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Plastics — Environmental aspects — General guidelines for their inclusion in standards

Matières plastiques — Aspects liés à l'environnement — Lignes directrices générales pour leur prise en compte dans les normes

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17422 was prepared by Technical Committee ISO/TC 61, *Plastics.*

Annex A of this International Standard is for information only.

Plastics — Environmental aspects — General guidelines for their inclusion in standards

1 Scope

This International Standard provides a structure for inclusion of environmental aspects in standards for plastics products. It proposes an approach which is directed at minimizing any adverse environmental impact without detracting from the primary purpose of ensuring adequate fitness for use of the products under consideration.

The guidance provided by this International Standard is intended primarily for use by standards writers. Over and above its primary purpose, however, the standard provides guidance of value to those involved in design work and other activities where environmental aspects of plastics are being considered.

NOTE This International Standard is intended to promote the following practices:

a) the use of techniques for identifying and assessing the environmental impact of technical provisions in standards, and for minimizing their adverse effects;

b) the adoption of good practices such as:

   1) procedures for pollution avoidance,

   2) material and energy conservation in the light of the intended use (and foreseeable misuse) of the product,

   3) safe use of hazardous substances,

   4) avoidance of technically unjustifiable restrictive practices,

   5) promotion of performance criteria rather than exclusion clauses such as are based, for example, only on chemical composition criteria;

c) the adoption of a balanced approach in standards development to issues such as environmental impact, product function and performance, health and safety, and other regulatory requirements;

d) the regular review and revision of existing standards in the light of technical innovations, permitting improvement in the environmental impact of products and processes;

e) the application of life cycle analytical approaches wherever applicable and technically justifiable.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 472:1999, *Plastics — Vocabulary*

ISO Guide 64:1997, *Guide for the inclusion of environmental aspects in product standards*

3 Terms and definitions

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

3.1
design
a creative activity that, based on expressed or implied needs, existing means and technological possibilities, results in the definition of technical solutions for a product that can be commercially manufactured or fabricated into prototypes

[FD X 30-310:1998]

3.2
eco-profile
partial life cycle inventory analysis beginning at the raw-material extraction phase and ending at the point where the plastics product (see 3.8) is ready for transfer to the next operator in the supply chain (so called cradle-to-gate analysis)

3.3
environmental aspect
element of an organization's activities, products or services that can interact with the environment

[ISO 14001:1996]

3.4
environmental impact
any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services

[ISO 14001:1996]

3.5
environmental provision
normative element of a standard that specifies measures for minimizing adverse environmental impact of a test method, material or product

3.6
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]

3.7
life cycle assessment
LCA
compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle

[ISO 14040:1997]

3.8
plastics product
any material or combination of materials, semi-finished or finished product that is within the scope of ISO/TC 61

3.9
product standard
a standard that specifies requirements to be fulfilled by a product or group of products

4 Inclusion of environmental aspects in standards

4.1 General

In the preparation of International Standards, close co-ordination within and among sub-committees and working groups responsible for different plastics products or processes is necessary in order to create a coherent approach to the incorporation of environmental provisions. Appropriate co-ordination will ensure that such activity on environmental provisions will neither retard nor inhibit the normal standards development process.

Any plan to prepare a new standard or to revise an existing standard with inclusion of environmental provisions should define, as far as possible, both the purpose of the standard and its expected major users. This exercise will help to determine how the standard is likely to be used, for example for quality control or for conformity assessment, to identify the relevant environmental aspects and to assess the users' level of expertise, needs and expectations.

Standards should be drafted with a view to providing provisions which eliminate or reduce any identified environmental hazards, and, where possible, these provisions should be expressed in terms of verifiable preventive measures. Requirements for preventive measures should be expressed precisely, clearly and with technical accuracy, and the requirements for verification should be clearly stated.

Whenever appropriate, the standard should state what environmentally relevant information has to be provided to persons involved with the product or process.

NOTE Use should be made of terminology as defined by ISO 472. This International Standard additionally includes environmental terms.

4.2 Test method standards

4.2.1 General

International standards for the testing of plastics products should also provide scope for application of ISO Guide 64 by drawing attention to the importance of product sustainability issues such as resource conservation and pollution prevention.

Where such issues are already being addressed (for example, within ISO/TC 61/SC 6, *Ageing, chemical and environmental resistance*), this fact should be brought to the attention of the users of the standards by means of an introductory statement within the text of the standard. Standards writers should take this into account whenever existing standards are being revised or new ones are being prepared.

NOTE To avoid unnecessary proliferation of tests, standards writers should consider combining, or selecting between, similar test methods that are used for measuring identical product properties.

