INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDE 114

First edition
2005-05

Environmentally conscious design – Integrating environmental aspects into design and development of electrotechnical products

Reference number
GUIDE 114:2005(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/online_news/ justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDE 114

First edition
2005-05

Environmentally conscious design – Integrating environmental aspects into design and development of electrotechnical products

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE S

For price, see current catalogue

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENVIRONMENTALLY CONSCIOUS DESIGN – INTEGRATING ENVIRONMENTAL ASPECTS INTO DESIGN AND DEVELOPMENT OF ELECTROTECHNICAL PRODUCTS

FOREWORD

This first edition of IEC Guide 114 has been prepared in accordance with Annex A of Part 1 of the ISO/IEC Directives by the Advisory Committee on Environmental Aspects (ACEA).

The text of this guide is based on the following documents:

Approval document	Report on voting
C/1357/DV	C/1369/RV

Full information on the voting for the approval of this guide can be found in the report on voting indicated in the above table.

INTRODUCTION

Every product has an effect on the environment, which may occur at any or all stages of its life cycle – raw-material acquisition, manufacture, distribution, use, and disposal. These effects may range from slight to significant; they may be short-term or long-term; and they may occur at the local, regional or global level (or a combination thereof).

The interest of customers, users, developers and others in the environmental aspects and effects of products is increasing. The information provided by this document may also be of interest to external stakeholders who are not directly involved in the product design and development process.

Anticipating or identifying the environmental aspects of a product throughout its life cycle may be complex. The environmental aspects of a product must also be balanced against other factors, such as its intended use, performance, safety and health, cost, marketability, quality, and legal and regulatory requirements. It is important to consider its function within the context of the system where it will be used.

The process of integrating environmental aspects into product design and development must be continuous and flexible, promoting creativity and maximizing innovation and opportunities for environmental improvement. As a basis for this integration, environmental issues may be addressed in the policies and strategies of the organization involved.

Early identification and planning enable organizations to make effective decisions about environmental aspects that they control and to understand better how their decisions may affect environmental aspects controlled by others – for example, at the raw-material acquisition or end-of-life stages.

The widespread use of electrotechnical products has drawn increased attention to their effects on the environment. In many countries all over the world, this has resulted in the adoption of electrical and electronic equipment regulations affecting wastes, hazardous substances and energy efficiency.

The purpose of this document is to help designers of electrotechnical products appropriately to manage related environmental issues within the design process. Principles of integrating environmental aspects into product design and development have been described in ISO 14062. Though electrotechnical products have some specific features which have given rise to the present document, some aspects of ISO 14062 have been taken up in this document to make it capable of standing alone.

Subsequent sector-specific design documents may be developed to address specific sector needs not covered in this document.

ENVIRONMENTALLY CONSCIOUS DESIGN – INTEGRATING ENVIRONMENTAL ASPECTS INTO DESIGN AND DEVELOPMENT OF ELECTROTECHNICAL PRODUCTS

1 Scope

IEC Guide 114 describes concepts relating to the integration of environmental aspects into electrotechnical product design and development. It is intended for use by all those involved in the design and development of products, regardless of organization type, size, location and complexity, and for all types of electrical and electronic equipment, whether new or modified. It is written for those directly involved in the process of product development and for those responsible for the policy and decision-making process within the organization.

2 Reference documents

ISO 1043 (all parts), *Plastics – Symbols and abbreviated terms*

ISO 9000:2000, *Quality management systems – Fundamentals and vocabulary*

ISO 11469:2000, *Plastics – Generic identification and marking of plastics products*

ISO 14001:1996, *Environmental management systems – Specification with guidance for use*

ISO 14040:1997, *Environmental management – Life cycle assessment – Principles and framework*

ISO/TR 14062:2002, *Environmental management – Integrating environmental aspects into product design and development*

IEC Guide 109:2003, *Environmental aspects – Inclusion in electrotechnical product standards*

3 Terms and definitions

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

3.1
consumable
user-replaceable part or piece of equipment that manufacturers place on the market for direct sale for use in equipment

NOTE Examples of consumables include printer cartridges and photographic films.

3.2
design and development
set of processes that transform requirements into specified characteristics or into the specification of a product, process or system

NOTE 1 The terms "design" and "development" are sometimes used synonymously and sometimes used to define different stages of the overall process of turning an idea into a product.

[ISO 9000:2000, definition 3.4.4]

NOTE 2 Product development is the process of taking a product idea from planning to market launch and reviewing the product, in which business strategies, marketing considerations, research methods and design aspects are used to take a product to a point of practical use. It includes improvements or modifications to existing products or processes.

3.3
design specification
specification which describes how to meet the functional requirements that are set by the performance specification

3.4
environment
surroundings in which a product operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation

NOTE Surroundings in this context extend from within a product to the global system.

[ISO 14001:1996, definition 3.2]

3.5
environmental aspect
element of an organization's activities, products or services that can interact with the environment

NOTE A significant environmental aspect is an environmental aspect that has or can have a significant environmental impact

[ISO 14001:1996, definition 3.3]

3.6
environmental impact
any change to the environment, whether adverse or beneficial, wholly or partly resulting from an organization's activities, products or services

[ISO 14001:1996, definition 3.4]

3.7
field replaceable unit
part, component or subassembly that is easily removed (mechanically disjointed) using ordinary tools

NOTE "Easily removed" consists of using ordinary tools to perform such functions as screwing or disconnecting, and only without irreversibly destroying the unit.

