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Packaging and the environment — Energy recovery

Emballage et environnement — Récupération d'énergie

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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 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18605 was prepared by Technical Committee ISO/TC 122, *Packaging*, Subcommittee SC 4, *Packaging and environment*.

Introduction

Packaging plays a critical role in almost every industry, every sector and every supply chain. Appropriate packaging is essential to prevent loss of goods and, as a result, decrease impact on the environment. Effective packaging makes a positive contribution towards achieving a sustainable society by, (e.g.):

a) meeting consumers' needs and expectation for the protection of goods, safety, handling and information;

b) efficiently using resources and limiting environmental impact;

c) saving costs in the distribution and merchandising of goods.

An environmental assessment of packaging may include the manufacturing and distribution system, the wastage of packaging material and goods, the relevant collection systems, as well as recovery or disposal operations. This group of ISO standards and supporting reports provides a set of procedures which aim to:

d) reduce environmental impact;

e) support innovation in products, packaging and the supply chain;

f) avoid undue restrictions on the use of packaging;

g) prevent barriers and restrictions to trade.

Packaging is designed to provide a number of functions for users and producers such as: containment, protection, information, convenience, unitization, handling, delivery or presentation of goods. A major role of packaging is prevention of damage to or loss of goods. (See ISO 18601:2012, Annex A for a list of the functions of packaging.)

ISO 18601 defines the interrelationships within the family of ISO standards which cover the environmental impact of packaging throughout its life cycle (see Figure 1). These standards will help define whether the selected packaging can be optimized and whether the packaging needs to be modified to ensure it can be reused or recovered after use.

Demonstration that the requirements of these standards are met can be performed by a first party (manufacturer or supplier), a second party (user or purchaser), or by the support of a third party (independent body).

Public claims on the environmental attributes of packaging may be addressed by different methods. Some of these are technical aspects on reuse or recovery, others relate to access by the population to reuse or recovery systems or the amount of packaging placed on the market for recovery. This series of standards addresses the technical aspects of the packaging. It does not address the requirements of ISO 14021 needed to support a claim or label.

This International Standard does not use the term "and/or" but, instead, the term "or" is used as an inclusive disjunction, meaning one or the other or both.

