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Testing and characterization of mechanically recycled polypropylene (PP) and polyethylene (PE) for intended use in different plastics processing techniques

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Contents

	Page
Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	2
4 Testing and characterisation.....	2
4.1 Melting point by differential scanning calorimetry(DSC).....	2
4.2 Density.....	2
4.3 Melt-mass flow rate (MFR).....	2
4.4 Ash content.....	2
4.5 Tensile properties.....	2
4.6 Charpy impact strength.....	3
4.7 Water content.....	3
4.8 Classification of recyclates.....	3
5 Test report.....	3
6 Quality assurance.....	5
Bibliography.....	6

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Foreword

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

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This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 14, *Environmental aspects*.

ISO/FDIS 5677

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In the present context, countries across the globe have been promoting and bringing in regulations to use recyclates in different plastics processing techniques for conversion into variety of end products. In a few countries, guidelines or regulations for use of mechanically recycled granules or pellets may be available from the respective national standardization bodies.

The broad objectives of this document are:

- listing of important test methods, which will be useful for processing of mechanically recycled PP and PE [in granular or pellet form, abbreviated as PP (REC) and PE (REC)];
- provide uniform guidelines to recyclers on testing and characterization for issue of technical specifications .
- facilitate plastics processors in selecting mechanically recycled granules or pellets based on test report.

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Testing and characterization of mechanically recycled polypropylene (PP) and polyethylene (PE) for intended use in different plastics processing techniques

1 Scope

This document specifies test methods for assessing important properties of mechanically recycled polypropylene [PP (REC)] and polyethylene [PE (REC)] in granular or pellet form for use in conventional plastics processing techniques.

General guidance is provided for determining the characteristics of PP (REC) and PE (REC), which can be used at 100 % or in a proportion with standard (virgin) material grades available for processing on machines such as injection moulding, blow moulding, types of extrusion techniques, etc.

This document intends to help plastics processors and end users who intend to use recyclates with agreement on product specifications, as applicable.

Country specific health and food-safety and environment related regulations for use of plastics recyclates are not in the scope of this document.

Mixture of recyclates of PP and PE is not in the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 472, *Plastics — Vocabulary*

ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 1133-1, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method*

ISO 3451-1, *Plastics — Determination of ash — Part 1: General methods*

ISO 15270, *Plastics — Guidelines for the recovery and recycling of plastics waste*

ISO 17855-2, *Plastics — Polyethylene (PE) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties*

ISO 19069-2, *Plastics — Polypropylene (PP) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties*

ISO 11357-1, *Plastics — Differential scanning calorimetry (DSC) — Part 1: General principles*

ISO 11357-3, *Plastics — Differential scanning calorimetry (DSC) — Part 3: Determination of temperature and enthalpy of melting and crystallization*

ISO 11357-6, *Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)*

ISO 13468-1, *Plastics — Determination of the total luminous transmittance of transparent materials — Part 1: Single-beam instrument*

ISO 15512, *Plastics — Determination of water content*

DIN/SPEC 91446:2021, *Classification of recycled plastics by data quality levels for use and (digital) trading*

CEN/TS 17627, *Plastics — Recycled plastics — Determination of solid contaminant content*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and ISO 15270 apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Testing and characterisation

4.1 Melting point by differential scanning calorimetry(DSC)

Supplier of PP (REC) and PE (REC) shall provide information about melting point temperature for general characterization of type of PE (REC) [Low density polyethylene (PE-LD), linear low density polyethylene (PE-LLD), high density polyethylene (PE-HD)] or PP (REC) [Homopolymer or Copolymer]. For semi crystalline plastics materials like PE and PP, melting point temperature is distinctive, which shall be determined by differential scanning calorimetry.

4.2 Density

Measurement of density of PP (REC) and PE (REC) shall be done in accordance with ISO 1183-1, applicable for non-cellular plastics. The measured value of density should be helpful in determining the type or variant of PP (REC) and PE (REC).

4.3 Melt-mass flow rate (MFR)

Melt-mass flow rate (MFR) is an important property for processability of material, which shall be tested in accordance with ISO 1133-1.

4.4 Ash content

The presence of ash (fillers, inorganic residues, etc.) shall be determined in accordance with ISO 3451-1. Information about ash content is helpful in assessing processability, particularly in extrusion techniques such as film, sheet, pipe, monofilament, strapping, tape, yarn, etc.

4.5 Tensile properties

Tensile properties shall be tested by preparing specimens in accordance with ISO 527-1 and ISO 527-2.