4.2.2 Minimization of adverse environmental impact

When test method standards are being written or revised, their associated environmental impact should be evaluated; test equipment and procedures should be reviewed to minimize adverse environmental impact. Such reviews should not in any way compromise the fitness for purpose of the test apparatus or procedure. Once a new test standard with reduced adverse environmental impact has been developed in replacement of an existing procedure, it should be validated and, thereafter, the existing test standard withdrawn.

The following considerations apply:

a) Any substance specified in a standard that becomes the subject of well-founded environmental concern should include the relevant clauses taken from the appropriate Material Safety Data Sheet (MSDS). Whenever possible, such a substance should be replaced by a substance with less adverse environmental impact.

b) Some test method standards may of necessity call for the use of substances that could represent an environmental hazard. In such cases, the standard should include an introductory statement such as:

   WARNING — Certain procedures specified in this International Standard may involve the use or generation of substances, or the generation of waste, that could constitute a local environmental hazard. Reference should be made to appropriate documentation on safe handling and disposal after use.

   This should be followed, at the appropriate place within the standard, by a specific warning statement such as:

   WARNING — Attention is drawn to the potential local environmental hazard deriving from the specified use of... [name of chemical].

4.2.3 Minimization of material and energy usage

The usage of materials and energy is affected by many factors such as the scale of the test, the specimen size and the number of specimens, the required levels of reproducibility and repeatability, and the power specifications of the test equipment.

Test method standards should be designed with a view to minimizing material and energy usage without compromising the quality of the test result obtained through use of the standard.

Where appropriate, guidance should be given to the user of the standard on how to minimize the use of material and energy.

4.3 Product standards

4.3.1 General

Writers of plastics product standards should incorporate a general introductory statement highlighting the fact that ISO 17422 and ISO Guide 64 have been taken into account in the preparation of the standard. In addition, ISO 17422 and ISO Guide 64 should be cited systematically as normative references within future plastics product standards for the benefit of the users of such standards.

4.3.2 Product functionality

Designing a product made of, or incorporating, plastic should avoid over-simplification of material-selection criteria. A balance should be maintained between the overriding functional requirements of the product and the potential adverse environmental impacts that are to be determined in the context of the product/application system.

4.3.3 Environmental aspects in product standards

Optimization of an environmental approach in the development of plastics product standards will usually involve the following stages:

a) the pre-selection of those materials ensuring appropriate technical and environmental performance as well as regulatory compliance throughout the intended service life;

b) short-listing of functional materials that eliminate or minimize major adverse environmental impacts throughout the product life cycle;

c) minimization of the quantities of materials used per unit produced;

d) ease of maintenance and cleaning where appropriate.

The environmental characteristics of the most appropriate material to use in a specific application can be determined only by taking into consideration the complete life cycle. The scope and limitations of life cycle assessment, the subject of the ISO 14040 series of standards, within the context of the present standard are discussed in Annex A.

NOTE 1 The precision of measurement of material properties and characteristics may not always be absolute or correlate to actual end-use performance requirements. Because of this, some degree of subjective assessment may be required in comparing life cycle assessments of alternative designs or materials.

NOTE 2 A bibliography of standards and other references relevant to environmental aspects of design in plastics product standards, including eco-profile data, is given in the bibliography.

4.3.4 Writers of standards

Writers of International Standards for plastics products should consider the potential environmental needs of the users of these standards. In particular, due consideration should be given to the needs of standards writers and specifiers developing environmental provisions for products incorporating or made from plastics; such products are within the scope of other ISO and IEC Technical Committees, as well as within national and industrial technical committees and organizations.

NOTE 1 Examples of such needs could be guidance on environmental impact assessment in applications sectors for plastics film and sheeting and also adhesives, or guidance on waste management options, including sorting and recycling plastics films and sheets.

NOTE 2 Provision of such guidance is already common practice among producers of plastics. This is done, for example, within the Product Stewardship chapter of the Responsible Care Initiative, in Material Safety Data Sheets (MSDSs) and within the context of product sustainability programmes.

Annex A
(informative)

Scope and limitations of life cycle analysis

A.1 General considerations

It is important to recognize that neither the standards writer nor the product manufacturer or designer can control the complete life cycle of a product. Thus, they are obliged to take into account the likely behaviour of the other participants in the life cycle.

For example, there would be little environmental advantage to be gained by developing a standard for a returnable plastic bottle that is technically capable of 500 use-cycles if the bottle is likely to be discarded as waste after only 50 cycles because it is scratched and aesthetically unacceptable to consumers, or because it is known that, on average, bottles only last 5 cycles before vanishing from the system because they are not collected and returned.