3.8
life cycle
consecutive and interlinked stages of a product system, from raw-material acquisition or generation of natural resources to the final disposal

[ISO 14040:1997, definition 3.8]

3.9
life cycle assessment (LCA)
compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

[ISO 14040:1997, definition 3.9]

3.10
performance specification
specification, based on the requirement specification, which defines the functional requirements, the context in which the product must operate, and interface and interchangeability characteristics

NOTE It does not state the methods for achieving the required results.

3.11
process
set of interrelated or interacting activities which transform inputs into outputs

NOTE 1 Inputs to a process are generally outputs of other processes.

NOTE 2 Processes in an organization are generally planned and carried out under controlled conditions to add value.

[ISO 9000:2000, definition 3.4.1]

3.12
product system
collection of materially and energetically connected unit processes which performs one or more defined functions

[ISO 14040:1997, definition 3.15]

3.13
requirement specification
specification of the requirements that the product has to fulfil; describes which user groups are aimed at and what basic functions the product should have

4 Strategic considerations

4.1 Goal and potential benefits

The goal of integrating environmental aspects into product design and development is the reduction of adverse environmental impacts of the product throughout its entire life cycle. In striving towards this goal, multiple benefits can be achieved for the organization, its competitiveness, its customers and other stakeholders. Potential benefits may include

- lower costs by optimizing the use of materials and energy, more efficient processes, reduced waste disposal;
- stimulation of innovation and creativity;
- increase in knowledge about the product, thus facilitating further improvements;
- reduction of risks, such as avoiding non-compliance to regulations or risks of increased costs for end-of-life treatment due to hazardous substances.

4.2 Organizational considerations

The existing policies, strategies and structure of an organization usually take account of their socio-economic context (for example, new regulations on wastes and on substances) and of their stakeholders (customers, competitors, suppliers, etc.). It is important to consider this context, because it may have economic and environmental implications for the organization and can provide valuable guidelines for the integration of environmental aspects into product design and development.

4.3 Product-related considerations

Integration of environmental aspects into product design and development should consider the following product-related issues:

- early integration, i.e. address the environmental aspects early in the design and development process;
- product life cycle, i.e. analyse from raw-material acquisition to end of life (see Figure 1);
- functionality, i.e. how well the product suits the purpose for which it is intended in terms of usability, useful lifetime, reliability, appearance, etc.;

- multi-criteria, i.e. consideration of all relevant environmental impacts and aspects;
- consideration of trade-offs in the process of seeking optimal solutions.

These issues are discussed in more detail in 4.3.2.

4.3.1 General considerations on product-related environmental aspects and impacts

This clause gives a global overview of product-related environmental aspects and impacts, basic issues and strategic environmental objectives.

Products may have a range of environmental aspects (for example, emissions generated, resources consumed) that result in environmental impacts (for example, air, water and soil pollution, climate change).

The environmental impacts of a product are largely determined by the material and energy inputs and outputs generated at all stages of its life cycle (see Figure 1). Environmental impacts can be greatly influenced by the actions of organizations and individuals using the product.

Inputs generally fall into two broad categories: material and energy.

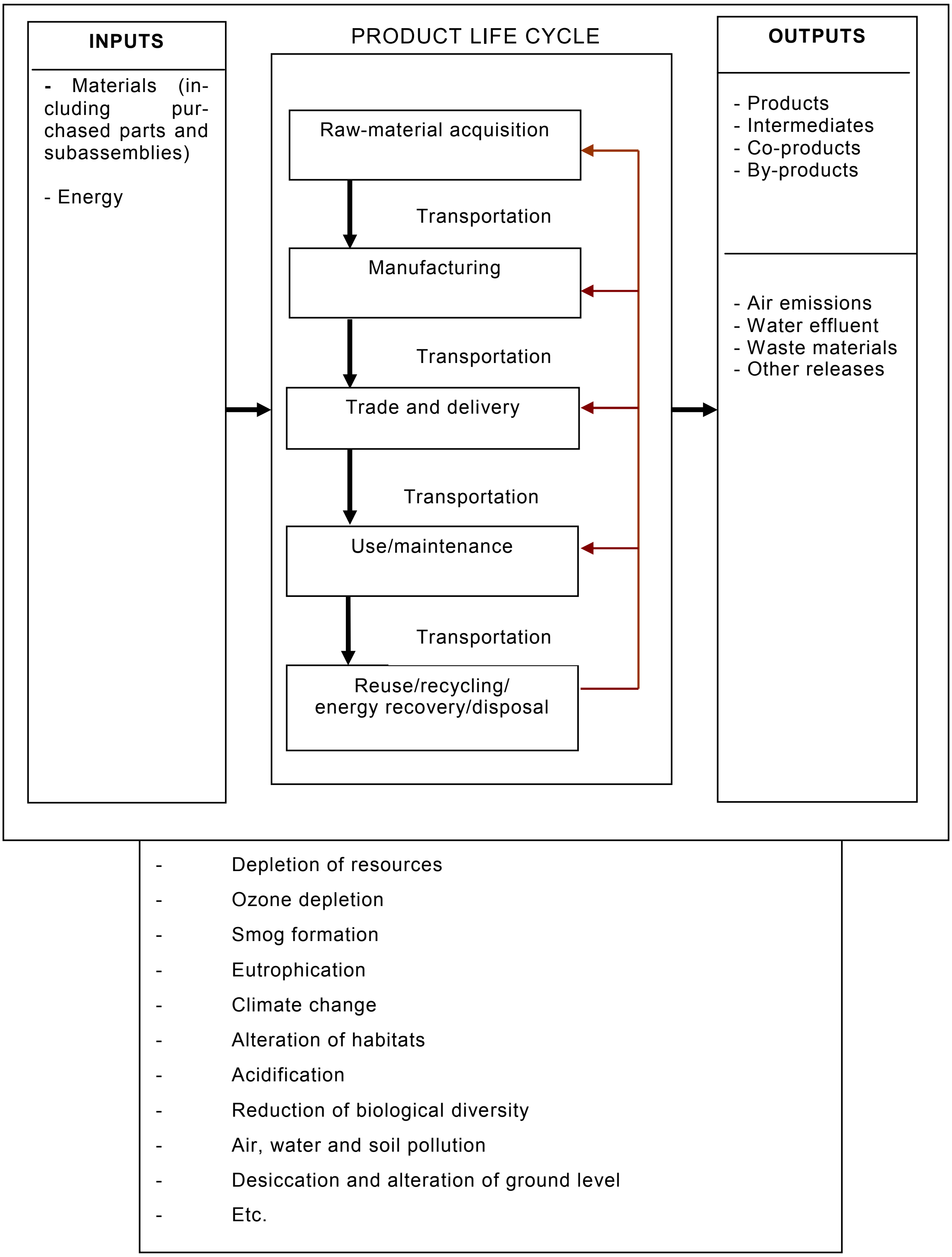
- Material inputs are associated with a variety of environmental aspects; for example, use of resources, exposure of humans and ecological systems to contaminants, emissions to air, water and soil and the generation of waste materials and their accumulation.
- Energy inputs are required at most stages of the life cycle of a product. Energy sources include fossil and biomass fuels, waste materials, nuclear, hydropower, geothermal, solar and wind energy. Each type of energy source has identifiable environmental aspects.