4.6 Charpy impact strength

The impact properties shall be tested in accordance with ISO 179-1, which specifies a method for determining Charpy impact strength of plastics under defined conditions.

4.7 Water content

Water content shall be tested in accordance with ISO 15512, which specifies methods for the determination of the water content of plastics in the form of powder, granules, and finished articles.

4.8 Classification of recyclates

For classification of PP (REC) and PE (REC), DIN SPEC 91446 shall be used which should help in trading of recyclates in a transparent manner.

5 Test report

The characteristics of a batch of material shall be determined using the test methods given in [Table 1](#) and [Table 2](#).

Table 1 — Test methods for characterization of PP (REC)

Characteristics	Unit	Test method	Test conditions, supplementary information
Melting point by differential scanning calorimetry (DSC)	Degree Celsius	ISO 11357-1, ISO 11357-3	Graph of heat flow and temperature shall be included with the test certificate
Density	kg/m ³	ISO 1183-1	Method B: Liquid pycnometer method, applicable for granules as agreed by the purchaser and supplier
Water content	%	ISO 15512	
Melt-mass flow rate	g/10 min	ISO 1133-1	Condition M (230 °C, 2,16 kg)
Colour of granule/pellet, classification of recyclates		Visual inspection for colour, gel spot DIN SPEC 91446 for classification	Classification of recyclate shall be as per DIN SPEC 91446
Ash content	%	ISO 3451-1	With this method, any additive or pigment with lower melting point temperature than temperature of muffle furnace gets evaporated or destroyed.
Tensile stress at yield and Tensile modulus	MPa	ISO 527-1, ISO 527-2	Specimen preparation and test conditions shall be in accordance with ISO 19069-2
Tensile strain at break	%	ISO 527-1, ISO 527-2	Specimen preparation and test conditions shall be in accordance with ISO 19069-2
Charpy impact strength	kJ/m ²	ISO 179-1	
Optional			
Oxidation induction time (Isothermal OIT)		ISO 11357-6	
Filtration Level	Mesh size		Supplier should provide information on mesh size, important for extrusion-based processing techniques. ISO 17422 provides general guidance. EN 13900-5 may be followed for determination of filter pressure.

Table 1 (continued)

Characteristics	Unit	Test method	Test conditions, supplementary information
Contaminants		CEN/TS17627	This method is for determination by melt filtration of solid contaminants content in a sample of recycled thermoplastic material, evaluating their number and, optionally, their size and substance (material), as agreed by the purchaser and supplier. ISO 17422 provides general guidance.
Total luminous transmittance		ISO 13468-1	
Fourier-transform infrared spectroscopy (FTIR)		ISO 10640	This method assesses the ageing of polymeric systems and may be helpful in identification based on IR method

Table 2 — Test methods for characterization of PE (REC)

Characteristics	Unit	Test method	Test conditions, supplementary information
Melting point by differential scanning calorimetry (DSC)	Degree Celsius	ISO 11357-1, ISO 11357-3	Graph of heat flow and temperature shall be included with the test certificate
Density	kg/m ³	ISO 1183-1	Method B: Liquid pycnometer method, applicable for granules as agreed by the purchaser and supplier
Water content	%	ISO 15512	
Melt-mass flow rate	g/10 min	ISO 1133-1	190 °C, 2,16 kg
Colour of granule/pellet, classification of recyclates		Visual inspection for colour, gel spot, DIN SPEC 91446 for classification	Classification of recyclate shall be as per DIN SPEC 91446
Ash content	%	ISO 3451-1	With this method, any additive or pigment with lower melting point temperature than temperature of muffle furnace gets evaporated or destroyed.
Tensile stress at yield and Tensile modulus	MPa	ISO 527-1, ISO 527-2	Specimen preparation and test conditions shall be as per ISO 17855-2
Tensile strain at break	%	ISO 527-1, ISO 527-2	Specimen preparation and test conditions shall be as per ISO 17855-2
Optional			
Charpy impact strength	kJ/m ²	ISO 179-1	
Filtration Level	Mesh size		Supplier should provide information on mesh size, important for extrusion-based processing techniques. ISO 17422 provides general guidance. EN 13900-5 may be followed for determination of filter pressure.
Contaminants		CEN/TS 17627	This method is for determination by melt filtration of solid contaminants content in a sample of recyclate evaluating their number and, optionally, their size and substance (material), as agreed by the purchaser and supplier. ISO 17422 provides general guidance.