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Suitability of typical electrical insulating material (EIM) for polymer recycling

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SUITABILITY OF TYPICAL ELECTRICAL INSULATING MATERIAL (EIM) FOR POLYMER RECYCLING

FOREWORD

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IEC 62392, which is a technical report, has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.[1]

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
15/235/DTR	15/263/RVC

[1] Technical committee 112 was created by combining the activities of sub-committee 15E and techical committee 98. This project was initially developed in technical committee 15 and then transferred to technical committee 112.

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

SUITABILITY OF TYPICAL ELECTRICAL INSULATING MATERIAL (EIM) FOR POLYMER RECYCLING

1 Scope

This Technical Report gives information for the assessment of factors associated with the polymer recycling and/or reuse of typical insulating materials in electrotechnical equipment. It gives information and assistance to developers and design engineers for assessment in selecting polymers and polymer combinations, and is a contribution to the preservation of resources and the minimization of disposal costs at the end of a product life. The environmental compatibility of polymers must be assessed in the light of the function of the materials in the product and the total service life. An important aspect is the recovery of the material at the end of the product life. The value level of material recycling as recovery option can be improved by incorporation of suitability for dismantling into the design of the article and the choice of insulating materials which are generally used. This document will cover material recycling only as part of recovery.

2 Normative references

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

IEC 60093, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60216-1, *Electrical insulating materials – Properties of thermal endurance – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*

IEC 60216-3, *Electrical insulating materials – Thermal endurance properties – Part 3: Instructions for calculating thermal endurance characteristics*

IEC 60216-4-1, *Electrical insulating materials – Thermal endurance properties – Part 4-1: Ageing ovens – Single-chamber ovens*

IEC 60216-4-2, *Electrical insulating materials – Thermal endurance properties – Part 4-2: Ageing ovens – Precision ovens for use up to 300 °C*

IEC 60216-4-3, *Electrical insulating materials – Thermal endurance properties – Part 4-3: Ageing ovens – Multi-chamber ovens*

IEC 60216-5, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

IEC 60216-6, *Electrical insulating materials – Thermal endurance properties – Part 6: Determination of thermal endurance indices (TI and RTE) of an insulating material using the fixed time frame method*

IEC 60505, *Evaluation and qualification of electrical insulation systems*

IEC 61244-3, *Long-term radiation ageing in polymers – Part 3: Procedures for in-service monitoring of low-voltage cable materials*

ISO 179 (all parts), *Plastics – Determination of Charpy impact properties*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

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

ISO 1043-1, *Plastics – Symbols and abbreviated terms – Part 1: Basic polymers and their special characteristics*

ISO 1043-2, *Plastics – Symbols and abbreviated terms – Part 2: Fillers and reinforcing materials*

ISO 1043-3, *Plastics – Symbols and abbreviated terms – Part 3: Plasticizers*

ISO 1043-4, *Plastics – Symbols and abbreviated terms – Part 4: Flame retardants*

3 Terms and definitions

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

3.1
electrical insulating material
EIM
material with negligibly low electric conductivity, used to separate conducting parts at different electrical potentials

[IEV 212-01-01:1990, MOD]

3.2
composite

1) solid product consisting of two or more distinct phases, including a binding material (matrix) and a particulate or fibrous material

   NOTE Example: Moulding material containing reinforcing fibres, particulate fillers or hollow spheres.

2) solid product consisting of two or more layers (often in a symmetrical assembly) of plastic film or sheet, normal or syntactic cellular plastic, metal, wood, composite according to definition 1), etc. with or without adhesive interlayers

   NOTE Examples: Film composites for packaging, sandwich cellular composite for structural applications, laminates made with paper, fabric, etc.

[ISO 472: 1999]

3.3
(mechanical) recycling
reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery

[IEC Guide 109:2003]

NOTE This definition excludes the chemical recycling during which the molecular structure is broken down to produce monomers.