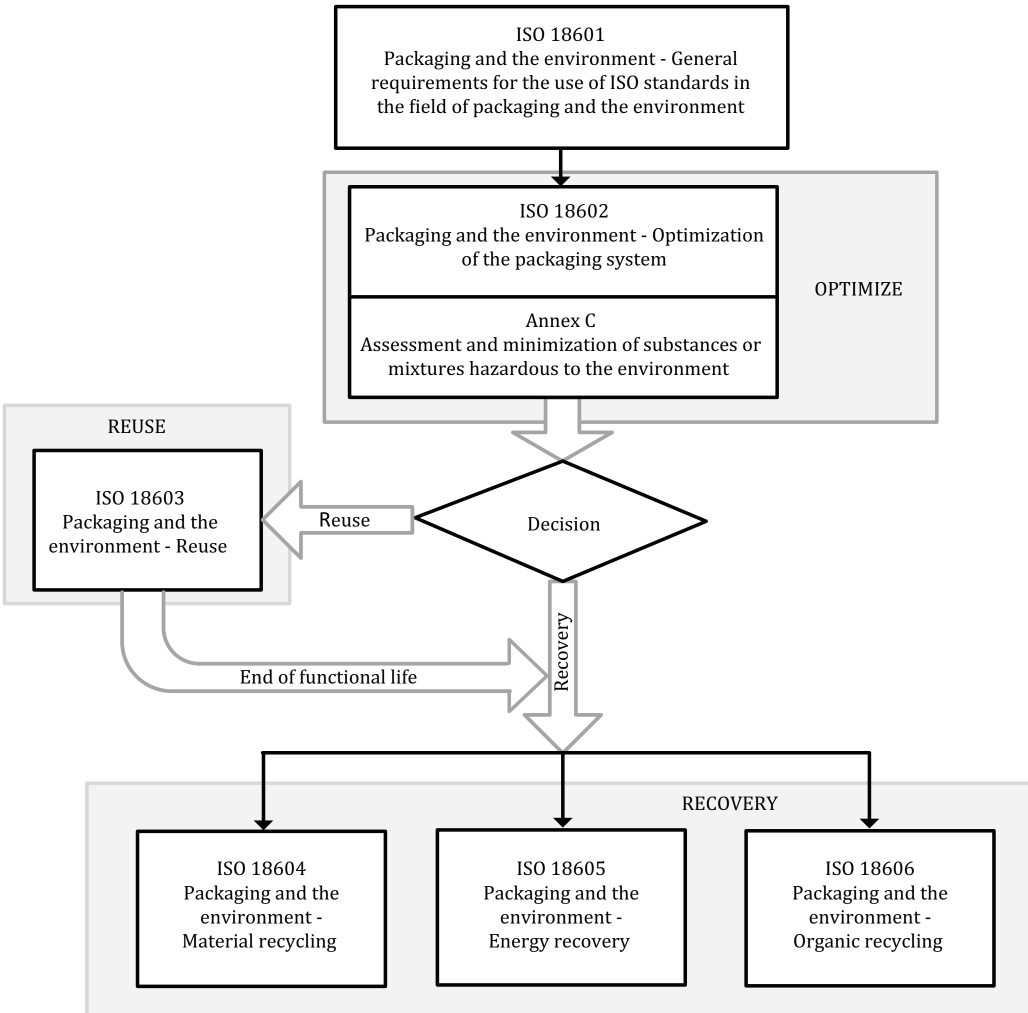

Figure 1 — Relationship of the Packaging and environment standards

Packaging and the environment — Energy recovery

1 Scope

This International Standard specifies the requirements for packaging to be classified as recoverable in the form of energy recovery and sets out assessment procedures for fulfilling the requirements of this International Standard.

This International Standard is a part of a series of International Standards. The procedure for applying it is contained in ISO 18601.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18601:2012, *Packaging and the environment — General requirements for the use of ISO standards in the field of packaging and the environment*

ISO 21067:2007, *Packaging — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18601, ISO 21067 and the following apply.

3.1
net calorific value at constant volume
absolute value of the specific energy of combustion, for unit mass of a solid fuel burned in oxygen under conditions of constant volume and such that all the water of the reaction products remains as water vapour (in a hypothetical state at 0,1 MPa), the other products being as for the gross calorific value, all at the reference temperature

Note 1 to entry: For the purpose of this document, 'fuel' as indicated above means used packaging.

[SOURCE: ISO 1928:2009, definition 3.1.3]

3.2
required energy
H_a
energy necessary to adiabatically heat the post combustion substances of a material and excess air from ambient temperature to a specified final temperature

3.3
calorific gain
positive difference between the energy released on combustion of a material and H_a

3.4
theoretical minimum net calorific value
$q_{net, min,theor}$
fraction of the energy released on combustion sufficient to adiabatically heat the post-combustion substances of a material or product and excess air from a specified ambient temperature to a specified final temperature

3.5
available thermal energy
fraction of the energy released on combustion in a real industrial system which is transferred for example to the steam cycle of a boiler, i.e. the total released energy minus the thermal losses

3.6
combustion
incineration
oxidation reaction covering both organic materials and metals

Note 1 to entry: Modern incineration plants are able to decouple energy efficiently and use it in the form of energy recovery. The term "incineration" in normal usage means the process of reducing solid waste volume by combustion with or without energy recovery. For the purpose of this International Standard, they refer only to the incineration process with energy recovery.

3.7
energy recovery
production of useful energy through direct and controlled combustion

Note 1 to entry: Solid-waste incinerators producing hot water, steam or electricity are a common form of energy recovery.

[SOURCE: ISO 15270:2008, definition 3.11]

4 Specification of minimum net calorific value

The theoretical minimum net calorific value, $q_{net,min,theor.}$, is material specific. It depends on the temperature and other conditions required by the combustion process. In this International Standard it is identified as H_a and may be determined by the method described in Annex A. This Annex specifies the theoretical minimum net calorific value through the technical concept of calorific gain.

The real minimum net calorific value, $q_{net,min,real.}$ is set to allow optimization of energy recovery in a real industrial system and is defined in Annex B.

5 Requirements

To allow optimization of energy recovery in a real industrial system, the theoretical calorific gain shall be well above zero. To claim energy recovery q_{net} shall be equal to or greater than $q_{net,min,real}$, as defined for various incineration conditions listed in Table B.2 in Annex B.

NOTE 1 Packaging composed of at least 50 % (by weight) of organic content, e.g. wood, cardboard, paper and other organic fibres, starch, plastics, provides calorific gain and meets the requirement of q_{net} equal to or greater than $q_{net,min,real.}$, as defined for various incineration conditions listed in Table B.2 in Annex B.

NOTE 2 Packaging consisting of more than 50 % by weight of inorganic constituents, e.g. inorganic fillers and layers, is recoverable in the form of energy, provided q_{net} is equal to or greater than $q_{net,min,real.}$, as defined for various incineration conditions listed in Table B.2 in Annex B.

NOTE 3 Packaging consisting of more than 50 % by weight of inorganic components, of which the primary constituent is not energy recoverable, e.g. glass or rigid metal containers with a plastic closure, is not deemed to be energy recoverable.

