



Technical Report

ISO/TR 19032

Plastics — Use of polyethylene reference film (PERF) for monitoring laboratory and outdoor weathering conditions

*Plastiques — Utilisation d'un film de référence en polyéthylène
(PERF) pour le contrôle des conditions de vieillissement
climatique en laboratoire et en extérieur*

**Third edition
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	1
5 Background information	1
6 Material	2
6.1 Properties.....	2
6.2 Preparation.....	3
7 Method for measuring the carbonyl index of PERF	3
8 Interlaboratory tests: exposure of PERF to laboratory light-sources	4
8.1 General.....	4
8.2 Protocol for the artificial exposures.....	5
8.2.1 General.....	5
8.2.2 Xenon-arc lamp exposure.....	5
8.2.3 Fluorescent UV lamp exposure.....	5
8.2.4 Medium pressure mercury vapour lamp exposure.....	6
8.2.5 Measurement of the carbonyl index C_i	6
8.3 Outdoor exposure test of PERF.....	6
8.4 Results and discussion.....	6
8.4.1 Artificial exposures of PERF to laboratory light-source.....	6
8.4.2 Exposure of PERF to natural outdoor conditions.....	17
8.5 Conclusion.....	19
Annex A (informative) History of polyethylene reference specimens (PERS)	21
Bibliography	23

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.

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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

This third edition cancels and replaces the second edition (ISO/TR 19032:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the reference material has been replaced;
- the physicochemical properties and the use of new PERF are described;
- results of interlaboratory tests with new PERF are detailed and commented.

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

This document describes the physicochemical properties of polyethylene reference film (PERF) as well as a method for using PERF as a weathering reference material to monitor the performance of natural or artificial exposures. Under the action of UV radiation and heat, polyethylene materials undergo photo-oxidation reactions leading to the formation and accumulation of various oxidation products. Among the compounds formed during these photochemical processes, carboxylic acids end-groups are easily detected by their specific infrared absorption in the carbonyl domain. Measuring the relative concentration of carboxylic acids groups allows calculating a carbonyl index that reflects the polymer oxidation level. The photo-oxidation rates being directly dependent on the environmental factors and especially UV radiation and heat, determining the change in the carbonyl index of PERF during natural or artificial exposures allows monitoring polymer ageing conditions.

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Plastics — Use of polyethylene reference film (PERF) for monitoring laboratory and outdoor weathering conditions

1 Scope

This document describes a method that demonstrates the use of polyethylene reference film (PERF) for monitoring laboratory and outdoor conditions as a weathering reference material in weathering tests used for plastics.

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 472:2013, *Plastics — Vocabulary*

3 Terms and definitions

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

ISO and IEC maintain terminology 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/>

3.1

weathering reference material

material of known performance when exposed to solar radiation, heat, and moisture

Note 1 to entry: Weathering reference materials are used for weathering and irradiation testing.

Note 2 to entry: A weathering reference material is typically commercially available.

[SOURCE: ISO 4892-1:2024^[1], 3.5, modified – Note 2 to entry added]

4 Abbreviated terms

PERF	Polyethylene reference film
PERS	Polyethylene reference specimens
FTIR	Fourier transform infrared

5 Background information

When subjected to natural or artificial environmental stresses (such as heat, light or humidity), polymer materials are likely to degrade by photo-oxidative pathways.^[2] The rate of polymer photo-oxidation mainly depends on two factors: spectral irradiance and temperature. However, the temperature dependence being linked to an exponential law involving an activation energy (similar to an Arrhenius law), the influence of the temperature on the global oxidation rate is the most important. Photo-initiated processes lead to thermally

activated oxidation reactions responsible for chain scissions of the polymer backbone and to the formation of a variety of oxidations products, including hydroperoxides,^{[3],[4]} ketones, carboxylic acids, esters, lactones, etc.^{[5],[6]} Some of these compounds are not retained by the polymer matrix because they are volatile whereas other ones accumulate in the material as new functional groups linked to the polymer chains (often as end-groups). Chain cleavages of polymer materials through oxidation reactions are often responsible for loss of functional properties (such as aspect degradation or decrease in mechanical properties). Monitoring the environmental conditions leading to these phenomena requires therefore precise and simultaneous measurements of irradiance and temperature. Another way to evaluate environmental conditions consists in monitoring the degradation of a suitable reference material whose oxidation rate was previously well characterized.^{[7],[8],[9],[10]} This document refers to this approach and describes the properties and the use of polyethylene reference film (PERF) to evaluate environmental ageing conditions resulting from the combined effect of temperature and UV irradiance.

NOTE 1 The first and second edition of this document referred to PERS (polyethylene reference specimens) that were produced by the Japan Weathering Test Center.^{[7],[8],[9],[10]} This material is no longer available (see [Annex A](#)).

