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Technical product documentation — Design for manufacturing, assembling, disassembling and end-of-life processing —

Part 1: General concepts and requirements

Conception et documentation pour la fabrication, le montage, le démontage et le traitement en fin de vie (MADE) —

Partie 1: Concepts généraux, processus et exigences

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 10, *Technical product documentation*.

A list of all parts in the ISO 8887 series can be found on the ISO website.

Introduction

In recent years, policy makers throughout the world have focused their attention on ways to reduce environmental impact. In many countries, this has led to, or will soon lead to, new incentives with the result that end-of-life processes now need to be considered at the design stage. Consequently, there is an increasing focus on not only the production of a product but also what is to be done when the user has finished with it. Thus, this document includes consideration of disassembling the product and the treatment of the components through processes such as reworking, recycling, reusing or disposing.

This document aims to specify the documentation requirements for integrating these environmental aspects into the design and development of products. It relates to the following four stages:

With regard to production:

— the manufacturing of the components;

— the assembling of the components to produce a product.

With regard to end of use:

— the disassembling into component parts;

— the end-of-life processing of those components.

It addresses the design task, irrespective of whether the designer works for a manufacturer, a design company, or is freelance. It is applicable to all types of manufactured products.

This document expands the life cycle model in ISO 15226 to cover multiple life cycles.

Technical product documentation — Design for manufacturing, assembling, disassembling and end-of-life processing —

Part 1: General concepts and requirements

1 Scope

This document specifies the requirements for the preparation, content and structure of technical product documentation (TPD) of design output for the cycles of manufacturing, assembling, disassembling and end-of-life processing of products. It describes the TPD needed at the critical stages of a design process.

It identifies and describes methods and conventions appropriate to the preparation of documentation, in whatever form, necessary to realize a design including the application to multiple life cycles. It extends beyond specification for the manufacturing and assembling of products to incorporate guidance on the ultimate reusing, recovering, recycling and disposing of the components and materials used.

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.

ISO 10209, *Technical product documentation — Vocabulary — Terms relating to technical drawings, product definition and related documentation*

ISO 11442, *Technical product documentation — Document management*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms, definitions and abbreviated terms given in ISO 10209 and the following apply.

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
assembling
bringing together of components in a functional relationship

3.1.2
brief
working document which specifies at any point in time the relevant needs and aims, the resources of the client and user, the context of the project and any appropriate design requirements within which all subsequent briefing (when needed) and designing can take place

Note 1 to entry: The term "design brief" is used interchangeably with "brief" in this document.

[SOURCE: ISO 10209:2012, 11.18, modified — Note 1 to entry has been added.]

3.1.3
disassembling
taking apart of an assembled product into constituent materials and/or components

3.1.4
end-of-life
point at which a product or component is taken out of use

3.1.5
manufacturing
production of components

3.1.6
recycling
action of reprocessing a material or component which has previously been processed for inclusion in a product

3.1.7
renewable
replenishable naturally at source at a rate at least the same as consumption

Note 1 to entry: This can apply to materials and energy.

3.1.8
recovery
process in which waste material is either treated to release materials in a form where they can be used again, or used as fuel in energy recovery

3.2 Abbreviated terms

TPD technical product documentation

TPS technical product specification

4 Documentation

4.1 Design aims

This document is intended to describe the considerations to be applied during the design and manufacturing processes in order to document and record the utilization of the materials and components of a product to optimize their efficient use through multiple life cycles. This holistic approach (see the schematic diagram in Figure 1) has the potential to lower long-term costs and to minimize the environmental impact, for example, by reducing the need for obtaining and processing new materials.

NOTE For more information on the design stages within the product development process, see, for example, ISO 11442:2006, Figure 1.