NOTE 4 Thin gauge aluminium (typically up to 50 µm thick) contributes to q_{net} of the packaging and is deemed to be energy recoverable. Aluminium over 50 µm is not deemed to be energy recoverable.

NOTE 5 Substances hazardous to the environment are addressed in ISO 18602. Other aspects regarding packaging not suitable for energy recovery are also discussed in Annex C.

6 Procedures

6.1 Application

The application of this International Standard to any particular packaging shall be as specified in ISO 18601.

6.2 Assessment

Packaging may be assessed for energy recoverability by calculation from data given in Annex B or use of the methodology in Annex A.

6.3 Demonstration of meeting the requirements

In order to demonstrate that the requirements stated in Clause 5 in ISO 18601:2012 have been met, a written statement shall be prepared. Annex D in this International Standard may be used as guidance.

Annex A
(informative)

Determination of calorific gain and specification of the theoretical minimum net calorific value

The determination of calorific gain is based on standard procedures for calculating the adiabatic final temperature in combustion chemistry and thermodynamics.

The net calorific value, q_{net}, of a material is the amount of heat released when it burns and when all water remains in the gas phase. In order to be recoverable in the form of energy, packaging should provide a calorific gain in the energy recovery process. For the purpose of this International Standard, this is assumed to be fulfilled when q_{net} exceeds the amount of required energy, H_a, to raise adiabatically the temperature of the post-combustion substances (including excess air) from ambient temperature to the specified final temperature. A calorific gain is obtained when Formula (1) is fulfilled:

$$q_{net} - H_a > 0 \qquad (1)$$

The net calorific value of a packaging consisting of different components or constituents can be calculated according to Formula (2):

$$q_{net} = \sum_{i=1}^{n} f_i \, q_{net,i} \qquad (2)$$

where

q_{net} net calorific value of the packaging;

f_i mass fraction of component or constituent ”i” in the packaging;

$q_{net,i}$ net calorific value of component or constituent ”i” in the packaging.

A combustible packaging may contain non-combustible components or constituents of inert or reactive nature, which may have a negative effect on calorific gain.

The theoretical minimum net calorific value specified as H_a can be determined by the application of Formulae (3) and (4):

$$q_{net,min,theor.} = H_a = \sum_{i=1}^{n} f_i \, H_{a,i} \qquad (3)$$

where

H_a the energy required to heat adiabatically combustion products, residues and excess air from T_0 to T_a;

$H_{a.i}$ the energy required to heat adiabatically combustion products, residues and excess air from T_0 to T_a of component or constituent ”i” of the packaging.

$$H_{a,i} = \sum_{j=1}^{m} g_j C_{pj} \left(T_a - T_0 \right) \quad (4)$$

where

g_j the ratio of combustion products and residues (flue gas and ashes) and excess air (j) resulting from the amount of component or constituent “i” in the packaging;

C_{pj} the specific heat capacity of post combustion product ”j” at constant pressure;

T_a the adiabatic final temperature;

T_0 the ambient temperature.

Formula (4) is valid for an adiabatic situation. For the purpose of this International Standard, H_a should be calculated for specified incineration conditions. Since the incineration condition differs, H_a should be calculated based on T_a without prejudice to the requirements of existing national legislation.

EXAMPLE 1 For EU countries, H_a shall be calculated for specified conditions, presently as given in Directive 2000/76/EC, i.e. a final temperature T_a of 850 °C. T_0 is set at 25 °C at 6 % O_2.

EXAMPLE 2 For Canada, H_a shall be calculated for specified conditions, presently as given in report CCME-TS/WM-TRE003, i.e. a final temperature T_a of 1000 °C. T_0 is set at 25 °C at 7 ~11 % O_2.

EXAMPLE 3 For Japan, H_a shall be calculated for specified conditions, presently as given in national regulation, i.e. a final temperature T_a of 800 °C. T_0 is set at 25 °C.

H_a may be calculated from the declaration of chemical composition obtained from the material supplier.

Values of q_{net} for individual packaging materials are obtained from the raw material supplier or from standard handbooks. q_{net} of a packaging is calculated according to Formula (2). q_{net} can also be determined experimentally according to ISO 1928:2009.

The ash content (or solid residues), where required for the calculation of H_a, should be determined by the method specified in ISO 1171:2010.

Annex B
(informative)

Derivation of a minimum net calorific value for packaging to allow optimization of energy recovery in a real industrial system

For energy recovery, the packaging should generate energy when incinerated at conditions mentioned in Annex A. Calorific gain is determined for an ideal adiabatic case, at steady-state conditions and with no losses. In the real industrial system, the available thermal energy is always greater than the theoretical calorific gain. Although there are heat losses in a combustion plant, the heat recovery of the hot flue gases results in an overall thermal efficiency of 75-90 %. Table B.1 gives values of q_{net}, calorific gain and available thermal energy for typical packaging constituents, packaging components, packaging materials and packaging. Some of the packaging materials illustrated are not in common use, but have been chosen to demonstrate the range of possibilities.