A.2 Terms and definitions

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

A.2.1
energy recovery
use of combustible material that would otherwise have been disposed of as waste, but instead has been collected through a managed process, to generate energy through direct incineration, with or without other waste but with recovery of the heat

NOTE From a technical point of view, the term “energy recovery” applies to any process where the calorific value or the sensible heat of a material is wholly, or partially, converted into useful energy.

A.2.2
input
material or energy which enters a unit process

A.2.3
life cycle impact assessment
LCIA
phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system

[ISO 14040:1997]

A.2.4
life cycle inventory analysis
phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system, throughout its life cycle

[ISO 14040:1997]

NOTE As life cycle inventory analysis describes a product system and not the product in isolation, the life cycle data cover factors including materials, design, performance, use pattern and waste management.

A.2.5
mechanical recycling
re-use of a product or its component materials that would otherwise have been disposed of as waste, but instead have been collected for re-utilization through a managed process

NOTE This definition does not generally cover chemical or feedstock recycling processes applied to plastics.

A.2.6
output
material or energy which leaves a unit process

NOTE Such material may include raw materials, intermediate products, finished products, emissions and waste.

A.3 Subdivisions of environmental aspects

Quantitative environmental aspects include such factors as energy, raw materials and the solid, liquid and gaseous wastes that are commonly calculated in life cycle inventory analyses. These aspects may be conveniently evaluated using a matrix similar to that shown in Table A.1 which permits incorporation of the various input and output parameters arranged horizontally and the various stages of the product life cycle arranged vertically. This representation can make it easier to appreciate where and when in the product life cycle environmental effects may occur and how they could be mitigated.

NOTE 1 For standards other than product standards, such as test method standards, this matrix may not be appropriate as shown and, if so, it should be replaced with another format.

Table A.1 — Evaluation of quantitative environmental aspects

Environmental aspects (inputs and outputs)	**Product life cycle**			
	Manufacturing and premanufacturing phase	**Distribution phase including packaging**	**Use phase**	**End-of-life phase**
	A	**B**	**C**	**D**
Resource use Raw-material consumption				
Energy consumption				
Emissions to air Ozone depletion Global warming				
Emissions to water Ecotoxicity				
Emissions to soil Ecotoxicity				
Noise				
Migration of hazardous substances				
Waste-management options				
Risks to the environment from accidents or misuse				

Qualitative environmental aspects are those which there is currently no satisfactory way of quantifying (e.g. biodiversity) and those which there is unlikely ever to be any way of quantifying (e.g. aesthetics).

Global aspects: Greenhouse gas emissions produce a global effect (planetary warming and its consequences).

Regional aspects: Industrial and domestic emission of acidic gases and their contribution to acid rain is a regional effect.

Local aspects: Emission of a toxic chemical from a site is generally a local issue.

NOTE 2 Because of the very large number of environmental aspects that can be identified, the standards writer or product designer must inevitably choose those which are thought to be of the greatest significance. This choice involves subjective judgement. For example, deciding whether the emission of greenhouse gases is more important than the incidence of acid rain is subjective, and it would be even more subjective to decide, for example, that greenhouse gases are 10 times more important than acid rain. It is important to recognize, however, that, as the relevant branches of science or technology advance, subjectivity can progressively be eliminated from the judgement.

A.4 Design parameters

Introducing environmental provisions into the standardization or design process is an important factor in the choice of materials and products. It is important to remember, however, that the consideration of environmental effects is only one of a number of factors that should be taken into account.

Technical requirements such as strength, toughness, thermal conductivity and electrical conductivity should also be taken into account so that the final product satisfies the purpose for which it is intended. Such factors automatically eliminate many materials so that eventually there will be a shortlist of materials that could be used.

A.5 Plastics manufacturing and feedstock considerations

A unique feature of plastics is that they are essentially made from fossil-fuel feedstocks (oil and gas) and, because these feedstocks can also be used as a fuel, it is common practice to describe feedstock in energy terms.

The total energy input required in a polyethylene-manufacturing plant, for example, is the sum of the energy used up in the production process plus the intrinsic fuel energy of the ethylene feedstock which remains within the polymer product. Thus, the total energy required to produce 1 kg of low-density polyethylene is typically given by:

— process energy 30 MJ/kg;

— feedstock energy 51 MJ/kg;

— total energy 81 MJ/kg.

NOTE 1 These values are intended as examples. Differences in feedstock sources or processes may result in different values.

