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English Version

General method for the assessment of the ability to re-manufacture energy related products

Méthode générale pour l'évaluation de la capacité de refabrication

Allgemeines Verfahren zur Bewertung der Wiederaufbereitbarkeit 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 45553:2018] 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• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	dor + 36 months (to be confirmed or modified when voting)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.

Introduction

This standard provides a method for accessing the ability of an ErP to be remanufactured. It identifies seven general process steps which are crucial to the remanufacturing process. Each of the seven steps is linked to several attributes of the ErP. Therefore, to assess the ability to remanufacture an ErP these product attributes which are linked to the remanufacture process have to be assessed accordingly. The general assessment method, presented in this document, is intended to be used to develop product-specific standards .

As the terms refurbishment and remanufacturing are used interchangeably in different industry sectors it is necessary to provide guidance to the user of the standard how to distinguish between these two industrial processes.

Remanufacturing is identified as an industrial process where important changes are applied to the ErP in such way that it has to be considered a new product when placed on the market, after finishing the remanufacturing process.

Refurbishment is identified as an industrial process in which no important changes to the energy-related product are made. Checks for basic safety and performance attributes are performed.

1 Scope

This document proposes a general method to assess the ability of ErPs to be remanufactured on a generic level. Where a product specific standard for assessing the ability to remanufacture does not exist, this document can be used for such an assessment.

The assessment of the ability of parts to be remanufactured is not considered in this document.

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 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 See prCEN/CLC/TR 45550 for additional definitions related to Material Efficiency.

3.1
important change
modification which influences the safety, original performance, purpose or type of the product

Note 1 to entry: to entry: Refer to the EU Blue Guide [1] for conditions under which a product has to be considered as a new product when placing on the market after such changes.

Note 2 to entry: to entry: The person who carries out the changes becomes then the manufacturer with the corresponding obligations.

3.2
remanufacturing
industrial process which creates a product from used products or used parts where at least one important change is made to the product

3.3
refurbishment
industrial process of returning a used product to a satisfactory working condition without making any important changes to the product

3.4
part
hardware or software constituent of a product

3.5
disassembly
process whereby a product is taken apart in such a way that it could subsequently be reassembled and made operational

[SOURCE: IEV 904]

3.6
reprocessing
restore or modify the functionality of a product or part

Note 1 to entry: to entry: Reprocessing may consist of repairing, rework, replacement of worn parts, and/or upgrade of soft- and/or hardware.

3.7
qualified person
person whose competence and knowledge have been obtained by education, training and/or relevant practical experience

Note 1 to entry: to entry: Refer to national requirements which may vary from country to country

[SOURCE ISO/TR 25901-1:2016, 2.5.22]

4 Guidance on how to use this standard

4.1 General guidance

The ability to remanufacture a product is very much dependant on the type of product which is being remanufactured and which remanufacturing process steps are the most relevant to that product.

Users of this standard shall identify the order and importance of each remanufacturing process step for their ErP. They shall evaluate if the link between process steps and product attribute reflects their product group and make amendments where necessary. Each product attribute can be evaluated by the aspects given in sections 5.1.1 to 5.1.5 which are non-exhaustive and general in nature. The user of this standard shall define the relevant aspects for their product group and assess the ability of an ErP to be remanufactured accordingly.

NOTE 1 If a scoring is desired, the user of the standard can develop classes for the different aspects of the product attributes to evaluate them and weight this with the before defined importance of each process step they are represented in.

NOTE 2 If required a list of priority parts can be created which is assessed according to the defined aspects.

4.2 General considerations

A pre-condition to assess the ability of an ErP to be remanufactured involves the ability to create and maintain strict rules of procedures to be applied during every step of the remanufacturing process, ensuring that neither safety nor performance of the product to be remanufactured will be impaired by the remanufacturing process.

It is assumed that an organization performing remanufacturing is able to demonstrate it has identified and formally nominated a qualified person as being the solely responsible person for the remanufactured process.

It is assumed that the organization performing remanufacturing is able to demonstrate that it can guarantee the traceability of products or parts belonging to the remanufacturing process at all times, either by having dedicated remanufacturing lines and/or thorough a traceability system. Also, for the purpose of storage during the remanufacturing process, it is important to identify the ErP and its parts by, for instance, attributing an article number or code that makes its identification simple.