The energy consumption for flue gas cleaning and residue handling is of the order of a few percent of the energy input. All waste recovery or disposal options require energy for transportation and handling. This varies according to circumstances, but is normally well below 1 MJ/kg waste.

Figure B.1 is a graphic presentation of Table B.1. Calorific gain is plotted as function of q_{net} for final temperatures of various incineration conditions. For each final temperature, a mean line is calculated according to the least square method and extended to q_{net} = 0. From this statistical analysis, a practical required value for energy recovery, $q_{net,min,real}$, can be calculated for each incineration final temperature. At first, the intercept of q_{net} at calorific gain = 0 is calculated for each curve. Then the theoretical minimum value, $q_{net,min,theor}$, is obtained applying the 95 % confidence limit to each intercept of q_{net}. Applying a safety factor of 2, commonly used in design and construction of industrial processes, on the $q_{net,min,theor}$, the required value, $q_{net,min,real}$, is calculated.

In the case of the final temperature of 850 °C, for example, the extrapolation shows that calorific gain > 0 when q_{net} > 1,9 MJ/kg. Taking the 95 % confidence limit into account, the theoretical minimum value, $q_{net,min,theor}$, is between 1,3 and 2,5 MJ/kg. Applying a safety factor of 2, the required value, $q_{net,min,real}$, is set at 5 MJ/kg. In this case, the calorific gain is approximately 2 MJ/kg and the calculated available thermal energy 4 MJ/kg or more. Even when the energy consumption for additional transportation and handling, flue gas cleaning and residue handling are taken into account, the available thermal energy exceeds the energy consumed by these operations.

Minimum net calorific value, $q_{net,min,real}$, based on these calculations for various incineration temperatures are summarized in Table B.2, since the incineration temperatures differ among countries, $q_{net,min,real}$ should be set for the specified conditions given in the incineration regulation of each country.

EXAMPLE 1 For EU countries, $q_{net,min,real}$ should be set at 5 MJ/Kg considering the final incineration temperature as given in Directive 2000/76/EC, i.e. a final temperature T_a of 850 °C.

EXAMPLE 2 For Canada, $q_{net,min,real}$ should be set at 6,8 MJ/Kg considering the final incineration temperature as given in report CCME-TS/WM-TRE003, i.e. a final temperature T_a of 1000 °C.

EXAMPLE 3 For Japan, $q_{net,min,real}$ should be set at 4,6 MJ/Kg considering the final incineration temperature as given in national regulation, i.e. a final temperature T_a of 800 °C.

Table B.1 — Calorific gain calculated for an ambient temperature of 25 °C and various final temperatures at 6 % O_2, for a range of constituents, components and packaging. q_{net} is material specific and may be determined by standard methods, e.g. by calorimetry (ISO 1928:2009). Data for most materials are available in the literature (e.g. Handbook of Chemistry and Physics)