As a rule, energy consumption of an electrotechnical product during the use stage is a very important factor for the determination of its environmental impacts. In many cases, it is the most important one.

Outputs generated during the life cycle of a product fall into several categories: the product itself, intermediates, co-products, by-products and other outputs as described below.

- Air emissions comprise releases of gases, vapours and particulate matter into the air.
- Water effluent discharges comprise discharges of substances to either surface or groundwater.
- Waste is generated during each stage of the life cycle of a product. Waste products can become inputs to other processes, or can be treated, recycled, used as energy sources, incinerated or land-filled.
- Other releases may include noise, electromagnetic fields, etc.

For design and development, it is useful to describe inputs and outputs in terms that are measurable and comparable.



IEC 746/05

Figure 1 – Inputs and outputs and examples of environmental impacts associated with the life cycle of a product

4.3.2 General considerations for integrating environmental aspects into product design

The integration of environmental aspects as early as possible into the product design and development process offers the flexibility to make changes and improvements to products. In contrast, postponing to later stages of the process may preclude the use of desirable environmental options, because all the major technical decisions have already been made.

A life-cycle approach is used to identify the relevant environmental aspects and impacts during the entire product life cycle, thus helping in defining design approaches. It is important to take into account all stages of the life cycle of a product, as shown in Figure 1, and to recognize how products can affect the environment at different stages.

Changing any single input (for example, altering a material used) or influencing a single output (for example, reducing specific emissions or making provisions for reducing hazardous wastes) may affect other inputs or outputs. Therefore, it is important to ensure that any emphasis on a single stage of the life cycle of a product does not unintentionally alter the environmental impacts at another stage, or result in additional impacts on other elements of the local, regional or global environment.

Considering a broad range of potential impacts and environmental criteria and exercising caution when excluding such criteria, help ensure that the reduction of one effect does not result in an increase in another impact.

When developing products, there is considerable value in thinking in terms of functionality (how well the product suits the purpose for which it is intended in terms of usability, useful life time, appearance, etc.) rather than in terms of a specific technical solution. It is, therefore, important to adopt a broad approach when searching for new options and to highlight the functionality required to fulfil customer or user demands and needs. Such thinking may lead to a service solution that has reduced environmental impacts when compared with traditional solutions only based on goods.

In addition to traditional design criteria (for example, performance, quality, cost), a variety of environmental criteria should be taken into account. This generally involves considering a range of different potential environmental impacts, as presented in Figure 1, through a multi-criteria concept.

The organization may recognize that different interested parties (scientific community, government, environmental groups, customers, etc.) may have varying perceptions of the importance of environmental issues. These different perceptions may have relevance for product design and development.

An integrated perspective of, and pragmatic approach to, the different life-cycle stages and environmental aspects can help ensure that adequate solutions are found for dealing with the trade-offs associated with most design decisions. There are three types of trade-offs:

- trade-offs between different environmental aspects; for example, optimizing a product for weight reduction might negatively affect its recyclability. The comparison of potential environmental impacts associated with each option can help decision-makers find the best solution;
- trade-offs between environmental, economic and social benefits. These can be tangible (for example, lower cost, waste reduction), intangible (for example, convenience) and emotional (for example, image). For example, making a product more robust increases the lifetime and, as a result, may benefit the environment by reducing long-term resource use and waste but may also increase initial costs. This may have social as well as economic effects;

- trade-offs between environmental, technical and/or quality aspects; for example, design decisions related to the use of a particular material might negatively affect the reliability and durability of a product, even though this produces environmental benefits.

Experience has shown that the best solutions are specific to the product and the characteristics of the organization. Products are complex and diverse, knowledge and techniques evolve rapidly, and new experience improves the ability to apply novel solutions. It is, therefore, important to find an appropriate strategy for the integration of the environmental aspects into the product design and development process.