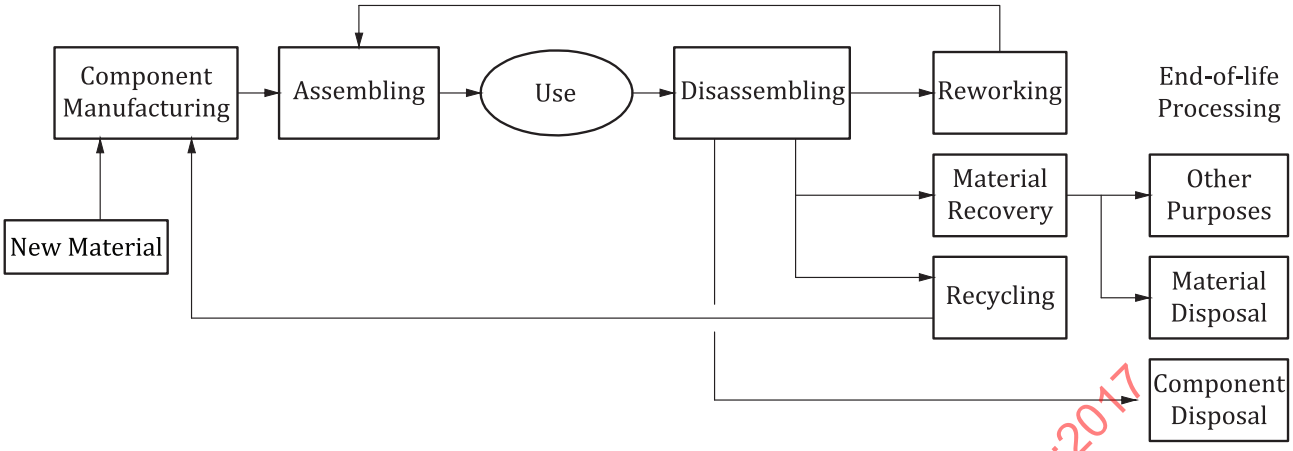

Figure 1 — Basic stages in the life cycle of a product

4.2 Design documentation

Design documentation for manufacturing, assembling, disassembling and end-of-life processing shall be prepared, maintained, and archived so that the information is available for reference, maintenance and further development (see ISO 11442).

Design documentation should include a record of the reasoning behind all basic design decisions (see 4.3 to 4.8), as well as the resulting TPS, to provide the information which may be required for further decisions.

Design is an iterative process. Each stage of the process should be recorded in the documentation. Initial options for design solutions which will meet the requirements of the design brief are assessed to find that solution with the best potential for meeting the brief.

4.3 Design brief

The design brief is a documentation collating the set of requirements which identify and define a perceived market need. The design brief includes the following, which are expanded in Table 1:

— establishment of market/customer need;

— determination of technical feasibility;

— assessment of serviceability;

— consideration of end-of-life implications.

Table 1 is presented in the form of a checklist of subjects to be considered as potential elements of a design brief that may be included, as appropriate. This list is not necessarily exhaustive for any particular project and the format is provided by way of example only although it might be of assistance to users.

Table 1 — Typical parameters for consideration in the preparation of a design brief

Market/customer need	Technical feasibility	Serviceability	End-of-life
— Market sensitivity — Sales potential — Competition — Opportunities — Aesthetics — Price — Potential for on-going development — Impact on company image — Performance — Potential benefits of sale as a function rather than a product — Confidentiality — Time scale — Quantity required — Inclusive design	— Material (suitability and performance) — Available processes, including quality and conformance — Health and safety — Prototyping — Function verification — Risk assessment — Milestones	— Ease and practicality of access to relevant levels (e.g. module/component) — Required tools (cost and availability) — Health and safety — Skills requirement — Repair — Upgradability — Spare stock implications	— Materials — Manufacturing processes — Product operation — Life cycle assessment — Legal constraints — Whole life costs — Health and safety — Recovery of materials — Recycling — Recovery of energy — Reuse — Ease and practicality of disassembling
NOTE For further detail on end-of-life, see Annex B.			

4.4 Design concept

The output of the above process in 4.3 shall be the documentation of the preferred design concept. As a result of this process, new information may have become apparent which results in a modification of the original design brief.

