorized repair service providers as described above (classes A, B and C), but is available to the product manufacturer.
- Information is considered to be available to target group classes A, B, C and/or D respectively, if the following information is publicly available from the manufacturer:
- Unequivocal identification of the product and of the information available for that product, based on the commercial product name and type designation;
 - For target group class A: the basic, comprehensive or complete information to facilitate repair, re-use or upgrade, as relevant;
 - For target group classes B and C: the procedure by which each target group can obtain the relevant information, including any costs related to the access to the information concerned.

NOTE 2 The availability of information cannot be dependent on the specific priority part. In that case, the availability of information to relevant target groups can be assessed for the product as a whole and the same score can be used for the assessment of each priority part.

NOTE 3 The availability of information cannot be dependent on the specific product. In that case, the availability of information to relevant target groups can be assessed based on product identification combined with general statements from the manufacturer about the availability of information for a given brand or product portfolio.

A.1.10 Return models

To assess the ability to repair or upgrade, the model available to return the used or defective product should be considered. This is assessed according to Table A.12.

Table A.12 — Classification of return models

Category Description	Class
Return model existing	A
No return model	B

The classes of return model are described below.

- Return model existing (class A):** A repair, re-use or upgrade process, for which a return model exists, such as a mail-back programme.
- No return model (class B):** A repair, re-use or upgrade process, for which no collection is organized. Product repair is left up to the owner.

A.1.11 Data transfer and deletion

If the intention is to establish direct reusability of whole products for either direct re-use or refurbishment, the pre-requisite is that the product allows transfer of ownership without transfer of any personal data.

Where data are stored on storage internal to the product, secure data deletion tools should be pre-installed or built in or made available which permanently delete all user data without compromising the functionality of the device for further use.

Simplified transfer of data from an old to a new product can be made available via installed or downloadable tools such as an application, a cloud-based service or instructions detailing a manual process.

In addition to data points from EN 45552 indicating the durability of the product and its parts, data transfer and deletion should be separately assessed, using the classes below:

Table A.13 — Classification of data transfer and deletion

Category Description	Class
Built-in	A
On request	B
Not available	C

The various classes of data transfer and deletion are described below.

- **Built-in (class A):** A re-use process, for which built-in secure data transfer or deletion functionality is available and easily accessible to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid-state drives) in function of the risks faced and in order to grant the security of personal data and to facilitate the re-use of these parts.
- **On request (class B):** A re-use process, for which secure data transfer or deletion is available on request to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid-state drives) in function of the risks faced and in order to grant the security of personal data and to facilitate the re-use of these parts.
- **Not available (class C):** A re-use process, for which secure data transfer or deletion is not available.

A.1.12 Password and factory reset for reuse

In the case that a product is discarded by its original user before entering a reuse process, even if all original functionality is still intact, the product may become impossible to reuse. Thus, the inability to reset a password and restore factory settings on a product can pose a major barrier to reuse. A score for password and factory reset could be assessed as follows:

Table A.14 — Process classification of password and factory reset

Category Description	Class
Integrated reset	A
External reset	B
Service reset	C
No reset	D

The various classes of process classification by password reset are described below.

- **Integrated reset (class A):** A reuse process, for which password reset and restoration of factory settings (whilst ensuring security of personal data of the previous user) is permitted without restrictions, using functionality integrated within the product.
- **External reset (class B):** A reuse process, for which password reset and restoration of factory settings (whilst ensuring security of personal data of the previous user) is permitted without restrictions, using freely accessible software or hardware solutions.
- **Service reset (class C):** A reuse process, for which password reset and restoration of factory settings (whilst ensuring security of personal data of the previous user) is permitted without restrictions, using freely accessible services offered by the manufacturer.
- **No reset (class D):** A reuse process, for which password reset and restoration of factory settings is not provided.