5 General method to assess the ability of an ErP to be remanufacture

5.1 Assessing the ability of an ErP to be remanufactured

5.1.1 General

The ability of an ErP to be remanufactured shall be assessed based on the feasibility of performing the following seven general remanufacturing process steps [2] considered to be key for the remanufacturing of a product. These process steps, which can occur in different order, are:

- Inspection
- Disassembly
- Cleaning
- Reprocessing
- Reassembly
- Testing
- Storage

NOTE 1 Storage will take place at any point in the remanufacturing process

Each remanufacturing process step is linked to one or more product-related attributes that allow the assessment of the ability of a product to be remanufactured. The link between the remanufacturing process steps and product-related attributes is shown in a matrix in Table 1. This matrix shows which product attributes are relevant for the different steps in the remanufacturing process and can be used as a design tool.

NOTE 2 Using this matrix, the designer can easily identify what product attributes are relevant or needed for the different remanufacturing steps; depending on which product is being considered, a step can be of more or less importance and be emphasized or not.

A more detailed description of the product attributes is provided in Clauses 5.1.2 to 5.1.6.

Table 1 — Remanufacturing Attribute Matrix – Showing the link between the remanufacturing process steps and product-related attributes

	Remanufacturing Process Step						
Product Attribute	**Inspection**	**Disassembly**	**Cleaning**	**Reprocessing**	**Reassembly**	**Testing**	**Storage**
Ease of locating access points and fasteners	X	X			X	X	
Ease of identification and verification	X					X	X
Ease of access	X	X	X	X	X	X	
Ease of disassembly / reassembly		X	X	X	X		X
Wear resistance	X	X	X	X	X	X	X

5.1.2 Ease of locating access points and fasteners

Clear location of access points can facilitate verification of certain conditions, for instance, making clear where to insert the diagnostic equipment to the product. Easy and clear identification of fasteners (points or sequence) will allow for easy disassembly or reassembly of the parts.

The degree of difficulty in locating access points or fasteners can be determined by, for instance, the presence of markings or intuitive product design, influencing positively or negatively the ability of an ErP to be remanufactured. Typical aspect that influence the ease of locating access points and fasteners is:

— Indication of where access points are located (e.g. by markings)

— Indication of where fasteners are located

— Provision of diagrams/drawings with the location of access points and fasteners

The ease of locating access points and fasteners facilitates inspection, testing, disassembly or reassembly and energy-related product or product-group. User of this standard shall determine to which extent the ease of locating access points and fasteners contribute to the ability of a product to be remanufactured. They should also draft a list of aspects that will be used to determine the ability of locating access points and fasteners.

5.1.3 Ease of identification and verification

The degree of difficulty in identifying and / or verifying the working conditions of the ErP and its parts, to determine which parts need to be reprocessed e.g. repaired, reworked, replaced, upgraded, is an important contributor to the overall ability of a product to be remanufactured. Typical aspects that influence the ease of identification and verification of the ErP and its parts are:

— Indication of the functionality

— Indication of wear sensitive parts (e.g. if certain parts do not withstand specific cleaning methods)

— Indication of parts containing hazardous substances

— Indication of the need for special care / handling during the testing in view of e.g. safety of the testing expert, of others, or of the equipment itself

— Information on how to determine the condition to determine its operability

— Access of diagnostics (e.g. embedded diagnostic tools to verify condition)

User of this standard should identify to which extent the ease of identification and verification, as to determine if it is possible or useful to reuse its parts or whether reprocessing, contributes to the ability of a product to be remanufactured. They should draft a list of aspects that will help determine the ability of identification and verification of that specific product or product-group, including verification of aspects critical to safety and performance

5.1.4 Ease of access

In order to facilitate remanufacturing, it can be important that areas which need to be cleaned are accessible, and where special conditions of cleaning are to be applied, clear indication or instructions are provided. Aspects that influence cleaning are:

— Use of materials that prevent the attachment of dirt will reduce the need for cleaning.

— Surfaces to be cleaned should be smooth and wear resistant, as the presence of sharp edges and uneven surface boundaries could attract dirt and decrease the ability to perform the cleaning process

For disassembly it is important to have access to the parts that need to be disassembled. Aspects that influence disassembly are:

— Access to handle parts during the disassembly process step e.g. parts known to need reprocessing during the remanufacturing

— Modularity of the constituents

— Access to fasteners, e.g. joints, gripping points and breaking points

For reprocessing it is important to have access to parts that needs to be repaired, reworked, replaced or upgraded.