4.3.3 Considerations for integrating environmental aspects into electrotechnical product design

While following the general principles presented in 4.3.2, designers of electrotechnical equipment should take into consideration

- new legislation highlighting the importance of waste recovery and energy conservation, and restricting the use of potentially hazardous substances;
- the preponderant role of the use stage which, for many products whose lifetime is long (10 years or more), is the main source of environmental impacts, either directly, for example, water consumption, or indirectly, for example, energy consumption. Production of the energy consumed is an important source of emission of pollutants to air, water or soil.

These specific features of electrotechnical products should be considered by designers as a major source of improvements as part of a life-cycle and multi-criteria approach, so as to avoid “improvements” made to the detriment of other environmental aspects.

Designers of electrotechnical products should consider the elements described in Clause 4 and, for this purpose, follow the approach presented in Clause 5.

5 Models for the integration of environmental aspects into the product design and development process

The environmental compatibility of products is to be tracked throughout the product design and development process, along with their ability to perform the technical function concerned and their economic viability.

A major proportion of the product properties, the manufacturing costs and the environmental effects are determined during the initial phases of the product design and development process so it is important to consider environmental compatibility aspects during the earliest phases. Furthermore, it is important to consider the product in the context of the system in which it is used.

In Figure 2 and Table 1, examples of schemes are outlined for the integration of environmental aspects into the design and development process in the electrical and electronic industry. Different approaches may be applied within this industry; the scheme described here should be applicable analogously if other models and other terminologies are used.

The objectives and main points of focus of environmentally conscious design (ECD) are to be laid down during the product strategy and product profile development phases on the basis of a product evaluation process. The objectives and points of focus are set down in the requirement specification.

Concepts for achieving environmental objectives are set down during the product concept development, thereby specifying the environmental product features. The concepts and attributes are incorporated into the performance specification.

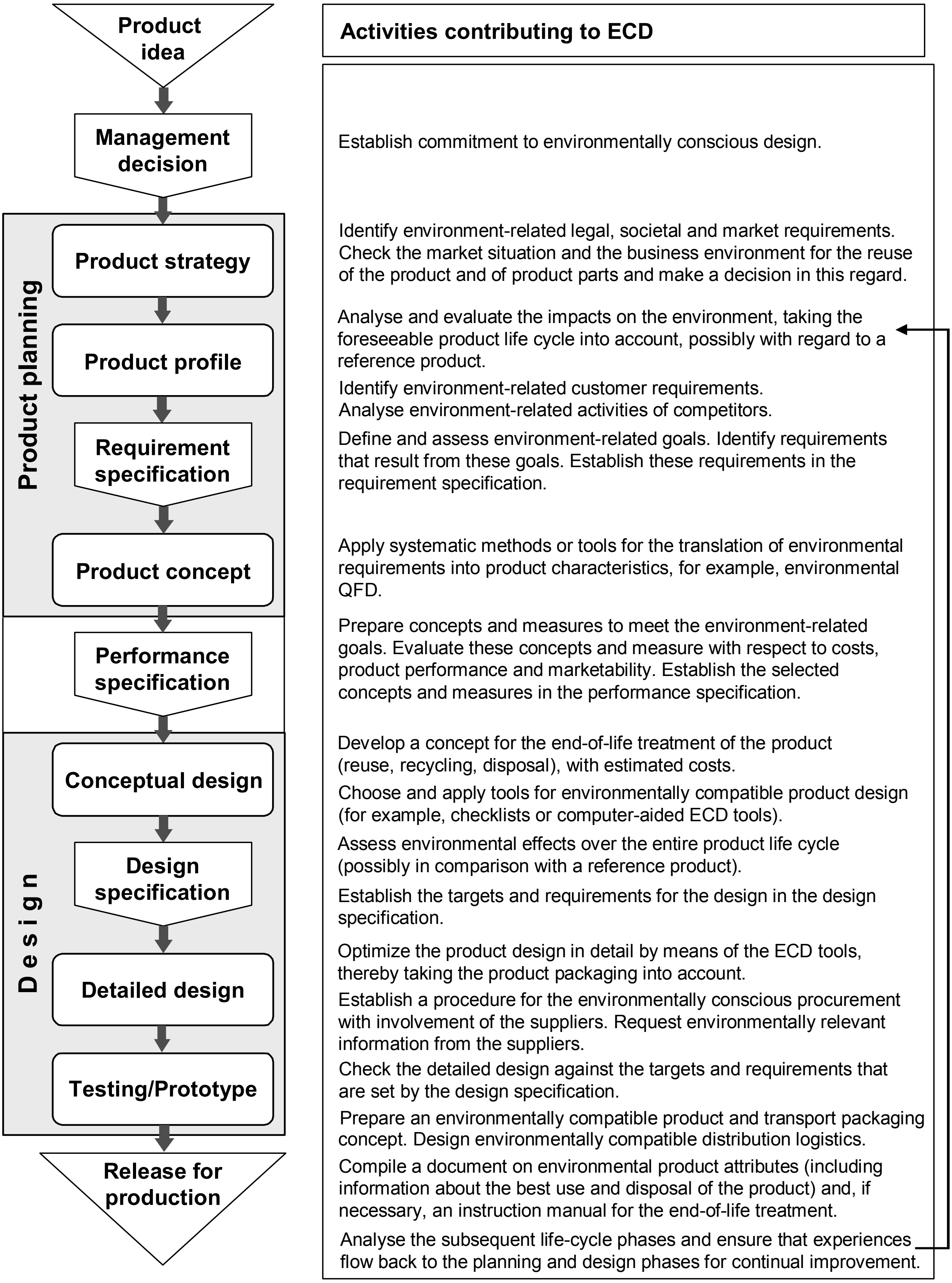
Fixed points within the product design process are to be identified for target/actual comparison.