Examples fulfils requirement for energy recovery does not fulfil requirement for energy recovery	q_{net} (MJ/kg) [e]	H_a (MJ/kg) for various incineration temperature (T_a,°C)				q_{net} – H_a, **Calorific Gain** (MJ/kg) for various incineration temperature (T_a,°C)				**Available Thermal Energy** (MJ/kg) [f]	**Ash or solid residues** (weight %) [g]
		800	850	900	1000	800	850	900	1000		
- cellulose	**16,1**	7,4	7,9	8,4	9,3	8,7	8,2	7,7	6,8	12,1	< 0,1
- lignin	**26,0**	11,3	12	12,7	14,2	14,7	14,0	13,3	11,8	19,5	< 0,1
- starch	**16,1**	7,4	7,9	8,4	9,3	8,7	8,2	7,7	6,8	12,0	< 0,1
- inert material (ceramic, glass, etc.)	0,0	0,9	1,0	1,1	1,2	-0,9	-1,0	-1,1	-1,2	-	100,0
- calcium carbonate [a]	-2,0	0,9	1,0	1,1	1,2	-2,9	-3,0	-3,1	-3,2	-	56,0
- water (as moisture)	-2,0	1,9	2,0	2,1	2,4	-3,9	-4,0	-4,1	-4,4	-	0,0
Wood											
- wood, dry	**20,0**	9,1	9,7	10,3	11,5	10,9	10,3	9,7	8,5	15,0	0,4
- wood, 20 % moisture	**15,6**	7,5	8,0	8,5	9,5	8,1	7,6	7,1	6,1	11,7	0,3
- wood, 30 % moisture	**13,3**	6,9	7,3	7,7	8,6	6,4	6,0	5,6	4,7	10,0	0,3
- wood, 50 % moisture	**8,8**	5,4	5,7	6,0	6,7	3,4	3,1	2,8	2,1	6,6	0,2
Paper and board											
- cardboard (66 % cellulose, 23 % lignin, 11 % inert coating), dry	**16,6**	7,6	8,1	8,6	9,6	9,0	8,5	8,0	7,0	12,5	11,0
- cardboard (66 % cellulose, 23 % lignin, 11 % inert coating), 7 % moisture	**15,3**	7,1	7,6	8,1	9,0	8,2	7,7	7,2	6,3	11,5	10,0
- cardboard (85 % cellulose, 15 % inert filler), dry	**13,7**	6,4	6,8	7,2	8,0	7,3	6,9	6,5	5,7	10,3	15,0
- cardboard (85 % cellulose, 15 % carbonate filler, dry), 7 % moisture	**12,6**	6,1	6,5	6,9	7,7	6,5	6,1	5,7	4,9	9,5	14,0
- wrapping paper (80 % cellulose, 20 % inert filler) dry	**12,9**	6,1	6,5	6,9	7,7	6,8	6,4	6,0	5,2	9,7	20,0
- wrapping paper (80 % cellulose, 20 % inert filler, dry) 3 % moisture	**12,4**	6,0	6,4	6,8	7,6	6,4	6,0	5,6	4,8	9,4	19,0
- wrapping paper (60 % cellulose, 40 % inert filler) dry	**9,7**	4,8	5,1	5,4	6,0	4,9	4,6	4,3	3,7	7,3	40,0
- wrapping paper (60 % cellulose, 40 % inert filler, dry) 3 % moisture	**9,3**	4,7	5,0	5,3	5,9	4,6	4,3	4,0	3,4	7,0	39,0

a During the combustion process, calcium carbonate forms calcium oxide and carbon dioxide endothermically.

b Thin gauge aluminium up to 50 µm should be deemed to be energy recoverable according to Clause 5, NOTE 4.

c Aluminium over 50 µm should be deemed not energy recoverable (Clause 5, NOTE 4).

d Packaging does not fulfil the requirements for energy recoverability, but organic components provide available thermal energy (Clause 5, NOTE 3).

e q_{net} values in bold letters indicate that the packaging, constituent or component fulfils the requirements of Clause 5.

f For conditions of a waste-to-energy plant with 25 % heat losses. Available thermal energy = 0,75 x q_{net}.

g As determined by ISO 1171:2010.

Table B.1 *(continued)*

- bleached paper (100 % cellulose), 7 % moisture	**14,8**	6,9	7,4	7,8	8,7	7,9	7,4	7,0	6,1	11,1	< 0,1
- coated kraft paper (80 % cellulose, 20 % calcium carbonate) 6 % moisture	**11,6**	5,9	6,2	6,6	7,4	5,7	5,4	5,0	4,2	8,7	19,0
Polymers											
- polyethylene, PE	**43,0**	19,7	21,0	22,3	24,8	23,3	22,0	20,7	18,2	32,2	< 0,1
- polypropylene, PP	**44,0**	19,2	20,4	21,6	24,1	24,8	23,6	22,4	19,9	33,0	< 0,1
- polystyrene, PS	**40,0**	17,1	18,2	19,3	21,5	22,9	21,8	20,7	18,5	30,0	< 0,1
- polyvinyl chloride, PVC	**17,0**	7,5	8,0	8,5	9,5	9,5	9,0	8,5	7,5	12,8	< 0,1
- polyethylene terephthalate, PET	**22,0**	9,4	10,0	10,6	11,8	12,6	12,0	11,4	10,2	16,5	< 0,1
- polycarbonate	**29,0**	13,2	14,0	14,8	16,5	15,8	15,0	14,2	12,5	22,0	< 0,1
Metals											
- aluminium (combustible) [b]	**31,0**	6,0	6,4	6,8	7,6	25,0	24,6	24,2	23,4	23,3	189,0
- aluminium (inert) [c]	0,0	0,9	1,0	1,1	1,2	-0,9	-1,0	-1,1	-1,2	-	100,0
- steel (inert)	0,0	0,4	0,4	0,4	0,5	-0,4	-0,4	-0,4	-0,5	-	100,0
Plastics											
- PP with 50 % carbonate filler	**21,1**	10,1	10,7	11,3	12,6	11,0	10,4	9,8	8,5	15,8	28,0
- PP with 70 % carbonate filler	**12,0**	6,4	6,8	7,2	8,0	5,6	5,2	4,8	4,0	9,0	39,0
- PS with 2 % TiO_2	**39,2**	16,8	17,9	19,0	21,2	22,4	21,3	20,2	18,0	29,4	2,0
Laminates											
- cardboard (66 % cellulose, 23 % lignin, 11 % inert coating, dry) with 7 % moisture, 20 % PE, 5 % Al	**21,6**	9,6	10,2	10,8	12,1	12,0	11,4	10,8	9,5	16,2	17,0
- 71 %PE, 12 %Al, 17 %PET	**38,0**	16,3	17,3	18,3	20,4	21,7	20,6	19,7	17,6	28,5	23,0
- 49 %PE, 22 %Al, 29 %PET	**34,2**	13,7	14,6	15,5	17,3	20,5	19,7	18,7	16,9	25,7	42,0
- 23 %PE, 46 %Al, 31 %PET	**31,0**	10,2	10,9	11,6	12,9	20,8	20,1	19,4	18,1	23,3	87,0
- PP film with 0,7 % Al metalised layer	**43,9**	19,1	20,3	21,5	24,0	24,8	23,6	22,4	19,9	32,9	1,0
- PET film with 0,7 % SiO_x layer	**21,9**	9,3	9,9	10,5	11,7	12,6	11,9	11,4	10,2	16,4	1,0
- 58,1 % Al, 41,9 % PVC	**25,0**	6,6	7,0	7,4	8,3	18,4	18,0	17,6	16,7	19,0	110,0
Packaging											
- wood pallet, 2 % nails, 16 % moisture	**16,1**	7,9	8,4	8,9	9,9	8,2	7,7	7,2	6,2	11,9	2,0

