SLOVENSKI STANDARD
oSIST prEN ISO 4349:2023

01-julij-2023

Trdna alternativna goriva - Določitev indeksa recikliranja za soprocesiranje (ISO/DIS 4349:2023)

Solid recovered fuels - Determination of the Recycling Index for co-processing (ISO/DIS 4349:2023)

Feste Sekundärbrennstoffe - Verfahren zur Bestimmung des Recycling-Index (ISO/DIS 4349:2023)

Combustibles solides de récupération - Détermination de l'indice de recyclage pour le cotraitement (ISO/DIS 4349:2023)

Ta slovenski standard je istoveten z: **prEN ISO 4349**

ICS:

75.160.10	Trda goriva	Solid fuels

oSIST prEN ISO 4349:2023 **en,fr,de**

DRAFT INTERNATIONAL STANDARD

ISO/DIS 4349

ISO/TC **300**

Secretariat: **SFS**

Voting begins on:
2023-04-27

Voting terminates on:
2023-07-20

Solid recovered fuels — Determination of the Recycling Index for co-processing

Combustibles solides de récupération — Détermination de l'indice de recyclage pour le cotraitement

ICS: 75.160.10

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 4349:2023(E)

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Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 300 *Solid recovered materials, including solid recovered fuels*.

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

When solid recovered fuels (SRF) are co-processed mainly in the cement industry, simultaneous energy recovery and recycling of mineral components of waste material takes place because the ash is directly incorporated into the clinker. SRF co-processing therefore allows for the replacement of both mineral resources and fossil fuels.

SRF ashes contain various chemical components that either are crucial raw materials for cement manufacturers, fulfill specific tasks in cement clinker production or represent clinker phases giving the clinker its specific properties. For example, major part of SRF ashes from mixed municipal and commercial waste consists of the four main chemical components that are required for cement clinker production: Al_2O_3, CaO, Fe_2O_3, and SiO_2 (see Annex A). Additionally, minor ash constituents include MgO and TiO_2, both of which are present in or as clinker phases. K_2O, Na_2O are typical constituents of feldspars that are present in the clay used as a raw material for the process. SO_3, which is also present in SRF ash, or another sulfate carrier, is needed in order to convert these alkali oxides into alkali sulfates, a clinker phase that alters the clinker's chemical reactivity with water.

Solid recovered fuels — Determination of the Recycling Index for co-processing

1 Scope

This document specifies the determination of the share of material recovery in the case of energy recovery (i.e. co-processing) of SRF, i.a., in a cement kiln. This share, called Recycling Index, is calculated on the basis of the ash content and the ash composition.

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 21645, *Solid recovered fuels — Methods for sampling*

ISO 21646, *Solid recovered fuels — Sample preparation*

ISO 21656, *Solid recovered fuels — Determination of ash content*

ISO 21665, *Solid recovered fuels – Determination of elemental content (Al, Ca, Fe, K, Mg, Na, P, Si, Ti, As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, Se, Tl, V an Zn)*

ISO 22940, *Solid recovered fuels — Determination of elemental composition by X-ray fluorescence*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1
R-index
share of SRF that can be considered as recycled on a material level, expressed as mass fraction in percent of the dry matter

3.2
co-processing
the use of SRF in manufacturing processes for energy recovery and simultaneously for material recovery of mineral components

4 Symbols and abbreviations

R-index	Recycling Index
(d)	dry (dry basis)
A_{db}	ash content at 815 °C on a dry basis

Al_2O_3	Aluminium(III) oxide
CaO	Calcium oxide
Fe_2O_3	Iron(III) oxide
K_2O	Potassium oxide
MgO	Magnesium oxide
Na_2O	Sodium oxide
P_2O_5	Phosphorus pentoxide
SiO_2	Silicon dioxide
SO_3	Sulfur trioxide
TiO_2	Titanium dioxide

5 Reagents

5.1 Water, e.g. deionized (< 0,055 µS/cm).

5.2 Nitric acid (HNO_3), approximately 15 mol/l, 65 % to 70 % (w/w).

5.3 Hydrofluoric acid (HF), approximately 23 mol/l, 40 % to 45 % (w/w).

5.4 Hydrochloric acid (HCl), approximately 12 mol/l, 35 % to 37 % (w/w).

5.5 Lithium metaborate ($LiBO_2$), solid.

5.6 Binder, solid or liquid, e.g. wax. Specifications given in EN 15309.

6 Apparatus

6.1 Analytical balance with an accuracy of 1 mg or better

6.2 Muffle furnace for temperatures of 1 050 °C

6.3 Inductively coupled plasma

Normal commercial instrumentation with optical or mass spectrometric detector (ICP-OES, ICP-MS).

6.4 X-ray fluorescence spectrometer

Energy or wavelength dispersion system suitable for qualitative and (semi-)quantitative analysis of the elements listed in this document.

6.5 Microwave unit according to PWI3884

6.6 Press according to ISO 22940 or EN 15309

6.7 Platinum crucible, e.g. Pt/Au5 %

6.8 Inert bowl, e.g. out of porcelain, silicon dioxide or platinum with a depth of 10 mm to 20 mm and with a size selected in a way that the occupancy of the bottom area does not exceed 0,1 g/cm^2.