The concepts are put into increasingly detailed concrete form during the remaining phases of the product design. Tools for ECD such as checklists and computer-aided methods are employed here to support well-founded design decisions.

The product features achieved as a result of ECD are documented in the design specification.

Experience from the subsequent manufacturing, sales, product usage, maintenance and disposal stages should be gathered and evaluated in order to continually improve the process of environmentally compatible product design.

Figure 2 shows a possible standard model of the integration of environmental aspects into the product design and development process, describing the correlation of activities contributing to ECD with typical stages and documentation of this process.



QFD = Quality Function Deployment

IEC 747/05

Figure 2 – Integration of environmental aspects into the design and development process in the electrical and electronic industries: possible model 1

An alternative as well as supplementary model for the integration of environmental aspects into product design and development is shown in Table 1. The basic premise of this approach is that there is a reference product of which environmental aspects are to be improved. A total of 12 steps for product improvement are delineated, spanning from the identification of the technical parameters of a product to the generation of the product concept, for the integration for environmental aspects mainly occurs during the product planning and conceptual design phases.

Table 1 – Integration of environmental aspects into the design and development process in the electrical and electronic industries: possible model 2

Step	Leading questions	Tasks
1	What product is to be redesigned?	Describing the product with technical parameters
2	Who are the customers and what do they expect from the product?	Identifying customer and stakeholders needs
3	What are the competitor's strength and weakness?	Benchmarking with the competitor's products
4	What are the key environmental weaknesses of my product throughout its entire life-cycle stages?	Performing environmental assessment based on life-cycle thinking and/or LCA
5	How to combine customer's needs, benchmarking results and environmental assessment results into common improvement tasks?	Developing environmental parameters and redesign specifications
6	Which ecodesign strategies and guidelines should be adopted for the identified redesign specifications?	Performing checklist operation to determine redesign tasks
7	What are the relevant functions of the reference product?	Performing function analysis of the reference product
8	What are possible new functions of the redesigned product?	Adding new functions to, and/or modifying, functions of the reference product
9	How to generate new ideas for the specific function of the product?	Performing creativity session and/or searching patents
10	How to generate product concept variants?	Assembling ideas corresponding to each function of the redesigned product
11	How to select the best product concept variant?	Evaluating variants against criteria such as economic, technical, social, and environmental ones
12	What to do next?	Continuing detailed embodiment design, layout, testing, prototype, production and market launch

Reference: Wimmer W., Zust R., and Lee K., "Ecodesign Implementation: A systematic guidance to integrating environmental aspects into product development", Kluwer Academic Press, 2004 (in print).

6 Design considerations in the development process of electrotechnical products

6.1 General

According to the above principles of ECD, the development process of an electrotechnical product should include the following steps:

– identification of significant environmental aspects (see 6.2);

– development of the improvement alternatives or options (see 6.3);

– final assessment to check effectiveness of improvements (see 6.4).

6.2 Identification of significant environmental aspects

As a first step in ECD, i.e. integrating environmental aspects into the design of electrotechnical products, identification of significant environmental aspects or key issues related to the product throughout its entire life cycle is required. The key issues include those activities, processes, and materials which involve potential problems, associated with the product from raw-material acquisition, manufacturing, distribution, use, and disposal, i.e. the entire life cycle.

Since a product cannot exist without materials, components, transport, disposal or energy, identification of key environmental issues of the product in its entire life cycle is a complicated but essential process. Analysis of the contributions of each process and each activity to the overall life-cycle impact can be used for the identification of key issues of a product system.

In general, the following aspects should be kept in mind during the analysis of the environmental impacts of electrotechnical products:

- materials should not be arbitrarily excluded;
- all the environmental characteristics of a product should be taken into account;
- the most relevant environmental impacts during the product's life cycle should be identified;
- consideration should be given to impacts generated by intermediate products or auxiliary materials that are associated with manufacture but are not present in the finished product;
- consideration should be given to a component or element arbitrarily considered as being minor that may turn out to have significant environmental impacts;
- focus should be placed not only on the environmental impacts of the product itself but also of the system in which the product will perform;
- environmental impacts should not be shifted from one life-cycle phase to another or from one medium to another.

Commonly used tools for the analysis of environmental aspects of a product are classified into quantitative and qualitative, depending on the nature of the information produced by the tools.

– In general, quantitative information yields numeric values based on reasonably objective methods; thus, the information may be quite reliable. However, the analysis requires highly skilled experts and often involves complicated processes.
– Qualitative information yields results based on pre-set parameters for the analysis and evaluates those parameters qualitatively; thus, the reliability of the information is relatively low, but the analysis can be carried out quickly and simply.

Simplified quantitative life-cycle methods are being developed to provide designers with tools adapted to their real needs. Such an approach may be based on two elements that could be construed as contradictory: the assessment of the environmental impact of a product throughout its entire life cycle with accuracy and the minimization of the cost and time required for the assessment. Simplification can be classified into two different approaches: one is the approach that reduces the effort required for data collection (quantitative) and the other is the qualitative approach. Use of similar data, omitting certain life-cycle stages and exclusion of particular inventory parameters, are examples of the quantitative approach. The qualitative approach includes, among others, focusing only on particular types of environmental impacts or issues. Generic databases may be used for this assessment, which serves to identify significant environmental aspects and to quantify progress made.

Assessments of, and improvements in, the environmental performance of the product must be made by comparing not products but equivalent functional units. The assessment should concentrate on, and give priority to, those factors which can be substantially influenced through product design.

A significant aspect is defined as an aspect which predominantly contributes either to the global environmental impacts or to a priority environmental item of the policy of the organization.

