SLOVENSKI STANDARD
SIST-TS CEN/TS 16010:2021

01-februar-2021

Nadomešča:
SIST-TS CEN/TS 16010:2014

Polimerni materiali - Reciklirani polimerni materiali - Postopki vzorčenja za preskušanje polimernih odpadkov in reciklatov

Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates

Kunststoffe - Kunststoff-Rezyklate - Probenahmeverfahren zur Prüfung von Kunststoffabfall und Rezyklaten

Plastiques - Plastiques recyclés - Procédures d'échantillonnage pour l'essai des déchets de plastiques et des recyclats

Ta slovenski standard je istoveten z: **CEN/TS 16010:2020**

ICS:

13.030.50	Recikliranje	Recycling
83.080.01	Polimerni materiali na splošno	Plastics in general

SIST-TS CEN/TS 16010:2021 **en,fr,de**

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN/TS 16010

December 2020

ICS 13.030.50; 83.080.01

Supersedes CEN/TS 16010:2013

English Version

Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates

Plastiques - Plastiques recyclés - Procédures d'échantillonnage pour l'essai des déchets de plastiques et des recyclats

Kunststoffe - Kunststoff-Rezyklate - Probenahmeverfahren zur Prüfung von Kunststoffabfall und Rezyklaten

This Technical Specification (CEN/TS) was approved by CEN on 9 November 2020 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. CEN/TS 16010:2020 E

Contents

Page

European foreword

This document (CEN/TS 16010:2020) has been prepared by Technical Committee CEN/TC 249 "Plastics", the secretariat of which is held by NBN.

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

This document supersedes CEN/TS 16010:2013.

In comparison with the previous edition, the following technical modifications have been made:

— formula in A.5.3 "Calculation of arithmetic mean" was corrected.

This document is one part of a series of CEN publications on Plastics Recycling that is structured as follows:

— EN 15342, *Plastics — Recycled Plastics — Characterization of polystyrene (PS) recyclates*

— EN 15343, *Plastics — Recycled Plastics — Plastics recycling traceability and assessment of conformity and recycled content*

— EN 15344, *Plastics — Recycled Plastics — Characterization of Polyethylene (PE) recyclates*

— EN 15345, *Plastics — Recycled Plastics — Characterization of Polypropylene (PP) recyclates*

— EN 15346, *Plastics — Recycled plastics — Characterization of poly(vinyl chloride) (PVC) recyclates*

— EN 15347, *Plastics — Recycled Plastics — Characterization of plastics wastes*

— EN 15348, *Plastics — Recycled plastics — Characterization of poly(ethylene terephthalate) (PET) recyclates*

— CEN/TR 15353, *Plastics — Recycled plastics — Guidelines for the development of standards for recycled plastics*

— CEN/TS 16011, *Plastics — Recycled plastics — Sample preparation*

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Recycling of plastics waste is one type of material recovery process intended to save resources (virgin raw materials, water, energy), while minimizing harmful emissions into air, water and soil as well as their impacts on human health. The environmental impact of recycling should be assessed over the whole life cycle of the recycling system (from the waste generation point to the disposal of final residues). To ensure that recycling constitutes the best environmental option for treating the available waste, some prerequisites should preferably be met:

— the recycling scheme being contemplated should generate lower environmental impacts than alternative recovery options;

— existing or potential market outlets should be identified that will secure a sustainable industrial recycling operation;

— the collection and sorting schemes should be properly designed to deliver recyclable plastics waste fractions fitting reasonably well with the available recycling technologies and with the (changing) needs of the identified market outlets, preferably at minimum costs for society.

This document has been produced in accordance with the guidance produced by CEN on Environmental Aspects and in accordance with CEN/TR 15353, *Plastics — Recycled plastics — Guidelines for the development of standards for recycled plastics*.

NOTE CEN/TR 15353 considers the general environmental aspects which are specific to the recycling process.

This document is intended to serve two purposes.

1. To provide a guide to plastic recyclers and others that enables a calculation to be made of the risk of inaccuracy presented by a chosen sampling regime. This will help to inform decisions about sampling that can also be influenced by factors such as the supply record of a supplier or the reliability of a process. This is covered in Clause 5.

2. To define the sampling procedures to be followed to characterize the material being sampled. These procedures may be followed where a particular level of accuracy is required, or where the sampling is in support of the resolution of a dispute. This is covered in Clause 7 and Annex A.