a During the combustion process, calcium carbonate forms calcium oxide and carbon dioxide endothermically.

b Thin gauge aluminium up to 50 µm should be deemed to be energy recoverable according to Clause 5, NOTE 4.

c Aluminium over 50 µm should be deemed not energy recoverable (Clause 5, NOTE 4).

d Packaging does not fulfil the requirements for energy recoverability, but organic components provide available thermal energy (Clause 5, NOTE 3).

e q_{net} values in bold letters indicate that the packaging, constituent or component fulfils the requirements of Clause 5.

f For conditions of a waste-to-energy plant with 25 % heat losses. Available thermal energy = 0,75 x q_{net}.

g As determined by ISO 1171:2010.

Table B.1 *(continued)*

- wood pallet, 4 % nails, 16 % moisture	**15,1**	7,6	8,1	8,6	9,6	8,2	7,7	7,2	6,2	11,9	4,0
- wood box, 5 % nails, 16 % moisture	**15,6**	7,5	8,0	8,5	9,5	8,1	7,6	7,1	6,1	11,7	5,0
- spice can (81,8 % steel, 18,2 %PP) [d]	8,0	3,8	4,0	4,2	4,7	4,2	4,0	3,8	3,3	6,0	82,0
- steel aerosol (85,2 % steel, 14,8 %PP) [d]	6,5	3,2	3,4	3,6	4,0	3,3	3,1	2,9	2,5	4,9	85,0
- syrup can (89,5 % steel, 10,5 %PP) [d]	4,6	2,3	2,5	2,7	3,0	2,3	2,1	1,9	1,6	3,5	89,0

a During the combustion process, calcium carbonate forms calcium oxide and carbon dioxide endothermically.

b Thin gauge aluminium up to 50 µm should be deemed to be energy recoverable according to Clause 5, NOTE 4.

c Aluminium over 50 µm should be deemed not energy recoverable (Clause 5, NOTE 4).

d Packaging does not fulfil the requirements for energy recoverability, but organic components provide available thermal energy (Clause 5, NOTE 3).