6.9 Magnetic stirrer with heating function and PTFE stirring bone

6.10 Volumetric flasks, e.g. 250 mL

7 Procedure

7.1 Preparation of the test sample

The sampling of SRF shall be carried out according to ISO 21645 and the sample preparation according to ISO 21646 with the final sample having a nominal top size of 1,0 mm or less. Hard impurities, i.e. inert materials or metals, that cannot be reduced in size with the apparatuses defined in ISO 21646 are sorted out during sample preparation and are not considered in the subsequent analysis steps. Their amount is to be documented. The sample is dried at 105 °C according to ISO 21660-3. Further procedures and analyses are carried out with the dried sample <1,0 mm free of hard impurities.

7.2 Determination of the ash content and preparation of ash sample

The determination of the ash content shall be carried out according to Method B of ISO 21656. If the determination provides a sufficient amount of material to proceed with the analyses, the ashed material shall be used for subsequent analyses. If the determination of the ash content provides insufficient amounts of ash for the subsequent analysis steps (examples for ash contents of typical constituents of SRF from mixed municipal and commercial waste are given in Annex A), the sufficient amount of ash shall be reached by using one or both of the following two approaches:

a) the ashing process is repeated and the ashes are collected and united in order to reach the minimum amounts required for subsequent ash analyses. This may be the preferable approach for Method A (wet digestion/ICP-MS, requiring approx. 200 mg of ash sample) and Method B (fused beads/ICP-OES, requiring approx. 100 mg of ash sample).

b) a correspondingly larger inert bowl is used and the amount of sample is increased accordingly, which may be the preferable option for pellet preparation and XRF analyses (Method C, ca. 4,5 – 10 g are required). The bowl shall fulfil the requirements defined by ISO 21656 and its size shall be selected in a way that the occupancy of the bottom area does not exceed 0,1 g/cm^2.

7.3 Determination of the elemental content

The determination of the elemental content shall be carried out according to ISO 21665 or ISO 22940. The element content shall be determined in the ashed sample.

7.4 Methods

7.4.1 Method A – wet digestion followed by ICP-MS or ICP-OES analysis

The ash is digested using microwave-assisted acid digestion with hydrochloric acid, nitric acid and hydrofluoric acid and analysed by ICP-MS or ICP-OES as described in ISO/AWI 3884.

7.4.2 Method B – preparation of fused beads followed by ICP-OES analysis

100 mg (±20 mg) of the ashed sample is thoroughly mixed with 1 000 mg (±10 mg) of the fluxing agent lithium metaborate in a platinum crucible. The mixture is melted in a muffle furnace at 1 050 °C ± 10 °C for 20 min. The resulting fused bead is allowed to cool down and dissolved incrementally by adding 80 mL of hydrochloric acid (c = 2 mol/L) into the crucible in small amounts. The dissolution is supported by heating (to approx. 60 °C) and stirring with a PTFE stirring bone. The digest solution is filled to a final

volume of 250 mL with deionised water (< 0,055 µS/cm). This solution contains 0,4 g/L of the sample and 4 g/L of the fluxing agent. Only clear solutions shall be subjected to subsequent analyses, turbid digest solutions are discarded. A blank is prepared using the same method, but no sample is added. The element content in the digestion solutions is determined by ICP-OES according to EN ISO 11885.

7.4.3 Method C – preparation of pellets followed by XRF analysis

The pellet preparation and XRF analyses is performed according to EN ISO 22940 or EN 15309. The fine ash sample is mixed and homogenized with binder at a defined ratio (different ratios can be applied and the dilution factor needs to be considered; a typical sample to wax mass ratio is 10:1) and is pressed with an automatic or manual press. For a pellet with a diameter of 40 mm, about 10,0 g of the ash sample is required. For a pellet with a diameter of 32 mm, ca. 4,5 g ash sample is required.

7.4.4 Alternative procedures

Alternative methods can be applied, if their performance is proved to be comparable with those listed above.

7.5 Calculation

7.5.1 Calculation of element oxides

The results for the concentrations of chemical elements need to be converted into concentrations of element oxides. The conversion is performed by multiplying the concentration of the respective element, expressed as mg/kg *(d)* with the corresponding conversion factor:

$$c_{i2} = CF_i * c_{i1}$$

where

c_{i1} is the concentration of a selected element expressed as mg/kg *(d)*

c_{i2} is the concentration of the corresponding element oxide expressed as mg/kg *(d)*, see Table 1

CF_i is the corresponding conversion factor as listed in Table 1

Table 1 — Conversion factors

Element	Element oxide	Conversion Factor CF
Al	Al_2O_3	1,889 5
Ca	CaO	1,399 2
Fe	Fe_2O_3	1,429 7
K	K_2O	1,204 6
Mg	MgO	1,658 3
Na	Na_2O	1,348 0
S	SO_3	2,496 9
Si	SiO_2	2,139 3
Ti	TiO_2	1,668 5

7.5.2 Calculation of R-index for co-processing

The share of the SRF that is recycled on a material level (i.e. R-index), expressed as mass fraction in percent of the dry matter [% (d)], can either be calculated considering the four main chemical compounds required for the production of cement clinker (R-index$_4$) or considering additional elements