It is not the intention of this document to develop new sampling methods.

1 Scope

This document specifies a system for sampling procedures for testing plastics waste and recyclates which take into account the specifics of the plastics waste and recyclates. It is intended to cover all stages of the plastic recycling process.

The sampling procedures include the statistical specifics of the plastic waste and the behaviour of recyclates.

The sampling method is expected to produce a representative testing sample. Differences can arise due to:

— the mixture of plastics;

— the origin (e.g. green dot in Germany, or electronic/automotive industry);

— the previous use of the plastic material;

— the residual contents (e.g. of containers);

— inert, residual or moisture content on or in the material.

This document is without prejudice to any existing legislation.

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.

CEN/TR 15353:2007, *Plastics — Recycled plastics — Guidelines for the development of standards for recycled plastics*

CEN/TS 16011, *Plastics — Recycled plastics — Sample preparation*

EN ISO 472:2013,[1] *Plastics — Vocabulary (ISO 472:1913)*

ISO 11648-1:2003, *Statistical aspects of sampling from bulk materials — Part 1: General principles*

ISO 11648-2:2001, *Statistical aspects of sampling from bulk materials — Part 2: Sampling of particulate materials*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 472:2013[1], CEN/TR 15353:2007 and the following apply.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

NOTE The terms used are confined to the field of bulk sampling.

[1] As impacted by EN ISO 472:2013/A1:2018.

3.1
bulk material
amount of material within which component parts are not initially distinguishable on the macroscopic level

[SOURCE: ISO 11648-1:2003]

3.2
sample
combination of a set of increments of material taken from a lot, intended to supply information, and possibly serve as a basis for a decision concerning the lot or the process by which it has been produced

[SOURCE: ISO 8656-1:1988]

3.3
increment
quantity of bulk material taken in one action by a sampling device

[SOURCE: ISO 11648-1:2003]

3.4
laboratory sample
sample intended to be used for an inspection or for laboratory tests

[SOURCE: ISO 8656-1:1988]

3.5
test sample
sample taken from the laboratory sample and prepared in a suitable manner for subjection to particular tests

Note 1 to entry: Test samples might be prepared, for example, for the determination of particle size distribution, moisture content, chemical composition, physical or other properties. See also CEN/TS 16011.

[SOURCE: ISO 8656-1:1988]

3.6
central limit theorem
fundamental theorem of probability and statistics, stating that the distribution of the mean of a random sample from a population with finite variance is approximately normally distributed when the sample size is large, regardless of the shape of the population's distribution

Note 1 to entry: If $x_1, x_2, ..., x_n$ are independent measurements (i.e. a random sample of size n), from a population where the mean of x is μ, and the standard deviation of x is σ, then:

The distribution of $\overline{x} = \frac{x_1 + x_2 + \ldots + x_n}{n}$ = has mean and standard deviation given by:

$$\mu_{\overline{x}} = \mu \text{ and } \sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}$$

When n is sufficiently large, then the distribution of $\overline{x}$ is approximately normal.

3.7
Student's *t*-distribution
***t*-distribution**
probability distribution that is effective in the problem for estimating the mean of a normally distributed population when the sample size is small

3.8
duration
length of sample time when sampling from a continuous stream

3.9
plastics waste
plastics fraction of waste

3.10
waste
material or object which the holder discards, or intends to discard, or is required to discard

[SOURCE: ISO 15270:2008]

4 Symbols and abbreviations

n number of single samples, number of measurements

x_n independent single measured value

$\bar{x}$ arithmetic mean (average value, average)

s standard deviation of samples

σ standard deviation of population

μ is the real value of the true mean of the known distribution

t the value of the Student deviation for different levels of confidence

5 Calculating the probability that a given set of samples is representative

5.1 General

In everyday circumstances plastics recyclers require sampling for two basic purposes: to provide input quality control and to verify the quality of the output recycled plastic. Although the physical properties of input and output materials might be very different, the underlying statistical principles are the same. The samples taken shall be sufficiently representative of the batch to satisfy the user of the sample information that it is relevant for his purpose. The sampling regime will be based on a number of factors including:

— the physical form and homogeneity of the material being sampled;

— the level of confidence in the consistency and reliability of the material being sampled;

— the consequences of the sample not being representative.