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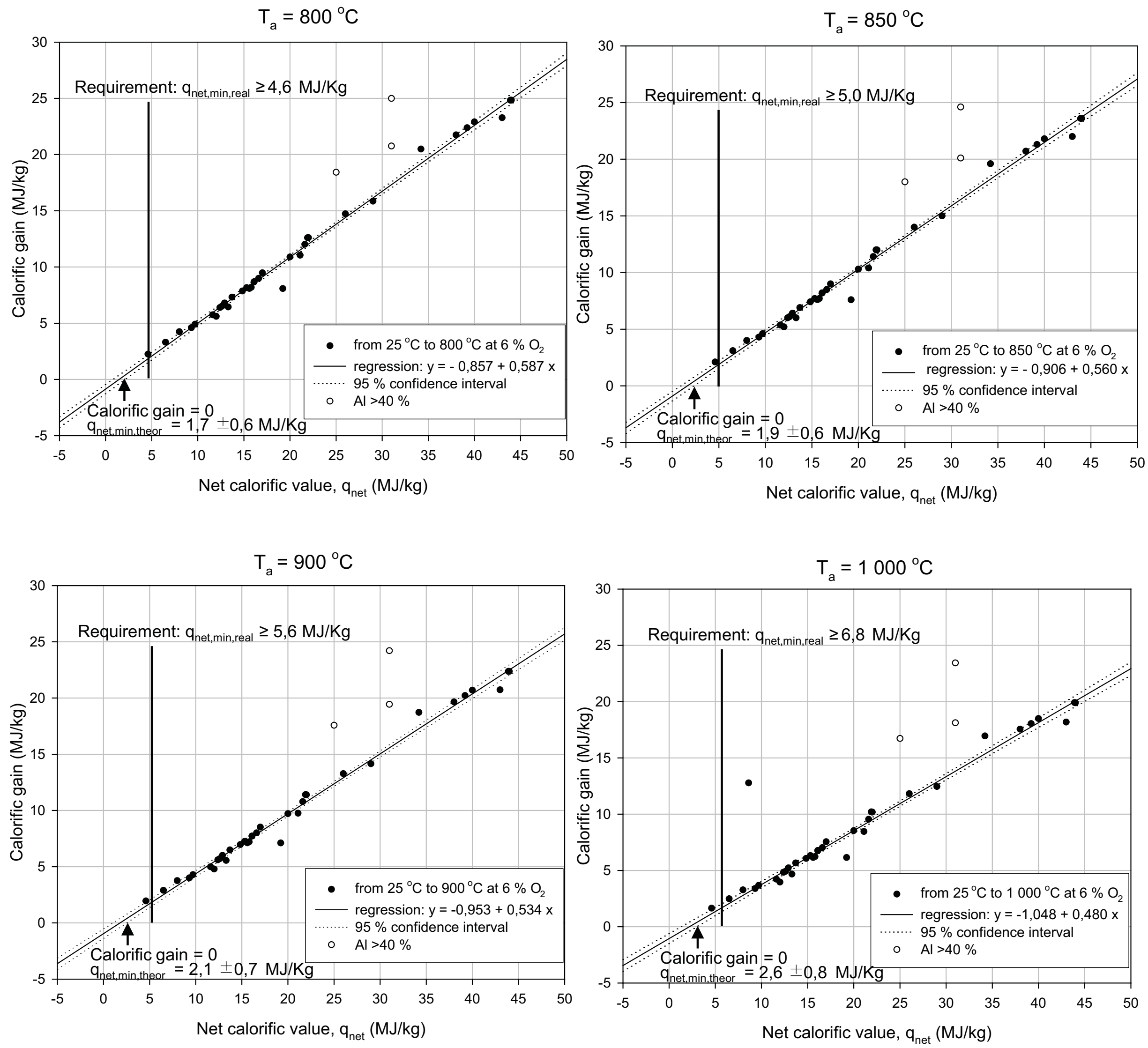

Figure B.1 — Calorific gain as function of qnet for various incineration conditions, for constituents, components and packaging from Table B.1. The line is calculated according to the least square method and extrapolated to q_{net} = 0

NOTE The three points well above the line represent examples containing more than 40 % aluminium (by weight). Thermodynamically, aluminium does not behave like organic materials, and these data are excluded from the calculations.

Table B.2 — Minimum net calorific value, $q_{net,min,real}$, calculated for an ambient temperature of 25 °C and various final incineration temperatures at 6 % O_2

	Incineration temperature (T_a,°C)			
	800	**850**	**900**	**1000**
Theoretical minimum calorific value, $q_{net,min,theor.}$ (MJ/Kg)	1,7	1,9	2,1	2,6
Confidence Interval (MJ/Kg)	± 0,6	± 0,6	± 0,7	± 0,8
Minimum net calorific value $q_{net,min,real}$ (MJ/Kg)	4,6	5,0	5,6	6,8

Annex C
(informative)

Packaging not suitable for the energy recovery process

Packaging in itself does not represent a hazard during collection or sorting prior to energy recovery. It is essential, however, that appropriate precautions are taken during the handling of any used packaging that may have previously contained hazardous substances and that the requirements of ISO 18601 and ISO 18602 relating to the substances hazardous to the environment are fulfilled.

The requirements with regard to the content of four heavy metals are set out in the ISO 18602. Their concentration in packaging materials can be determined by standard methods and may be calculated for any particular packaging from the material composition. This is covered in Annex C of ISO 18602:2012. Energy recovery facilities have to be designed to minimize the environmental impact related with these heavy metals.

Any organic substances hazardous to the environment that may be present in used packaging will be decomposed by the high temperature of the combustion process. Emissions are subject to regulations of each country.