The conceptual design stage should conclude with preparation of a set of design TPD.

These documents shall form the basis for a decision on whether to proceed with the design or to conclude that the design brief (see 4.3 and Table 1) cannot be adequately met or needs revision.

4.5 Iterative stages

At each refinement stage, the current state of the design shall be adequately defined to allow an analysis against the requirements of the design brief (see Table 1). As the design is refined, consideration of the appropriate materials and manufacturing processes can be undertaken including the number of components and ease of assembling and disassembling (see Annex A) and life cycle considerations (see Annex B).

When the requirements are fully met, the details of the product may then be defined as a specification for manufacturing.

For all but the simplest of products, the design task is usually broken down by function and level of detail, and the iterative process applied to each. All non-trivial decision processes should be documented.

4.6 Design archives

Design records shall be retained for purposes beyond the manufacturing phase in accordance with ISO 11442. These typically include:

a) records of design decisions and the reasoning behind them;

b) records of manufacturing decisions and the reasoning behind them;

c) other design information necessary for end-of-life decisions (see Annex B);

d) performance and results of modelling;

e) identity of legislative requirements and standards requirements;

f) product use documentation, including user and maintenance instructions;

g) intellectual property rights implications (e.g. patents, software rights, etc.).

4.7 Manufacturing and assembling documentation

Manufacturing and assembling documentation shall be prepared, maintained and archived so that records are available of how the product is made including information about particular batches of the product or individual products. This documentation typically includes the following:

a) design drawings (2D) and 3D models;

b) bills of material, including materials from previous life cycles;

c) purchasing information;

d) manufacturing process information;

e) assembling information;

f) jigs and fixtures;

g) relevant test specifications and results;

h) system integration procedures;

i) drawings/specifications for test equipment and tooling;

j) copies of test certificates, certificates of conformity, traceability information on the materials used and other appropriate quality control information;

k) manufacturing and assembling information necessary for end-of-life decisions (see 4.8).

Decisions on manufacturing processes are made in a similar iterative way to the design phase (see 4.5) and should be documented in a similar way.

4.8 Disassembling and end-of-life processing documentation

Documentation relevant to disassembling and end-of-life processing shall be prepared, maintained, and archived so that the materials and components of a product can be utilized to optimize their efficient use through multiple life cycles. This documentation will evolve through the information from:

— previous life cycles;

— design/manufacturing/use stages (4.2 to 4.7);

— end-of-life decisions.

This information will continue to evolve through further life cycles of the product and/or its components.

The disassembling and end-of-life documentation shall typically include:

a) records of maintenance and use;

b) changes in customer requirements;

c) changes in manufacturing capability;

d) identification of materials;

e) information on any take-back scheme.

Annex A
(informative)

Number of components and ease of assembling and disassembling

A.1 Number of components

A major factor in the application of design for assembling is the minimization of the number of components (also known as "part count"). This is necessary because it is the major contributor to the component holding and handling costs. If a component is eliminated, it does not need to be ordered, received, catalogued, handled or assembled. There are various techniques available to the designer which may be employed to minimize the number of components. By way of demonstration, the widely used Boothroyd and Dewhurst[5] technique is described in this annex.

For each component in the assembly, answers to the following questions need to be determined.

a) During operation, does the component move relative to other components already assembled?

b) Is it necessary that the component be of a different material from other components already assembled?

c) Is it necessary that the component be separable from all other components for inspection, maintenance or adjustment?

d) Is it necessary that the component be separable for end-of-life processing?

For any component, if the answer to all the questions is "no", that component is a candidate for elimination. The designer then decides, in accordance with all other design constraints, whether that component can be removed or amalgamated. This produces an initial design from which assembling times are determined, in accordance with the mode of assembling to be used (manual or machine).

The various designs are then compared and the most appropriate design selected.

A.2 Components in the assembly

The following should be taken into account for each component in an assembly:

a) tolerances;

b) geometrical tolerances;

c) surface finish.

A.3 Ease of assembling and disassembling

The design of each individual component needs to be considered with respect to its ease of assembling and disassembling (see also Annex B).