The purpose of this section is to provide a tool for the plastic recycler to use to calculate the effectiveness of his chosen sampling routine or, conversely, to calculate the risk associated with a particular sampling regime.

Sample sizes are often small, and the population standard deviation (σ) is usually unknown. The population standard deviation (σ) can be replaced with the sample standard deviation (s). To be more conservative in the analysis, the t-distribution may be used rather than the normal distribution. When sample sizes are large the results are the same (Central Limit Theorem).

Many common statistical procedures require data to be approximately normal, but the Central Limit Theorem enables these procedures to be applied to populations that are strongly non-normal. How large the sample size shall be depends on the shape of the original distribution. If the population's distribution is symmetric, a sample size of 5 might yield a good approximation; if the population's distribution is strongly asymmetric, a larger sample size is necessary (50 or more).

Sampling error is in effect $\sqrt{\frac{1}{n}}$ and this gives a guide to the limit of detection in that it would be possible to miss a 10 % component by taking a sample of 100 pieces. It is also important to recognize that the sampling error is based on the particles as sampled. If these particles have an average mass of 10 g then a sample of 1 kg is needed to get a 10 % error and 100 kg to get a 1 % error.

5.2 Power and sample size

Power is the likelihood of identifying a significant difference (effect) when one truly exists. Errors are referred to as Type 1 and Type 2 errors. A Type 1 error results in rejecting good material and a Type 2 error results in accepting bad material. The easiest way to improve power is to increase sample size.

5.3 Calculation of the variance of sampling

To understand the effect of changing the number of samples, see Annex C. With a number of samples 'n' the factor 't' is determined with different levels of confidence. Using an estimated or calculated standard deviation 's' it is possible to calculate the influence on the sampling by variation of the number of samples with the formula in Annex A under A.5.2 (reverse calculation).

5.4 Determining the confidence in a sampling routine

In this example a load of ten tonnes of waste plastic is delivered to a plastic recycler for processing.

— The load consists of ten bags of shredded plastic, each bag weighing approximately one tonne.

— The plastic has been shredded to give pieces averaging 150 mm × 150 mm (range > 75 mm to < 200 mm) by 3 mm thick (range > 2,5 mm to < 3,5 mm).

— The average mass of each shredded piece is 0,06 kg.

— The load is known to contain a mixture of polyethylene (PE) and polypropylene (PP). The supplier claims that the PP content is less than 5 %.

— The plastic recycler hand samples each bag, taking two sample pieces from each bag; a total of 20 samples.

— Each sample is analysed to find its PP content with the results shown in Table 1.

Table 1 — Analysis results

Sample No	PP%	Sample No	PP%
1	4,25	11	6,55
2	6,15	12	6,10
3	4,90	13	6,95
4	5,30	14	4,85
5	4,95	15	6,95
6	4,15	16	7,10
7	4,95	17	6,65
8	5,75	18	4,75
9	6,80	19	4,85
10	5,15	20	4,10

The average value (mean) $\bar{x}$ = 5,56 %.

The Standard Deviation, calculated according to A.5.1 gives *s* = 1,013 929.

The value for '*t*' to give an assumed 95 % confidence level with 20 samples can be taken from the table in Annex C giving a figure for '*t*' of 2,093.

The confidence interval is calculated using the formula in A.5.4 so that:

$$\bar{x} \pm t\frac{s}{\sqrt{n}} = 5{,}56 \pm 2{,}093 \times \frac{1{,}013\,929}{\sqrt{20}} = 5{,}56 \pm 0{,}474\,5$$

The end points for the confidence interval are therefore 5,085 5 % and 6,034 5 %

This means the recycler can be reasonably certain (95 %) that the PP content for the samples taken lies between 5,09 % and 6,03 %. Because the mean of the samples lies within this range it is also possible that the mean of the batch is approximately equal to 5,56 %.

Based on this result the buyer can be reasonably certain that the average PP content for the material being supplied is higher than stated by the supplier (<5 %).

For a higher confidence level the value of '*t*' will change. For an assumed confidence level of 99 %, '*t*' will become 2,861 and the calculated end points would become 4,91 % and 6,21 % indicating the probability of a much wider spread of the value of the PP content.

Conversely, for a lower level of confidence, say 90 %, '*t*' will become 1,729 and the calculated end points would become 5,17 % and 5,95 % respectively.

Similar calculations could be made for properties such as particle size, dirt content, moisture content or other contaminants.