NOTE 2 Relative humidity and wetness have no influence on PERF or this influence is unknown.

6 Material

6.1 Properties

Some physicochemical properties of PERF are reported in [Table 1](#).

Table 1 — Physicochemical properties of PERF

Property	Range of values	Test method
Relative infrared (IR) absorbance of vinylidene insaturations	0,6 to 0,8 ^a	ASTM E168 ^[27]
Relative IR absorbance of carbonyl compounds (ketones)	< 0,15 ^b	ASTM E168 ^[27]
Density	920 to 924 kg/m ³	ISO 1183-1 ^[21]
Melt flow rate (temperature 190 °C, load 2,16 kg)	0,2 to 0,4 g/10 min	ISO 1133-1 ^[20]
Melting point ^c	110-120 °C	ISO 11357-3 ^[23]
Crystallinity ^c	20 to 40 %	ISO 11357-3 ^[23]
Number average molar mass (M _n) ^d	25 000 g/mol to 40 000 g/mol	ISO 16014-4 ^[25]
Mass average molar mass (M _w) ^d	400 000 g/mol to 600 000 g/mol	ISO 16014-4 ^[25]
Polydispersity index (PDI) ^d	10 to 20	ISO 16014-4 ^[25]
Thermal phenolic stabilizer content ^e	< 20 ppm	ASTM D6953 ^[26]
Oxidation induction time (OIT) at 210 °C	< 1 min	ISO 11357-6 ^[24]
Film thickness	0,15 ± 0,02 mm	ISO 4593 ^[22]

^a Determined by FTIR spectroscopy in transmission mode by calculating the ratio A_{888}/A_{2020} , A_{888} corresponding to the IR absorbance of vinylidene groups at 888 cm⁻¹ and A_{2020} to the absorbance at 2020 cm⁻¹ of a polyethylene thickness correction band.

^b Determined by FTIR spectroscopy in transmission mode by calculating the ratio A_{1723}/A_{2020} , A_{1723} corresponding to the IR absorbance of carbonyl compounds at 1 723 cm⁻¹ and A_{2020} to the absorbance at 2020 cm⁻¹ of a polyethylene thickness correction band.

^c Determined by differential scanning calorimetry (DSC). The crystallinity was calculated using a heat of fusion of a 100 % crystalline polyethylene of 293 J/g.

^d Determined by gel permeation chromatography (GPC) using a polystyrene calibration curve. The molar masses are therefore expressed as “polystyrene-equivalent molecular weight”.

^e Determined by high-performance liquid chromatography (HPLC).

6.2 Preparation

PERF are made of a free-radical polymerized low-density polyethylene produced by a high-pressure autoclave process. The films are obtained by blown film extrusion at 200 °C.

NOTE 1 The only known supplier of PERF at the time of publication of this document is the National Centre for Evaluation of Photoprotection (Centre National d'Evaluation de Photoprotection, CNEP) in France. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

NOTE 2 Former PERS were obtained from a high-density polyethylene material polymerized with molybdenum dioxide as a catalyst containing trans-form vinylene groups. The specimens were produced by a compression process. The physicochemical properties as well as the production method being different, results obtained with former PERS described in the first and second edition of this document are not comparable to the ones obtained with the new material of this edition of this document (see [Annex A](#)).

7 Method for measuring the carbonyl index of PERF

An FTIR spectrophotometer is used in accordance with ISO 10640.^[11] The FTIR spectrum of PERF is recorded in transmission mode after natural or artificial exposure in a range comprising at least the interval (2 200 cm^{-1} to 1 600 cm^{-1}).

A scanning speed suitable for a quantitative analysis is used and all preliminary steps for reliable FTIR analyses (such as an atmosphere baseline acquisition) are performed prior to the measurements. The FTIR spectrum of the exposed PERF is then used to measure the IR absorbance at 2 020 cm^{-1} and 1 715 cm^{-1} . The IR absorption at 2 020 cm^{-1} is employed as an internal standard to correct potential thickness variations of the film while the IR band at 1 715 cm^{-1} corresponds to the content of carboxylic groups formed in the film by the photo-oxidation processes. A theoretical IR spectrum of an oxidized PERF (after exposure) is shown in [Figure 1](#). The absorbance of the two infrared bands is determined by a tangent method that consists in measuring the absolute absorbance at each wavenumber, i.e. 2 020 cm^{-1} and 1 715 cm^{-1} , and in subtracting the absorbance of a hypothetical baseline corresponding to each band. The baseline is a straight line connecting the values of the spectrum comprised between 1 850 cm^{-1} and 1 660 cm^{-1} for the band at 1 715 cm^{-1} , and between 2 100 cm^{-1} and 1 980 cm^{-1} for the band at 2 020 cm^{-1} (see [Figure 1](#)).