Once the significant aspects have been identified, a multi-criteria analysis will provide information, making it possible to prioritize the goals of improved solutions with the ongoing concern of continuously reducing the environmental impacts of products.

6.3 Search for improvements

Evaluation of, and efforts towards, reducing the environmental effects of the product should be made at every key stage of its development, so as to maintain a compromise between the fulfilment of the product specifications and the consideration of environmental concerns.

The designer should evaluate alternative design solutions with the aim of achieving a reduction in the environmental impacts of the product. The choice of a specific design solution should achieve a reasonable balance between the various environmental aspects and between environmental aspects and other relevant considerations, such as safety and health, technical requirements, functionality, quality, performance and economic aspects, including manufacturing costs and marketability, while complying with all relevant legislation.

The following paragraphs give some indications on how to address possible significant environmental aspects.

6.3.1 Improvement of materials efficiency

Generally speaking, reduction of material consumption is viewed as a

a) reduction in the volume of resources used in manufacturing a product;

b) reduction in resources consumed in operation of the product;

c) reduction in the use of resources through extended use of the product.

A designer should recognize that an effective means of reducing raw materials used in manufacturing a product would be to use recycled material, reduce the size, and study the product structure. Through such means, products can be made with less material and/or volume to the greatest possible extent while delivering features and functions identical to those of conventional products.

Reduction in the use of consumables for the product should also be promoted. From the standpoint of efficient use of natural resources, extended use with longer product life will ultimately contribute to the conservation of natural resources. This should apply not only to the product itself, but also to peripherals and supplies, such as the use of recycled paper for the product documentation.

Product packaging and packaging for protection or stabilization during transport should also be considered when designing a product, since it becomes superfluous when separated from the content. The evaluation should be conducted with a view to reducing the volume and mass of packaging material and utilizing the resources effectively. Reduction in volume and mass of packaging material is expected to be especially effective in diminishing environmental effects at the distribution stage. With less packaging material to deal with at disposal or recycling, transport efficiency will improve and environmental impacts will be reduced.

6.3.2 Avoidance of potentially hazardous substances and materials in the product

Substances (individual and combined) introduced at the various stages of the product life cycle may be hazardous to human health and to the environment. Reducing and/or eliminating potentially hazardous substances should be a priority in the design of electrical and electronic products. In particular, designers are advised to be aware of international, national and regional prohibitions on the use of certain hazardous substances in products, in order to ensure legal compliance for products sold in targeted countries. The product must comply with all applicable legislation.

Product designers should also attempt to reduce the use of substances that require special handling or disposal during the product use or recovery stage.

In some cases, threshold levels of hazardous substances cannot be achieved without compromising basic product functions. In these cases, designers should make sure that these substances are appropriately identified and easily accessible for removal and safe handling.

Parts or materials that contain more than threshold levels of substances that cannot be recycled or processed appropriately, and other substances regulated or prohibited by laws and regulations, should not be used unless collection and recycling processes for such parts and materials have been established. For parts and materials that must be used to secure product functions, complete replacement with parts and materials with less or controlled quantities of hazardous substances should be implemented.

6.3.3 Improvement of energy efficiency

Energy inputs are required at most stages of the life cycle of every electrotechnical product. As every energy source has its own set of environmental impacts, the more energy an electrotechnical product requires, the more energy has to be produced, and the more the negative impacts on the environment are extensive. It is not the designer's duty to deal with energy sources, but design engineers should consider product design features that reduce energy consumption during every stage of the life of the product.

It is generally accepted that, in most cases, energy consumption during the use of an electrotechnical product accounts for the dominant part of energy consumption. Improving the efficiency of energy use can then significantly reduce the environmental impacts of the product; but that is not always the case, and a complete assessment of the whole life cycle must be carried out to identify the truly significant aspects.

Where energy consumption has thus been shown to be a significant environmental aspect, the following requirements and recommendations should be considered by designers, insofar as they have a practical influence on the product concerned.

a) Identification of the main stages of energy inputs

   A complete evaluation of energy inputs needed for every stage of the life of the product is carried out in order to identify the most significant stage(s). The appraisal should take into consideration the functions and normal usage of the product.

b) Consideration of energy-saving features

   When one of the stages is dominant with respect to other stages, designers may focus their search for improvements on this stage.

   According to the nature of the product, designers may, where relevant, consider the following solutions, given as examples.

   - If the dominant stage is manufacturing,
     - ✓ Product architecture (which can influence assembly processes)
     - ✓ Assembly processes
     - ✓ Etc.

- If the dominant stage is usage,
  - ✓ Power-saving features
  - ✓ Various power modes (for example, off-mode, stand-by, low-power mode, etc.)
  - ✓ Automatic energy management

c) Assessment of improvements

The improvements resulting from the energy-saving features envisaged by the designer should be assessed with continuous feedback on the whole life-cycle impact evaluation, so as to avoid transfer of impacts from one stage to another.

6.3.4 Optimizing functionality

Consider opportunities for multiple functions, modularity, automated control and optimization; compare the environmental performance to that of products tailored for specific use.

6.3.5 Increase of product durability

When defining the lifetime of the product as part of its function, increasing the durability and extending the services associated with the product can reduce adverse environmental impacts. Achieving a balance between the technical lifetime of the product and its useful lifetime (i.e. how long a product is considered useful, before it is obsolete or no longer needed by the user) can also be beneficial.

A designer should bear in mind that possible extension of product lifetime by promoting field-replaceable units, and through component reuse or upgrade, is to be taken into account and implemented at the stage of product development. However, when parts and components collected from used products are reused, the procedure must be carried out carefully, since there are many problems involved in implementation. For reuse of parts and components, a broad range of actions need to be implemented, from new product planning, designing, manufacturing and sales to collection, disassembling and processing, as well as quality assurance. Furthermore, there are numerous technical issues that must be resolved, such as product-life forecast and methods for evaluating reliability.