The feedstock energy that remains available within the product is ultimately recoverable, and there are generally two options:

a) Mechanical recycling: The aim here is to spread the primary production energy over as many uses of the material as possible.

b) Energy recovery: The aim in this case is to recover as much of the feedstock energy as possible.

It follows from this that there are two factors to be considered:

a) The process energy of a material represents the maximum energy that can be used in any recycling process before it becomes energetically unfavourable to recycle that material.

b) No matter how many times a plastic is mechanically recycled, the feedstock energy remains unchanged. Thus, mechanical recycling and energy recovery are not mutually exclusive options.

NOTE 2 The hydrocarbon feed in polymer production provides the carbon backbone common to most synthetic polymers. Measured in units of mass, it makes little difference if this hydrocarbon feedstock is methane (natural gas) or crude oil. However, when feedstock is described in terms of energy, the type of feedstock can produce significant variations. For example, the calorific value of methane is 54 MJ/kg and 1 kg of methane will provide 12/16 = 0,75 kg of carbon backbone. This corresponds to an energy of 54/0,75 = 72 MJ/kg of carbon. In contrast, crude oil typically has a calorific value of the order of 45 MJ/kg and, using pentane as a surrogate for naphtha, 1 kg of pentane will provide 60/72 = 0,83 kg of carbon. This corresponds to an energy of 45/0,83 = 54 MJ/kg of carbon. Clearly, therefore, supplying carbon for use as a material using natural gas as the source will lead to a feedstock energy some 33 % higher than supplying the same carbon using crude oil.

Because of this effect, feedstock energy should not be represented as a single parameter but as a pair of parameters separately identifying oil-based and gas-based feedstock. Furthermore, in all comparisons, even between similar polymers, care should be taken to ensure that this feedstock energy is compared on an equivalent basis given that the mix of oil and gas feedstock changes with time and may vary based on the specific synthesis process.

One feature of most plastics is that at the end of their useful lives they can be burned and a proportion of the feedstock energy can be recovered. One common misconception is that feedstock energy is a measure of the energy available for recovery. This is not correct, however. Feedstock energy is a measure of the energy associated with the inputs to a polymer production system and so is calculated as the mass of the inputs multiplied by their calorific values. This will be different from the calorific value of the final polymer for two reasons:

a) During polymer production, there will inevitably be losses of material. These losses may be small but do nevertheless occur.

b) There will frequently be chemical changes during the production process, and some of these changes can exert a significant effect on the final results. For example, in PVC production, one of the hydrogen atoms in the hydrocarbon monomer is replaced with a chlorine atom and, in some polymers, such as PET, oxygen is incorporated into the polymer itself.

Such factors lead to the calorific value of the final polymer being different from the feedstock energy. It is therefore important that feedstock is *not* used as a measure of the potential for energy recovery. The relevant parameter for energy recovery is the calorific value of the final polymer.

A.6 Recyclability

It is widely believed, often with little justification, that recycling is generally environmentally beneficial and that products should be designed so that they are readily recyclable. The option of recycling should always be considered, if not maintained, in the design of plastic components. It is important, however, to remember that one of the major benefits of plastics is that design can often yield more beneficial environmental impact than that provided by recycling.

NOTE For example, it has been shown that, if a polypropylene (PP) film is coated with a 2,5 µm layer of poly(vinylidene chloride) (PVDC), its permeability to oxygen is reduced by a factor of 50. The alternative to a 35 µm polypropylene film carrying such a coating would be a 1 750 µm film without coating. In this case, the film would not fulfil all of the requirements specified for the application such as low mass and high flexibility. It follows that using a barrier layer leads to both a better answer to the technical requirements for the application and a greater environmental benefit than using a thicker, stiffer and heavier film, which is less fit for the application even if it is the more readily recyclable. Thus, when assessing the option of recycling, it is essential to maintain the design focus on fitness for purpose as well as on the overall environmental impact including the contribution that would come from exercising the recycling option.

A.7 Environmentally sound material-selection criteria

The choice of the most appropriate materials in a specific application inevitably results from making comparisons between and among potential alternatives.

There is as yet no generally accepted scientific way available of summarizing the various environmental parameters into a single parameter or index. Consequently, comparisons must be made using selected parameters that are chosen because they are thought to be of environmental significance. The selection of these parameters is largely subjective, and so it is important that the reasons for their choice are clearly stated.

It should be remembered that a life cycle inventory analysis is a description of a system, not of a product and most certainly not of a material. The life cycle data take into account such diverse factors as materials, design, performance, use, disposal and recycling. Such life cycle systems can be compared only when they perform equivalent functions.

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