3.4
feedstock recycling
processing of plastic waste material, with significant change to the chemical structure of the material including cracking, gasification and de-polymerisation but excluding energy recovery or incineration

3.5
recyclability
property of a substance or a material and parts/products made thereof that makes it possible for them to be recycled

NOTE Recyclability of a product is not only determined by the recyclability of the materials it contains. Product structure and logistics are also very important factors.

[IEC Guide 109, 2003]

3.6
recycled polymer
materials resulting from recycling

3.7
commingled
A mixture of materials or products consisting of different types of plastics

3.8
contamination
unwanted substance in polymeric materials according to the intended use

3.9
halogen containing
material containing the elements F, Cl or Br either in the polymer (as in PVC, PTFE, …) or in the fire-retardant additive package

3.10
thermoplastic
plastic capable of being repeatedly softened by heating and hardened by cooling through a temperature range characteristic of the plastic and, in the softened state, capable of being repeatedly shaped by flow into articles by moulding, extrusion or forming

NOTE 1 Thermoplastics can be reprocessed and recycled by remelting.

NOTE 2 Examples are given below as abbreviations after ISO 1043-1: PE, PVC, PS, PC, PP, PA, POM, SAN, ABS, PBT, PET, PMMA, ASA, TPU, LCP, PEEK, PPS, PBT + PC, PC + ABS, PC + PBT, PPE, PPE + PS.

3.11
thermoplastic elastomer
TPE
general term for specific elastomers like thermoplastic polyurethane (TPU)

NOTE For further abbreviations see ISO 18064:2003.

3.12
elastomer and other crosslinked polymer
macromolecular material which returns rapidly to approximately its initial dimensions and shape after substantial deformation by a week stress and release of the stress

NOTE 1 The definition applies to room temperature test conditions.

NOTE 2 Examples are EPR, nitril rubber, cross-linked PE according to ISO 1629 and ISO 1382 and cross-linked PE (PE-X according to ISO 1043-1).

3.13
thermoset
plastic which, when cured by heat or other means, changes into a substantially infusible and insoluble product

NOTE 1 Thermosets are often called thermosetting before curing and thermosets after cure. Their polymeric structure is cross-linked by curing.

NOTE 2 Examples are EP, SI, UP, MF, PF, UF, MP, PUR (thermoset polyurethane, PIR (polyisocyanurate).

NOTE 3 For a more complete list of vocabulary see ISO 472.

4 Environmental aspects of polymeric materials at the End Of Life (EOL) stage

The choice of the polymeric material for electrical applications should be done incorporating environmental considerations from a life cycle perspective. Handling of polymer waste is an important issue in the life cycle of polymers. Polymer waste can be recycled, incinerated or landfilled. Landfill deposition should be avoided, as it implies no recovery of materials or energy and may cause uncontrolled release of harmful additives or degradation products. Thus, the options that should be considered are mechanical recycling, feedstock recycling which may be the choice in case the material is commingled, and incineration with energy recovery. Overview of possible ways to recover polymers is shown in Figure 1.