A.1.13 Aggregation of criteria scores

As described in A.1.1., when defining assessment procedures to determine the ability of a specific type of product to be repaired, re-used or upgraded, the user of this document should select relevant classes of the relevant criteria and assign suitable numeric scores to each class. Each criterion may then be combined with a weighting coefficient to form a factor that can be used in a comprehensive index for the ability of a product to be repaired, re-used or upgraded respectively, as follows:

$$\sum_{i=1}^{i=p} W_{Need,i} \times \left[\begin{aligned} &W_{depth,i} * S_{depth,i} + W_{fasten,i} * S_{fasten,i} + W_{tool,i} * S_{tool,i} \\ &+ W_{environ,i} * S_{environ,i} + W_{skill,i} * S_{skill,i} + W_{inter,i} * S_{inter,i} \\ &+ W_{spare,i} * S_{spare,i} + W_{info,i} * S_{info,i} + W_{return,i} * S_{return,i} \\ &+ W_{data,i} * S_{data,i} + W_{reset,i} * S_{reset,i} \end{aligned} \right]$$

where

$W_{need,i}$	is the overall weighting factor of part i
$W_{depth,i}$	is the weighting factor for disassembly depth
$S_{depth,i}$	is the disassembly depth score for priority part i;
$W_{fasten,i}$	is the weighting factor for fastener
$S_{fasten,i}$	is the fastener score for priority part i
$W_{tool,i}$	is the weighting factor for tool
$S_{tool,i}$	is the tool score for priority part i
$W_{environ,i}$	is the weighting factor for working environment
$S_{environ,i}$	is the working environment score for priority part i
$W_{skill,i}$	is the weighting factor for skill
$S_{skill,i}$	is the skill score for priority part i
$W_{inter,i}$	is the weighting factor for interface
$S_{inter,i}$	is the interface score for priority part i
$W_{spare,i}$	is the weighting factor for spare parts
$S_{spare,i}$	is the spare parts score for priority part i
$W_{info,i}$	is the weighting factor for information
$S_{info,i}$	is the information score for priority part i
$W_{return,i}$	is the weighting factor for return model
$S_{return,i}$	is the return model score for priority part i
$W_{data,i}$	is the weighting factor for data transfer and deletion
$S_{data,i}$	is the data transfer and deletion score for priority part i
$W_{reset,i}$	is the weighting factor for password and factory reset
$S_{reset,i}$	is the password and factory reset score for priority part i

The higher the score the better the repair, re-use, upgrade of the part or product. Means to normalize the score should be specified by the user of this document when defining product specific methods.

Users of this document could decide to omit weighting or leave out certain criteria (e.g. because they are irrelevant for their product group). Ranking of priority parts can be expressed by an overall need for disassembly weighting factor W_{need} . This is discussed in 5.3. Weighting of the importance of criteria can also be done.

Product specific assessment methods should consider the interdependencies between criteria. For instance, a repair, re-use or upgrade operation is only to be considered accessible to a certain target group, if it can be done by that target group including all relevant criteria covered by the assessment method, be it product-related criteria (described in Clause 7) or support-related criteria (described in Clause 7). Where relevant, the aggregation above may be supplemented by logical operations to avoid scoring outputs for scenarios which are impossible. For instance, if spare parts are not available, scores for tools or skills needed may be irrelevant. Such correlations may be defined by logical operations.

A.2 Quantitative assessment

A.2.1 Disassemblability index

A disassembly index can be calculated based on the number of parts to be removed, the fastener types and difficulty coefficients.

Using the minimum number of fasteners is a key principle in design for disassembly. Different fastener types may indeed require different unfastening tools, different access directions and different disassembly configurations, which would ultimately result in an increase in the disassembly effort.

More information on the index can be found on source [1] provided in the Bibliography.

A.2.2 Time for disassembly

The disassemblability of products is influenced, among other technical aspects, by the number of steps needed to disassemble parts of the product, by the ease of access to parts and by the difficulty of the operation itself. The time for disassembly can be an aggregated parameter to assess the overall disassemblability of products. Time can easily be measured but the overall length depends on the operator skills and other factors. The Ease of Disassembly Metric (eDiM) [2] method is based on the Maynard Operation Sequence Technique (MOST) and requires information about product parts and adopted fasteners that can be directly verified within the product. The eDiM is a comprehensive method, although it comes with a significant computational effort.

NOTE MOST is a measurement technique used by industrial engineers and practitioners to measure assembly times for a wide variety of products. Reference values of eDiM have been determined by using it.

The tasks necessary to disassemble a particular part/product are listed in eDiM and reference time values are associated to each of them, representing the effort needed to perform such operation. The eDiM report includes a database of common disassembly tasks which can be adapted, extended and/or updated.

The overall eDiM, measured in time units, is calculated by summing all contributions associated to a determined disassembly sequence. Subjectivity is reduced when single disassembly activities are measured and standard values quantified, as done in MOST.

More information on eDiM and MOST can be found on sources [2], [3] and [4] provided in the Bibliography.

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