Substances from the combustion of acid-forming elements such as sulfur, nitrogen and halogens do have technical and environmental implications. For sound functional reasons, combustible packaging may contain some of these elements. Minimization of substances hazardous to the environment is covered in Annex C of ISO 18602:2012. Although requiring specific process management, packaging will still provide calorific gain in the combustion process. Municipal Solid Waste incinerators are equipped to deal with formed acids in a technically and environmentally satisfactory way that will meet the requirements of regulations on the incineration of waste of each country.

The residues, slags and bottom ashes from incineration are also subject to regulations. The option of other recovery processes such as material recycling is available for some elements (e.g. metals).

Inert materials used for packaging normally do not create impediment for energy recovery but may have an impact on the efficiency of the incineration process.

Annex D
(informative)

Example of format for the statement of meeting the requirements of this International Standard

Documentation No		**Date:**	
Packaging Identification			
Incineration condition (T_a)[a]		$q_{net,min,real}$[b]	

[a] Incineration conditions differ. Refer the incineration condition in the regulation of each country.

[b] See Table B.2 in Annex B. Use this value to determine the assessment C. in D.1. ASSESSMENT PROCEDURE.

D.1 ASSESSMENT PROCEDURE

D.1.A. **Organic content** **≥ 50 % (by weight)?**	**YES** *Suitable for energy recovery* *Go to D.3. a)*	**NO** *Go to D.1. B*
D.1.B. **Inorganic content** **> 50 % (by weight)** *Calculate by use of D.2.*	**YES** **If present as constituent:** *Go to D.2.*	**YES** **If present as component;** *Not suitable for energy recovery* *Go to D.3.b)*
D.1.C. **$q_{net} \geq q_{net,min,real}$?**	**YES** *Suitable for energy recovery* *Go to D.3.a)*	**NO** *Does not fulfil the requirements of* ISO 18605 *Go to D.3.b)*

D.2 PACKAGING DESCRIPTION, CALCULATION OF WEIGHT-% AND q_{net}

Material		Function		% (weight)	q_{net} (MJ/kg)	Weighted q_{net} (MJ/kg)	Remarks
		Component	Constituent				
1							
2							
3							
4							
5							
Sum							
Return to D.1.C							

D.3 ASSESSMENT OF MEETING THE REQUIREMENTS

a) Packaging is suitable for energy recovery. Go to D.4.

b) Packaging does not meet the requirements of ISO 18605.

D.4 DECLARATION OF MEETING THE REQUIREMENTS

This packaging meets the requirements of ISO 18605 regarding energy recovery.

Date and signature:

Name: Title: Organization:

Mailing Address:

Annex E
(informative)

Completed example of format for the statement of meeting the requirements of this International Standard

Documentation No		**Date:**	
Packaging Identification	Lid for cup container: PET(12 µm)/AL(30 µm)/PE(40 µm)		
Incineration condition (T_a)[a]	from 25 °C to 850 °C at 6 % O_2	$q_{net,min,real}$[b]	5 MJ/Kg

[a] Incineration conditions differ. Refer the incineration condition in the regulation of each country.

[b] See Table B.2 in Annex B. Use this value to determine the assessment C. in D.1. ASSESSMENT PROCEDURE.

E.1 ASSESSMENT PROCEDURE

E.1.A. **Organic content** **≥ 50 % (by weight)?**	**YES** *Suitable for energy recovery* *Go to E.3. a)*	**NO** *Go to E.1. B*
E.1.B. **Inorganic content** **> 50 % (by weight)?** *Calculate by use of E.2.*	**YES** **If present as constituent:** *Go to E.2.*	**YES** **If present as component;** *Not suitable for energy recovery* *Go to E.3.b)*
E.1.C. $q_{net} \geq q_{net,min,real}$?	**YES** *Suitable for energy recovery* *Go to E.3.a)*	**NO** *Does not fulfil the requirements of* ISO 18605 *Go to E.3.b)*

E.2 PACKAGING DESCRIPTION, CALCULATION OF WEIGHT-% AND q_{net}

	Material	Function		% (weight)	q_{net} (MJ/kg)	Weighted q_{net} (MJ/kg)	Remarks
		Component	Constituent				
1	Aluminium foil		○	60,5	31,0	18,8	
2	PET		○	12,5	22,0	2,8	
3	PE		○	27,0	43,0	11,6	
4							
5							
Sum						33,2	
Return to D.1.C							

E.3 ASSESSMENT OF MEETING THE REQUIREMENTS

a) Packaging is suitable for energy recovery. Go to E.4.

b) Packaging does not meet the requirements of ISO 18605.

E.4 DECLARATION OF MEETING THE REQUIREMENTS

This packaging meets the requirements of ISO 18605 regarding energy recovery.

Date and signature:

Name: Title: Organization:

Mailing Address:

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