A designer should recognize that important elements in increasing part and component reuse are selection of reusable parts and components at the stage of product planning and design planning. Therefore, the designer should take into account the sharing of components and parts by a broad range of products, as well as over time, and study the level of part-sharing at the design stage. In addition, it is necessary to determine whether every part or component removed from collected products and cleaned will be suitable for reuse. It is also important to promote the use of these parts in products once again or as repair parts.

6.3.6 Facilitating reuse, recycling and recovery

A designer should recognize that the fundamental approach to recycling requires selection of parts, materials and configurations designed for subsequent recycling, taking into account material recycling first and energy recovery second. One need is to evaluate elements that obstruct recycling. For metals that account for a large part of a product, choice of generic metals that facilitate material recycling (hereinafter called "recycling") is necessary. In energy recovery from, and disposal of, plastics that are difficult to recycle, material selection should be based on environmental considerations. For this reason, it is necessary to have an evaluation method in line with the characteristics of the product to be evaluated in the product planning and design stages, taking into account the stage of end-of-product life, to aid in selection of recyclable materials and parts and in quantitative estimation of material mass in rates.

The method of product disassembly should be quoted with attention to the various elements involved in a product. Evaluation should also be carried out for the tools to be used, the time required for disassembly, the ease of work, etc., when actually disassembling an end-of-life product.

The recycling process should be evaluated on whether technologies and channels have been established for removal of parts to be made available for reuse, recycling and appropriate removal and handling of hazardous parts that are flammable or volatile. Materials that remain after removal of such parts are ground, and recyclable scraps should be sorted. After sorting, the residue should be either incinerated or disposed of in landfills. Attention should be paid to ensuring that such processes do not adversely affect processing facilities.

For ease and safety in the handling of treatment and disposal processes, clear information should be provided to the parties responsible for work related to collection, transport, recycling and disposal of end-of-life products. Evaluation in collection and transport of end-of-life products focuses on product mass, volume, shape and structure in order to assure ease of work and safety. In the case of heavy products, ease in moving and loading should also be taken into account. For both light and heavy products, it is necessary to minimize transport loads and upgrade cargo efficiency.

6.3.7 Additional aspects

6.3.7.1 Batteries

Product designers should choose a battery by comparing the characteristics of each battery type with the requirements of the application. They should also consider the following characteristics of the battery: size, shape, voltage, drain or power requirements, shelf life or storage requirements and costs. The choice of which battery to purchase should not be made initially on the basis of battery disposal and recycling criteria because it has a high chance of leading to the selection of a battery that does not meet the performance requirements of an application. Designers should document the reasons for selecting a specific type of battery based on performance requirements.

Batteries must comply with all applicable restrictions on hazardous substances and all applicable labelling requirements. Batteries should be easily identifiable, given size constraints. Batteries should normally be removable, except where the user is not to remove the battery until the end of life, or there are no special disposal requirements for the battery. Manufacturers of products using batteries should provide information on the proper removal, safe handling and proper disposal of batteries.

6.3.7.2 Consumables

Designers should design electrical and electronic equipment to optimize the use of consumables relative to the functionality of the product. Manufacturers should provide information on the proper use and, where appropriate, end-of-life management of the consumables.

6.3.7.3 Cleaner production and use

Various emissions to the environment may be generated by the product itself or by processes related to it, throughout its life.

- Extraction and transformation of materials and components
- Manufacturing processes (for example, surface treatments)
- Transport for distribution (for example, substances from engines)
- Usage (for example, dust, volatile organic compounds)
- End of life (for example, substances and preparations the product may contain, such as refrigerants; substances generated during waste processes, such as incineration).

It is not the designer’s responsibility to deal with any emission not directly dependent on the product design.

First, the designer must make sure that products comply with all relevant regulations governing such emissions from products. Then he must assess the amount of the various emissions throughout the life of the product, and use this assessment to identify significant emissions and to evaluate alternative design solutions with the aim of reducing the levels of emissions over successive generations of products. The appraisal must take into consideration the functions and normal usage of the product.

The following are examples of the emissions an electrotechnical product may generate:

– acoustical noise;
– emissions to air: volatile organic compounds, greenhouse gases, acidifying chemicals, ozone-depleting substances, persistent organic pollutants, heavy metals, fine particles and suspended particulate matter, dust;
– emissions to water: heavy metals, oxygen-depleting substances, persistent organic pollutants;
– emissions to soil.

6.3.7.4 Plastic material identification

Plastic material should be labelled according to ISO 11469 using the nomenclature given in ISO 1043.

6.4 Assessment to check effectiveness of improvements

As mentioned above, environmental concerns have to be addressed as early as possible in the development process. This permits assessments and improvements on the basis of generic databases. A final assessment should be implemented in an appropriate manner which can secure objectivity of result with disclosure of specific detailed information and final design against the targets and requirements set by the design specification to relevant persons designated by organization's policy. This final assessment should only be aimed at confirming product conformance to the criteria identified above.

A document compiling environmental product attributes should be prepared to support the environmental communication policy of the organization.

Annex A

Checklists

The questions in the checklists do not always point in the same direction. In some cases, they could be dealing with contradictory issues, for example, weight reduction by use of fibre-reinforced plastics versus recyclability. It is important to assess which evaluation criterion has a greater effect on the overall environmental impact of the product. This can be done by means of an appropriate assessment tool in the framework of life-cycle methods (see 6.2).