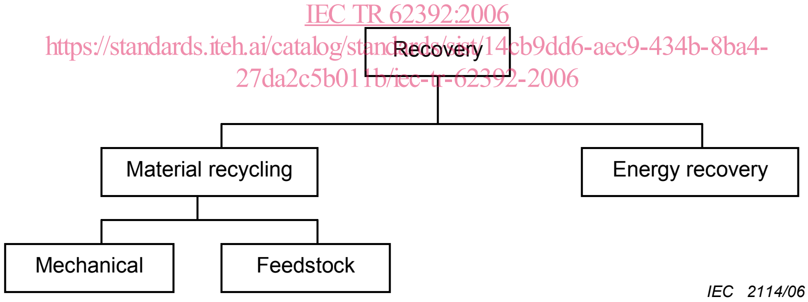


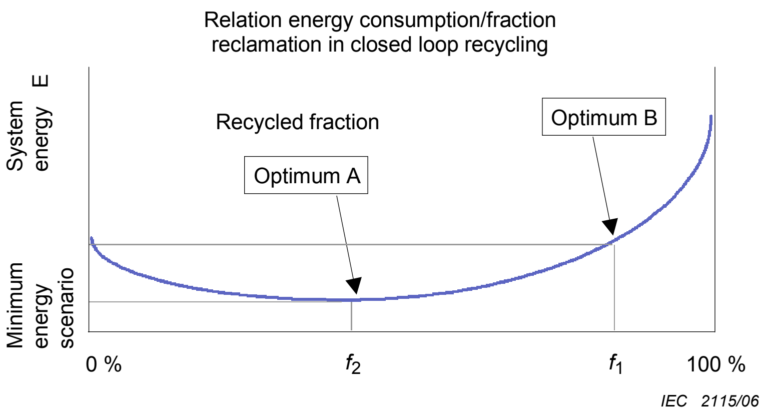
Figure 1 – Overview of possible ways to recover polymers

Mechanical recycling may be the choice if the waste material comply with the requirements of the recycling process intended to be used, and well-defined and there is an efficient infra-structure for collection, dismantling, and re-processing into new products.

However, if recycling conditions are not fulfilled, incineration with energy recovery is probably the most suitable treatment. Using polymer waste as fuel for power/heat generation is advantageous when the polymers have a high energy content. It is important, however, that incineration is carried out under controlled conditions in plants with efficient air pollution control. Polymers may for instance contain nitrogen, chlorine, fluorine, bromine and sulphur in their structure or in additives and combustion of such compounds may give rise to harmful substances. The preferred and most appropriate treatment of polymer waste containing undesired organic additives is incineration, enabling the destruction and removal of harmful compounds.

Whether or not a product or product part should be reused, recycled or incinerated is a complex issue which has to be considered from case to case.

Recycling of thermoplastic-based products is increasing. The recycling environmental benefits depend on the efficiency of the collecting mechanisms because the impacts arising from the collection could eliminate the environmental credits due to the recycled material availability. Energy consumption and recycled fraction are shown in Figure 2.



Environmental efficiency of a recovery program

optimum A = maximum energy recovery

optimum B = maximum material recovery in respect of energy balance

Figure 2 – Energy consumption and recycled fraction

If thermoplastics are incinerated under unregulated conditions with no air pollution control, harmful combustion products may be emitted into the air. This is particularly true if the polymer has other atoms than carbon, hydrogen and oxygen present in its structure (or in additives). Incineration of nitrogen-containing polymers induces the formation of cyanides/cyanates and NO_x, whereas hazardous halogenated organic compounds (dioxins, furans, etc.) may be formed under inappropriate incineration of halogen-containing polymers. If the latter polymers are incinerated in a plant with tuned combustion conditions, the halogens will come out as acids (HCl, HF) in the combustion gases. These acids can be neutralised with common air pollution control equipment.

If thermoplastics are deposited at a landfill site, the complete degradation of the material may take more than a century, and during this time span harmful additives (e.g. lead-based stabilisers) may be leached from the landfill site. It is generally accepted that land filling is not preferred. Incineration should be done under state of the art conditions.

Thermosets are currently not recycled to a great extent. Recycling is restricted to milling and use of the resultant powder as a filler. Methods for chemical recycling of thermosets, i.e. controlled degradation and recovery of components, have been developed but are presently not used on a large scale. If a thermoset resin contains substances which are classified as environmentally hazardous, then the waste may also be environmentally hazardous depending on applicable legislation.

Recycling of rubber materials has so far been limited to grinding and use of the milled rubber as a filler in other materials such as asphalt and athletic field materials. Rubbers may contain metal compounds (additives) which are classified as environmentally hazardous, which means that the waste is classified as environmentally hazardous. Thermoplastic elastomers can be recycled as the thermoplastics.

At the same time that plastic parts have been substituted for metals in many applications, plastic recycling has become more difficult. Special plastic composites, such as those with glass additives, require special separation. The introduction of more powerful electronic products, more sensitive to electronic noise, has led to the use of plastic resins containing