For reassembly it is important to have good access to points where the reprocessed or new parts are being inserted.

Clause A.1 provides an example of a method to calculate the accessibility of a product, which may be applied, if relevant.

Users of this standard shall identify the degree of difficulty in accessing parts, either manually, with the use of specific tools or automated processes, in order to inspect, clean, disassemble, reprocess, reassemble and/or test the ErP.

5.1.5 Ease of disassembly and reassembly

Aspects that will contribute to the disassembly, and as such to the ability of a product to be remanufactured, are the ability to disassemble parts known to need cleaning and / or reprocessing during the remanufacturing process. Different methods exist to determine the ability to disassemble parts and may be more or less appropriate, depending on the product (group) under consideration.

Aspects that influence the easy of disassembly and reassembly are:

— Handling should be possible by one person.

— Whether parts are asymmetric (avoiding mistakes during the reassembly)

— Avoid having handling difficulties (e.g. being too small, too bulky, heavy, soft, tendency to tangle, sticky or sharp).

— Ability to insert constituents (e.g. good visibility during assembly and low resistance during insertion.)

— Parts secured directly upon insertion without any extra operations after the insertion (e.g. screwing, tightening or gluing).

— Number of tools required during disassembly and reassembly may influence the complexity of the process

— Number of (different) fasteners needed during disassembly and reassembly

Clause A.2 shows calculation methods to assess the ability of an ErP to be disassembly and reassemble. Product specific technical committees should use the most suitable method described in this Annex to determine the ease of disassembly/reassembly. If none of the described methods are applicable, the product specific technical committees should develop more suitable methods.

User of this standard should identify the aspects that influence the degree of difficulty of which those specific ErP can be disassembled and/or reassembled.

5.1.6 Wear resistance during the remanufacturing process steps

Wear resistance is another key attribute for remanufacturing ErP. Products and/or parts should withstand all treatment necessary during the remanufacturing steps (see 4.1) without breaking. Aspects that influence wear resistance, and with it, the ability of an ErP to be remanufactured are:

— Strength of materials and fasteners, that enables the product to be remanufactured once or multiple times

— Resistance of surfaces or product markings to e.g. cleaning, including cleaning agents and/or the equipment that is used to remove dirt

— Materials used to make the parts shall withstand the cleaning agents (either chemical or mechanical).

— Parts should not show premature deterioration that is further accelerated by the remanufacturing process as to impair safety and performance

User of this standard can specify minimum requirements for the wear-resistance of specific ErPs.

5.2 Evaluating the ability of an ErP to be remanufactured

The ability of an ErP to be remanufactured is dependent on the product type that is being remanufactured. Characterization of the importance of product-related attributes shall be defined by the user of this standard. Therefore, at each remanufacturing process step the product attributes described in section 4.1 shall be assessed by the users of this standard and a set of rules (e.g. score methodology) shall be proposed for that product (group) on how to evaluate the ability of a product to be remanufactured.

If an ErP or its parts cannot be identified or if one or more of the remanufacturing process steps cannot be executed, the product is unable to be remanufactured.

6 Reporting the assessment of the ability of an ErP to be remanufactured

6.1 General

The users of this standard shall ensure that their standards include requirements for reporting material efficiency aspects as follows:

- The assessment of the ability to remanufacture a product(s) / product family <XXX> shall be documented in a report.
- The assessment report itself is likely to be considered as data sensitivity level <3> in accordance with prEN 45559.
- The assessment report shall also include data and information of importance for any results published in data sensitivity levels < 2 and / or 1 > , for the different stakeholders.
- 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.

6.2 Elements of the assessment report

The user of the standards 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

c. **Input data and approach for the assessment of the ability of a product to be remanufactured**

1. Description of data and other information used/needed for the assessment (e.g. manual, bill of material, drawings)

2. Calculations or scoring when relevant (e.g accessibility formula or scoring when relevant)

3. Methods or Tools used in the assessment (e.g. disassembly sequence)

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 (incl. standards, requirements and policies)

Annex A
(Informative)

Quantitative methods to assess different product attributes

A.1 Assessment of accessibility

The accessibility index (IAcc) of an ErP can be determined based on the respective accessibility indexes of all individual parts (IAcc_part) which are considered relevant for remanufacturing.

Distances to other parts are evaluated along 3 axis. The 3 axis can be arbitrarily chosen, providing they constitute an orthogonal reference. For each specific part its accessible range, describing the open approachable sector, should be compared with the dimension of the part by using the following formula:

$$I_{Acc\_part} = \left(\frac{\Delta X}{X_{part}} + \frac{\Delta Y}{Y_{part}} + \frac{\Delta Z}{Z_{part}} \right) / 3$$

X_{part} define the length of the specific part

Y_{part} define the width of the specific part

Z_{part} define the depth of the specific part

ΔX represent the accessible range along the x-axis during its specific disassembling sequence step

ΔY represent the accessible range along the y-axis during its specific disassembling sequence step

ΔZ represent the accessible range along the Z axis during its specific disassembling sequence step

The definition of the length, width and depth of a part is set by the definition of the length, width and depth of the product and needs to be aligned according to the built in state of the specific part.

Note The assessment of accessibility does not include fasteners.

The accessibility (I_{Acc}) of an ErP can be calculated by determining the median value of the individual accessibility indexes (I_{Acc_part}) of all evaluated parts.

A.2 Assessment of the ability to disassemble/reassemble

A.2.1 Disassembly sequence

The disassembly sequence [3] is the sequence of steps needed to remove a part from a product. This analysis of disassembly steps is fundamental to facilitate the disassembly of key parts from products:

1. Parts can be labelled in the progressive removal order.
2. Different strategies to disassemble a part from products can be compared in terms of disassembly steps.
3. Optimal disassembly sequences can be for instance found through process simulation or through the analysis of their relative accessibility and importance.

The disassembly depth is the minimum number of steps required to remove a part from a product and it is obtained by applying an iteration of steps:

— Step1: Every part that can be removed is set at Level 1 and a list of remaining parts is made

— Step2: Every part that can be removed is set at Level n+1 and a list of remaining parts is made

— Step3: Repeat step 2 until all parts are exhausted.

A.2.2 Disassembly index

The disassembly index [4] of a part is a normalized index 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 require different unfastening tools, different access directions and different disassembly configurations, which would ultimately result in an increase in the disassembly effort.

The parameter is calculated with the following equation:

$$dd = dd_n + \beta \cdot dd_f = \frac{1 + n_D}{n} + \beta \cdot \frac{\sum_{k=1}^{h} \propto_k \cdot f_k}{f}$$

Where:

dd	is the disassembly index of the part
$(1 + n_D)$	is the number of parts which have been removed (excluding the part whose disassembly index is being evaluated), before the specific part can be disassembled
n	is the total number of parts,
h	is the number of fastener types
f_k	is the number of fasteners of the k^{th} type to be removed,
f	is the total number of fasteners in the system,
α_k	is the difficulty of disassembling a k^{th} type fastener (α_k [1, 2], α_k = 2 indicates the maximum difficulty of disassembly),
β	is a coefficient (0 < β < 2) which takes into account the weight of the second term dd_f with respect to the first dd_n.

The index dd can assume values from $\frac{1}{n}$ to $1+\beta*\alpha_k$, with the maximum value (dd_{MAX}) expressing the maximum disassembly depth. The maximum disassembly depth describes the status in which all the fasteners and all the other parts present in the system are disassembled.

To assess the product itself the part with the highest dissemble index (dd_i) can be compared with the maximum disassembly depth (dd_{MAX}) and be evaluated accordingly.

$$DD_i = dd_i / dd_{MAX}$$

A.2.3 Time for disassembly (eDiM)

The eDiM method [5] requires information about product parts and adopted fasteners that can be directly verified within the product. 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 (Maynard Operation Sequence Technique) [5].

As shown in Table A1, a spreadsheet can be used to calculate the eDiM. The first five columns of the table contain the data required to compute the time taken to complete the six categories of disassembly tasks:

1. Parts are listed in Column 1 in the order of disassembly. If parts are attached by different fasteners, they can be repeated in the column.

2. Fastener types used are listed in Column 2 in the order in which they should be disassembled to remove the different parts. An example is provided in Table A.2 to show different fastener types and their main characteristics.

3. The number of fasteners of the same type in a part are specified in Column 3.

4. The number of any manipulations needed to access a fastener are listed in Column 4. This could for instance be the case of a product that is turned upside down to remove the fastener.

5. Information on the ease of identification of the fastener is contained in Column 5. Two categories, visible and hidden, are presented in Table A.2.

6. The type of tool required for removing the fasteners is listed in Column 6. Tools can be selected from a predefined list. The box is left empty if no tool is required.

The time needed for the disassembly process is estimated through the last seven columns based on the information provided in the first six columns and the MOST reference time values.

7. Column 7 indicates the time needed to change tools defined in column 6. This is calculated based on the information on fasteners provided in MOST, from which it can be determined whether a tool is required for disconnecting that type of fastener.

8. Column 8 indicates the time needed to identify fasteners. This is calculated using the information provided in Column 5 and the reference time values.

9. Column 9 indicates the time needed for product manipulation. This is calculated using the number of manipulations reported in Column 4 and the reference time values.

10. Column 10 indicates the time needed for positioning tools, in relation to the type of fasteners used. This is calculated by multiplying the fasteners specified in Column 3 by the reference time values for tool positioning.

11. Column 11 indicates the time needed for removing the fasteners. This is calculated by multiplying the fasteners indicated in Column 3 by the reference time values for removing the corresponding type of fastener.

12. Column 12 indicates the time needed for removing parts. This is calculated once per part.

13. The overall eDIM for a set of parts is assessed in Column 13 as sum of time values reported in columns 7 to 12.

The eDiM method is presented here as a method to estimate the time for disassembly, however the method could be used as well to estimate the time for reassembly, the sum of the two would allow the estimation of the total time needed for replacing one or more parts.

386 **Table A.1 — Generic eDiM calculation sheet for N parts**

1	2	3	4	5	6	7	8	9	10	11	12	13
Disassembly sequence of components	Disassembly sequence of fasteners of components	Number of components	Number of product manipulations	Identifiability (0,1)	Tool type	Tool change [s]	Identifying [s]	Manipulation [s]	Positioning [s]	Removing fasteners [s]	Removing parts [s]	eDiM [s]
1…												
2…												
…												
…												
…												
N												

387 **Table A.2 — Proposed MOST sequences for the removal of fasteners**

Fasteners	**Fastener characteristics**	**Tool**	**MOST sequence**	**TMU**	**Time (s)**
Screw	Length < 2 X diameter (D)				
Type 1	Screw D < = 6 mm	Power tool	|L3|	30	1.1
Type 2	Screw 6 mm < D < 25mm	Power tool	|L6|	60	2.2
Type 3	Screw D < = 6 mm	Screwdriver	|L10|	100	3.6
Snapfit					
Type 1	Force < 5 N	Hand	|L1|	10	0.4
Type 2	5 < Force < 20 N	Screwdriver	|L3|	30	1.1
Type 3	20 *N* < Force	Screwdriver	|L6|	60	2.2
Hinge					
Type 1	Force < 5 N	Hand	|L1|	10	0.4
Type 2	5 *N* < Force < 20 N	Hand	|L3|	30	1.1
Type 3	20 *N* < Force	Hand	|L6|	60	2.2
Cable Plug					
Type1	Force < 5 N	Hand	|L1|	10	0.4
Type2	5 *N* < Force < 20 N	Hand	|L3|	30	1.1
Type3	20 *N* < Force	Hand	|L6|	60	2.2
Clamp					
Type1	Force < 5 N	Hand	|L1|	10	0.4
Type2	5 *N* < Force < 20 N	Hand	|L3|	30	1.1

Fasteners	Fastener characteristics	Tool	MOST sequence	TMU	Time (s)
Type3	20 *N* < Force	Screwdriver	|L6|	60	2.2
Tape					
Type1	Force < 5 N	Hand	|L1|	10	0.4
Type2	5 *N* < Force < 20 N	Hand	|L3|	30	1.1
Type3	20 *N* < Force	Hand	|L6|	60	2.2

388 **Table A.3 — Example of table of reference values (time) for standard disassembly tasks based on**
389 **MOST sequences**

Disassembly task	Description	Sequence	TMU	Time (s/task)
Tool Change	Fetch and Put back	|A1B0G1|+|A1B0P1|	40	1.4
Identifying	Localizing fasteners			
	Visible are > 0.05 mm^2			0
	Hidden are < 0.05 mm^2	|T10|	100	3.6
Manipulation	Product handling to access fasteners	|A1B0G1|+|L3 |	50	1.8
Positioning	Positioning tool onto fastener	|A1B0P3A0|	40	1.4
Removing	Removing separated components	|A1B0G1| + |A1B0P1|	40	1.4

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[7] prEN 45552, *General method for the assessment of the durability of energy-related products*