The following aspects are typically included in the consideration of assembling and disassembling.

a) Maximize reliability of each assembling operation through the use of chamfers, avoidance of sharp corners and unnecessarily tight tolerances.

b) Aid individual component-orientation through either the use of symmetry or the use of significant asymmetry.

c) Use the principles of modularity so that assemblies and sub-assemblies can be built and tested independently.

d) Avoid the use of fasteners/fastening systems which mitigate against disassembling for end-of-life processing.

e) Avoid the use of permanent joining methods.

f) Use techniques such that if a component is mis-assembled, subsequent components cannot be assembled.

Annex B
(informative)

Life cycle considerations

B.1 General

In order to minimize environmental impact throughout the life cycle, the following issues should be addressed:

a) materials and components sourcing;

b) manufacturing processes;

c) product use and maintenance;

d) disassembling and end-of-life processing;

e) costs, savings and income.

The output from this process is a set of documents which identify the extent to which life cycle impact has been addressed, the methods used and the reasons for subsequent design decisions.

Some of the recommendations might constrain the application of others, according to particular design features. This requires the judgement of the designer and/or relevant colleagues.

Issues concerning the transport of raw materials, and intermediate and final products, have not been addressed in this annex as the factors involved are beyond the control or influence of the design function.

B.2 Materials and components sourcing

In selecting materials and components, the following should be considered.

a) Use materials which are as ubiquitous and abundant as possible.

b) Use materials and components which are as local in origin as possible.

c) Use less dense (lighter) materials, unless density contributes to lower energy or materials requirements of the product in use which outweigh the additional energy and material embodied in the product. Construction products and products requiring toughness are good examples of where this might apply.

d) Use materials with low embodied energy (that is, the energy used to extract, harvest or gather them from source, process and transport to the manufacturing facility).

e) Maximize the use of materials which can be extracted, harvested or gathered from source with zero or minimal collateral material not intended for the product.

f) Where possible, use materials which can perform or support more than one of the product functions.

g) Use renewable or recycled materials, which are environmentally and physiologically benign, where appropriate.

h) Reuse fit for purpose components.

B.3 Manufacturing processes

In specifying manufacturing processes, the following should be considered.

a) Materials

- Maximize the use of near net shape forming processes.
- Maximize precision of materials processing down to the smallest scale necessary for maximum material economy.
- Maximize capture and reuse of materials arising as waste during process (aim for zero waste residue from process).
- Minimize particulate emissions to air, land and water.
- Minimize materials which are/will be classified as hazardous waste at end-of-life.

b) Energy

- Consider alternative process technologies which are thermodynamically more efficient.
- Minimize energy input to chosen process.
- Maximize energy efficiency of chosen process.
- Maximize capture and use of waste process energy (both heat and power).
- Maximize use of renewably-sourced energy.

c) Water

- Minimize use of process water.
- Maximize capture and reuse of waste water, cleaned as necessary.

d) Chemicals

- Maximize use of process and product chemicals proven to be non-hazardous (benign) to health and environment.
- Maximize recovery, regeneration and reuse of process chemicals.

B.4 Disassembling and end-of-life processing

Most materials used in industrial societies require mechanical operations to disassemble, rework and recycle them. The main environmental issues arising from this are the use of carbon-positive energy and emissions of toxins and pollutants from materials (as well as from combustion of fuel for machinery).

The optimum approach to materials recycling involves the transformation of a material up or down in quality to a level suitable for use within a designated new product or class of product, through non-mechanical (microbial, biochemical, benign chemical) or energy efficient and zero carbon mechanical processes. Materials might have been chosen at earlier stages of the design process which enable this approach; otherwise, the following checklist enables the energy and emissions impacts of disassembling, reworking and recycling to be minimized.

a) Materials and components

- Minimize non-biodegradable materials.
- Maximize use of recyclable materials and take account of emerging technologies such as thermoset polymers which are switchable, under defined conditions, to thermoplastics.