A.1 Basic considerations

Evaluation criteria	Items to be considered
Are the environmental impacts of the product assessed over the entire life cycle?	Consumption of raw materials Energy consumption Emissions to air, water and land Waste
Are targets for the design and development of the product derived from the environmental assessment?	Resource efficiency Avoidance of hazardous substances Environmentally compatible end-of-life treatment
Are the potentialities for the reuse of the product analysed?	Foreseeable further technological development Quality and reliability aspects Logistic aspects
Is there a need for special end-of-life treatment of the product and, if so, does a concept for the end-of-life treatment of the product exist? Is there a need for special end-of-life treatment?	Reuse of parts, recycling, energy recovery, disposal Logistic aspects

A.2 Resource efficiency

Does the product user get information about resource-saving operating modes?	Energy consumption Material consumption Consumables

A.2.1 Energy efficiency

Has the reduction of energy input for the manufacturing of the product been evaluated?	
Has the reduction of energy consumption of the product during operation been evaluated?	Characteristics of the components
Has the reduction of energy consumption of the product in the non-operation mode been evaluated?	Stand-by mode Sleep mode

A.2.2 Material efficiency

Has the reduction in the amount of materials used been evaluated?	Mass Volume
Are recovered parts and materials (reused components, recycled plastics) used?	
Has there been an evaluation of the reduction of production waste?	Optimized layout of semi-finished parts
Has there been an evaluation of the reduction of product weight?	
Has there been an evaluation of the reduction in mass and volume of packaging?	
Is the packaging reusable or recyclable?	
Has there been an evaluation of the reduction in the consumption of operating materials?	
Has the product been designed for a long useful life?	Foreseeable further technological development Reliability of components
Is the product easily repairable and upgradeable?	

A.3 Materials needing special attention and emissions

Does a systematic approach exist to ensure compliance to all relevant legal restrictions on hazardous substances?	Involvement of the suppliers
Does a systematic approach exist to evaluate the use of non-restricted hazardous substances in product manufacturing?	
Are the hazardous substances contained in the product known?	Materials declaration Involvement of the suppliers
Does a systematic approach exist to evaluate the use of non-restricted hazardous substances as contents of the product?	Involvement of the suppliers
Have emissions of substances during product use been evaluated and do they meet appropriate standards?	
Are emissions of radiation during product use evaluated and do they meet appropriate standards?	Electromagnetic radiation
Has the noise emission during product use been evaluated and does it meet appropriate standards?	

A.4 End-of-life considerations

A.4.1 Reuse

Does the product consist of standardized parts?	
Are parts that are vulnerable to wear easily replaceable?	
Are the surfaces of visible parts resistant to wear and staining?	
Can components be identified that are suitable for reuse?	

A.4.2 Recovery

Has the variety of materials and components been evaluated?	
Are parts that contain hazardous substances easily separable?	
Are the materials recyclable?	Avoidance of non-recyclable composites and coatings Use of compatible or easily detachable labels
Are recyclable plastic parts identifiable?	Marking according to ISO 11469
Have the number and variety of connections between recyclable materials been reduced?	
Are the connections between recyclable materials easily accessible and detachable?	Low number of standard tools Low number of operations

Standards Survey

The IEC would like to offer you the best quality standards possible. To make sure that we continue to meet your needs, your feedback is essential. Would you please take a minute to answer the questions overleaf and fax them to us at +41 22 919 03 00 or mail them to the address below. Thank you!

Customer Service Centre (CSC)

International Electrotechnical Commission
3, rue de Varembé
1211 Genève 20
Switzerland

or

Fax to: **IEC**/CSC at +41 22 919 03 00

Thank you for your contribution to the standards-making process.

Nicht frankieren
Ne pas affranchir

Non affrancare
No stamp required

A Prioritaire

RÉPONSE PAYÉE

SUISSE

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
1211 GENEVA 20
Switzerland

Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: *(e.g. 60601-1-1)*

....

Q2 Please tell us in what capacity(ies) you bought the standard *(tick all that apply).* I am the/a:

- purchasing agent ❑
- librarian ❑
- researcher ❑
- design engineer ❑
- safety engineer ❑
- testing engineer ❑
- marketing specialist ❑
- other...

Q3 I work for/in/as a: *(tick all that apply)*

- manufacturing ❑
- consultant ❑
- government ❑
- test/certification facility ❑
- public utility ❑
- education ❑
- military ❑
- other...

Q4 This standard will be used for: *(tick all that apply)*

- general reference ❑
- product research ❑
- product design/development ❑
- specifications ❑
- tenders ❑
- quality assessment ❑
- certification ❑
- technical documentation ❑
- thesis ❑
- manufacturing ❑
- other...

Q5 This standard meets my needs: *(tick one)*

- not at all ❑
- nearly ❑
- fairly well ❑
- exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

- standard is out of date ❑
- standard is incomplete ❑
- standard is too academic ❑
- standard is too superficial ❑
- title is misleading ❑
- I made the wrong choice ❑
- other ....

Q7 Please assess the standard in the following categories, using the numbers:
(1) unacceptable,
(2) below average,
(3) average,
(4) above average,
(5) exceptional,
(6) not applicable

- timeliness ....
- quality of writing....................................
- technical contents...................................
- logic of arrangement of contents ....
- tables, charts, graphs, figures...............
- other ....

Q8 I read/use the: *(tick one)*

- French text only ❑
- English text only ❑
- both English and French texts ❑

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

....
....
....
....
....
....
....
....
....
....
....
....

ISBN 2-8318-7997-3

9 782831 879970

ICS 13.020

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND