

Safety assessment of the process Starlinger recoSTAR PET iV+ used to recycle post-consumer PET into food contact materials

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The declarations of interest of all scientific experts active in EFSA's work are available at <https://open.efsa.europa.eu/experts>

Abstract

The EFSA Panel on Food Contact Materials (FCM) assessed the safety of the recycling process Starlinger recoSTAR PET iV+ (EU register number RECYC333). The input is hot washed and dried poly(ethylene terephthalate) (PET) flakes mainly originating from collected post-consumer PET containers, with no more than 5% PET from non-food consumer applications. The flakes are dried and crystallised (step 2), melted in an extruder and crystallised (step 3) and treated in a solid-state polycondensation (SSP) reactor under high temperature and vacuum (step 4). Having examined the challenge test provided, the Panel concluded that all three steps are critical in determining the decontamination efficiency of the process, the SSP being the most relevant for decontamination. The operating parameters to control the efficiency are the pressure, the temperature, the residence time and the gas flow rate. It was demonstrated that this recycling process ensures that the level of migration of potential unknown contaminants into food is below the conservatively modelled migration of 0.0481 or 0.0962 µg/kg food, depending on the molar mass of a contaminant substance. Therefore, the Panel concluded that the recycled PET obtained from this process is not of safety concern when used at up to 100% for the manufacture of materials and articles for contact with all types of foodstuffs, including drinking water, for long-term storage at room temperature or below, with or without hot-fill. Articles made of this recycled PET are not intended to be used in microwave and conventional ovens, and such uses are not covered by this evaluation.

KEYWORDS

food contact materials, plastic, poly(ethylene terephthalate) (PET), recycling process, safety assessment, Starlinger recoSTAR PET iV+

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1 | INTRODUCTION

1.1 | Background

Recycled plastic materials and articles shall only be placed on the market if the recycled plastic is from an authorised recycling process. Before a recycling process is authorised, the European Food Safety Authority (EFSA)'s opinion on its safety is required. This procedure has been established in Articles 17 and 18 of Commission Regulation (EU) 2022/1616¹ on recycled plastic materials intended to come into contact with foods. More specifically, according to Article 18 of Commission Regulation (EU) 2022/1616 on recycled plastic materials intended to come into contact with foods, EFSA is required to carry out risk assessments on the risks originating from the migration of substances from recycled food contact plastic materials and articles into food, to evaluate the microbiological safety of these materials and articles and to deliver a scientific opinion on the recycling process examined.

According to this procedure, the process developers submit applications to the competent authorities of Member States, which transmit the applications to EFSA for evaluation. In this case, EFSA received an application from the Austrian Competent Authority (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz), for evaluating the recycling process Starlinger recoSTAR PET iv+, European Union (EU) register No RECYC333. The request has been registered in the EFSA's register of received questions under the number EFSA-Q-2023-00015. The dossier was submitted by lms consulting, on behalf of Starlinger & Co. GmbH, Furtherstrasse 47a, 2564 Weissenbach, Austria (see Section 'Documentation provided to EFSA').

1.2 | Terms of Reference

The Austrian Competent Authority (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz) requested the safety evaluation of the recycling process Starlinger recoSTAR PET iv+, in compliance with Article 17 of Commission Regulation (EU) 2022/1616. The recycling process uses the recycling technology number 1 of the list of suitable recycling technologies of Table 1 of Annex 1 of Commission Regulation (EU) 2022/1616.

2 | DATA AND METHODOLOGIES

2.1 | Data

The applicant submitted a confidential and a non-confidential version of a dossier, following EFSA's 'Scientific Guidance on the criteria for the evaluation and on the preparation of applications for the safety assessment of post-consumer mechanical PET recycling processes intended to be used for manufacture of materials and articles in contact with food' (EFSA CEP Panel, 2024) and EFSA's 'Administrative guidance for the preparation of applications for the authorisation of individual recycling processes to produce recycled plastics materials and articles intended to come into contact with food' (EFSA, 2024).

Additional information was received from the applicant during the assessment process, in response to requests from EFSA sent on 11 December 2023 and 25 February 2025 (see Section 6). Following the request made by the applicant, a clarification teleconference was held on 6 February 2024.

In accordance with Art. 38 of the Regulation (EC) No 178/2002² and taking into account the protection of confidential information and personal data in accordance with Articles 39 to 39e of the same Regulation, and of the Decision of the EFSA's Executive Director laying down practical arrangements concerning transparency and confidentiality,³ the non-confidential version of the dossier has been published in Open.EFSA.⁴

According to Art. 32c(2) of Regulation (EC) No 178/2002 and to the Decision of EFSA's Executive Director laying down the practical arrangements on pre-submission phase and public consultations,⁴ EFSA carried out a public consultation on the non-confidential version of the application from 11 September to 2 October 2024, for which no comments were received.

The following information on the recycling process was provided by the applicant and used for the evaluation (EFSA, 2024; EFSA CEP Panel, 2024):

- Recycling process.
- Determination of the decontamination efficiency of the recycling process.
- Table of operating parameters.
- Self-evaluation of the recycling process.

¹Commission Regulation (EU) 2022/1616 of 15 September 2022 on recycled plastic materials and articles intended to come into contact with foods, and repealing Commission Regulation (EC) No 282/2008. OJ L 243, 20.9.2022, pp. 3–46.

²Commission Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, 1.2.2002, pp. 1–48.

³Decision available at: <https://www.efsa.europa.eu/en/corporate-pubs/transparency-regulation-practical-arrangements>.

⁴The non-confidential version of the dossier has been published on Open.EFSA and is available at the following link: <https://open.efsa.europa.eu/dossier/FCM-2022-12291>.

2.2 | Methodologies

The risks associated with the use of recycled plastic materials and articles in contact with food come from the possible migration of chemicals into the food in amounts that would endanger human health. The quality of the input, the efficiency of the recycling process to remove contaminants as well as the intended use of the recycled plastic are crucial points for the risk assessment (EFSA CEP Panel, 2024).

The criteria for the safety evaluation of a mechanical recycling process to produce recycled PET intended to be used for the manufacture of materials and articles in contact with food are described in the scientific guidance developed by the EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (EFSA CEP Panel, 2024). The principle of the evaluation is to apply the decontamination efficiency of a recycling process, obtained from a challenge test with surrogate contaminants, to a reference contamination level for post-consumer PET, conservatively set at 3 mg/kg PET for contaminants resulting from possible misuse. The resulting residual concentration of each surrogate contaminant in recycled PET (C_{res}) is compared with a modelled concentration of the surrogate contaminants in PET (C_{mod}). This C_{mod} is calculated using generally recognised conservative migration models so that the related migration does not give rise to a dietary exposure exceeding 0.0025 µg/kg body weight (bw) per day (i.e. the human exposure threshold value for chemicals with structural alerts for genotoxicity), below which the risk to human health would be negligible, considering different dietary exposure scenarios (EFSA CEP Panel, 2024). If the C_{res} is not higher than the C_{mod} , the recycled PET manufactured by such recycling process is not considered of safety concern for the defined conditions of use (EFSA CEP Panel, 2024).

The assessment was conducted in line with the principles described in the EFSA Guidance on transparency in the scientific aspects of risk assessment, considering the relevant guidance from the EFSA Scientific Committee (EFSA, 2009).

3 | ASSESSMENT

3.1 | General information⁵

According to the applicant, the recycling process Starlinger recoSTAR PET iV+ is intended to recycle food grade PET containers. The recycled PET is intended to be used at up to 100% for the manufacture of materials and articles for direct contact with all kinds of foodstuffs, such as sheets, thermoformed trays or cups and preforms for bottles for mineral water, soft drinks, juices and beer. The final articles are intended for long-term storage at room temperature or below, with or without hot-fill. They are not intended to be used in microwave or conventional ovens.

3.2 | Description of the process

3.2.1 | General description⁶

The Starlinger recoSTAR PET iV+ recycling process produces recycled PET pellets from PET materials and articles originating from post-consumer collection systems.⁷

Input

- In step 1, the post-consumer PET is processed into hot-washed and dried flakes.

Decontamination and production of recycled PET material

The decontamination process comprises the three steps below:

- In step 2, the flakes are dried and crystallised under gas flow at elevated temperature;
- In step 3, the flakes are extruded under vacuum where they are molten. Flakes are subsequently pelletised and then crystallised;
- In step 4, the crystallised pellets are preheated before being treated in a solid-state polycondensation (SSP) reactor at high temperature and under vacuum.

The operating conditions of the process have been provided to EFSA.

⁵Technical dossier, Section 'Intended application in contact with food'.

⁶Technical dossier, Sections 'Recycling process', 'Characterisation of the input' and 'Characterisation of the recycled plastic'.

⁷The collected plastic waste should comply with Art. 6 of Reg. (EC) 2022/1616.

3.2.2 | Characterisation of the pre-processed plastic input⁸

According to the applicant, the input material consists of hot washed and dried flakes obtained from PET materials and articles, e.g. bottles, previously used for food packaging, from post-consumer collection systems.⁷ A small fraction may originate from non-food applications. According to the applicant, the proportion will be no more than 5%, as specified in Article 7 and Table 1 of Annex I of Commission Regulation (EU) 2022/1616.

Technical specifications on the hot washed and dried flakes are provided, such as on physical properties and residual contents of moisture, poly(vinyl chloride) (PVC), polyamide (PA), polycarbonate (PC), polystyrene (PS), other plastics, glue, and metals (see Appendix A).

3.3 | Starlinger recoSTAR PET iv+ process

3.3.1 | Description of the main steps⁹

The process flow diagram of the process, as provided by the applicant, is reported in Figure 1. The steps are:

- **Drying and crystallisation (step 2):** the flakes are continuously dried and crystallised under elevated temperature and hot air flow for a predefined residence time.
- **Extrusion and crystallisation (step 3):** the flakes from the previous step are fed and molten into a single screw extruder with degassing, operating under vacuum. Then, the material is pelletised and subsequently crystallised at elevated temperature in a continuous reactor under atmospheric pressure.
- **SSP (step 4):** the crystallised pellets are heated with hot air in one or more preheaters. After the temperature level is reached, the preheater(s) is(are) set under vacuum. When the vacuum set point is reached, the material is released into one or two semi-continuous SSP reactor(s) running under vacuum at high temperature and for a predefined residence time. There is no mixing of layers in the reactor.

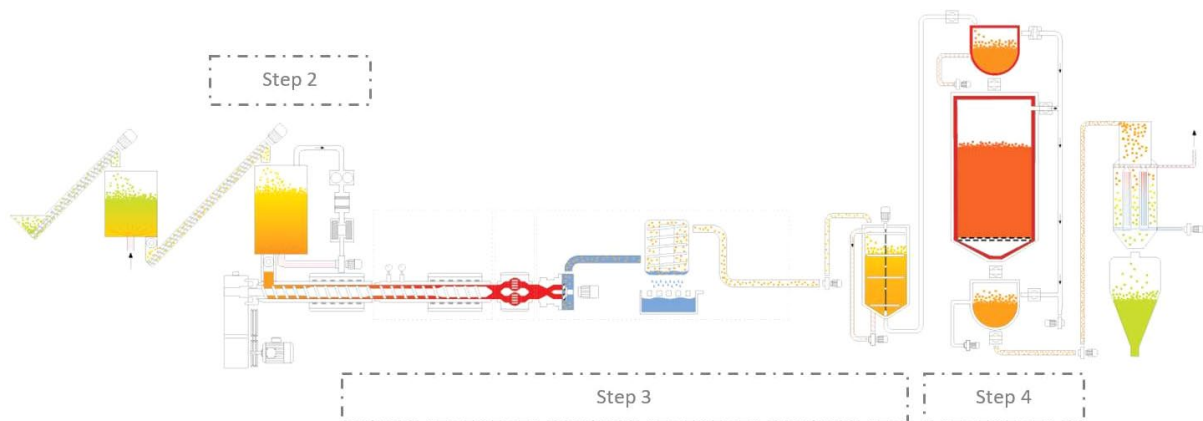


FIGURE 1 Process flow diagram of the Starlinger recoSTAR PET iv+ process (provided by the applicant).

The process is run under defined operating parameters¹⁰ of temperature, pressure, gas flow rate (expressed as air/PET ratio in m³ air/kg PET) and residence time (Appendix C). All critical parameters are automatically monitored. A dedicated software checks their values and as soon as one or more parameters are out of the specified range, the exiting material is automatically transferred to a non-food grade storage.¹¹

According to the applicant, the pellets, the final product of the process, are checked against technical requirements, such as intrinsic viscosity, acetaldehyde, pellet size and bulk density.

⁸Technical dossier, Section 'Characterisation of the input'.

⁹Technical dossier, Sections 'Recycling process' and 'Determination of the decontamination efficiency of the recycling process'.

¹⁰In accordance with Art. 9 and 20 of Regulation (EC) No 1935/2004, the parameters were provided to EFSA by the applicant and made available to the Member States and the European Commission (see Appendix C).

¹¹Technical dossier, Section 'Quality Assurance System'.

3.3.2 | Decontamination efficiency of the recycling process¹²

To demonstrate the decontamination efficiency of the recycling process, a challenge test performed at pilot plant scale on steps 2–4 was submitted to the EFSA.

PET flakes were contaminated with toluene, chloroform, phenylcyclohexane, benzophenone and lindane, selected as surrogates in agreement with the EFSA Scientific Guidance (EFSA CEP Panel, 2024) and in accordance with the recommendations of the US Food and Drug Administration (FDA, 2021). PET flakes were mixed with a heptane/isopropanol solution of the surrogates and then stored for 14 days at 40°C. The contaminated flakes were rinsed with water at room temperature. Subsequently, PET flakes were washed using a water solution with 1% caustic soda and 0.3% detergent at 85°C for 10 minutes, then dried centrifugally and further dried at 150°C. The concentration of the surrogates in these flakes was measured and then used for the calculation of the decontamination efficiency.

The contaminated flakes were introduced into the drier (step 2), then extruded and crystallised (step 3). Subsequently, preheated pellets were fed into the SSP reactor (step 4), which was run in batch mode instead of semi-continuously as in the process. The decontamination efficiency was calculated from the concentration differences of the surrogate substances in the flakes sampled before drying (step 2) and in the pellets after the SSP (step 4). Intermediate concentrations before and after extrusion were also provided.⁴ When surrogates were not detected, the limit of detection was considered for the calculation of the decontamination efficiency. The results are summarised in Table 1.

TABLE 1 Efficiency of the decontamination of the Starlinger recoSTAR PET iV+ process in the challenge test.

Surrogates	Concentration of surrogates before step 2 (mg/kg PET)	Concentration of surrogates after step 4 (mg/kg PET)	Decontamination efficiency (%)
Toluene	625.1	< 0.7 ^{a,b}	> 99.9
Chloroform	753.9	< 0.3 ^a	> 99.9
Phenylcyclohexane	439.6	0.8	99.8
Benzophenone	758.6	3.0 ^b	99.6
Lindane	234.4 ^b	14.8 ^b	93.7

Abbreviation: PET, poly(ethylene terephthalate).

^aNot detected at the limits of detection given.

^bData corrected by the Panel taking into account the recovery.

3.4 | Discussion

Considering the high temperatures used during the process, the possibility of contamination by microorganisms can be discounted. Therefore, this evaluation focuses on the chemical safety of the final product.

Specifications on the input material (i.e. washed and dried flakes, step 1) are listed in Appendix A.

The flakes are produced from PET containers, e.g. bottles, previously used for food packaging, collected through post-consumer collection systems. However, a small fraction may originate from non-food applications, such as bottles for soap, mouthwash or kitchen hygiene agents. According to the applicant, the collection system and the sorting are managed in such a way that this fraction will be no more than 5% in the input stream, as recommended by the EFSA CEP Panel in its Guidance (EFSA CEP Panel, 2024).

The Starlinger recoSTAR PET iV+ process is adequately described. It comprises the drying and crystallisation (step 2), extrusion and crystallisation (step 3) and SSP (step 4). The operating parameters of temperature, residence time, pressure and gas flow rate have been provided to EFSA.

A challenge test to measure the decontamination efficiency was conducted at pilot plant scale on process steps 2–4. The Panel considered that it was performed correctly according to the recommendations of the EFSA Guidance (EFSA CEP Panel, 2024). The installation was operated under pressure, gas flow rate and temperature conditions as well as residence time equivalent to or less severe than those of the commercial process. The SSP reactor was run in batch mode, instead of semi-continuously as in the process. However, since the reactor in the process works practically with no mixing, the FCM Panel agreed that the batch reactor in the challenge test provided the same cleaning efficiency when run at the same temperature, pressure and residence time. The FCM Panel considered that these three steps (drying and crystallisation, extrusion and crystallisation and SSP) are critical for the decontamination efficiency of the process, the SSP step being the most relevant for decontamination.

Consequently, the temperature, the gas flow rate and the residence time for the drying and crystallisation (step 2), the temperature, the residence time and the pressure (vacuum) in the extruder as well as the temperature in the crystalliser (step 3) and the temperature, the pressure (vacuum) and the residence time in the SSP (step 4), specified in Appendix C, are to be controlled to guarantee the efficiency of the decontamination.

¹²Technical dossier, Section 'Determination of the decontamination efficiency of the recycling process'.

The decontamination efficiencies obtained for each surrogate, ranging from 93.7% to above 99.9%, have been used to calculate the residual concentrations of potential unknown contaminants in PET (C_{res}). By applying the decontamination efficiency percentage to the reference contamination level of 3 mg/kg PET, the C_{res} values shown in Table 2 were obtained.

According to the evaluation principles (EFSA CEP Panel, 2024), the dietary exposure must not exceed 0.0025 $\mu\text{g}/\text{kg}$ bw per day, below which the risk to human health is considered negligible. The C_{res} value should not exceed the modelled concentration in PET (C_{mod}) that, after 1 year at 25°C, results in a migration giving rise to a dietary exposure of 0.0025 $\mu\text{g}/\text{kg}$ bw per day. As the recycled PET is intended for the manufacturing of articles (e.g. bottles) to be used in direct contact with drinking water, the exposure scenario for infants has been applied for the calculation of C_{mod} (exposure scenario A; water could be used to prepare infant formula). A maximum dietary exposure of 0.0025 $\mu\text{g}/\text{kg}$ bw per day corresponds to a maximum migration of 0.0481 $\mu\text{g}/\text{kg}$ ($= 5 \times 0.00962 \mu\text{g}/\text{kg}$) or 0.0962 $\mu\text{g}/\text{kg}$ ($= 10 \times 0.00962 \mu\text{g}/\text{kg}$), depending on the molar mass of a contaminant substance¹³ into infant food and has been used to calculate C_{mod} (EFSA CEP Panel, 2024). C_{res} reported in Table 2 is calculated for 100% recycled PET. The results of these calculations are shown in Table 2. The relationship between the key parameters for the evaluation scheme is reported in Appendix B.

TABLE 2 Decontamination efficiency from the challenge test, residual concentrations of the surrogates (C_{res}) related to the reference contamination level and calculated concentrations of the surrogates in PET (C_{mod}) corresponding to a modelled migration of 0.0481 $\mu\text{g}/\text{kg}$ or 0.0962 $\mu\text{g}/\text{kg}$ after 1 year at 25°C (C_{mod}).

Surrogates	Decontamination efficiency (%)	C_{res} for 100% rPET (mg/kg PET)	C_{mod} (mg/kg PET) Scenario A
Toluene	> 99.9	< 0.003	0.04
Chloroform	> 99.9	< 0.001	0.05
Phenylcyclohexane	99.8	0.005	0.13
Benzophenone	99.6	0.01	0.15
Lindane	93.7	0.19	0.28

Abbreviations: PET, poly(ethylene terephthalate); rPET, recycled poly(ethylene terephthalate).

On the basis of the provided data from the challenge test and the applied conservative assumptions, the Panel considered that, under the given operating conditions, the recycling process is able to ensure that the level of migration of unknown contaminants from the recycled PET into food is below the conservatively modelled migration of 0.0481 $\mu\text{g}/\text{kg}$ or 0.0962 $\mu\text{g}/\text{kg}$, depending on the molar mass of a contaminant substance into infant's food. At this level, the risk to human health is considered negligible when the recycled PET is used at up to 100% to produce materials and articles intended for contact with all types of foodstuffs, including drinking water (exposure scenario A), for long-term storage at room temperature or below, with or without hot-fill.

4 | CONCLUSIONS

The Panel considered that the process Starlinger recoSTAR PET iV+ is adequately characterised and that the main steps used to recycle the PET flakes into decontaminated PET pellets have been identified. Having examined the challenge test provided, the Panel concluded that the three steps (drying and crystallisation, extrusion and crystallisation, and SSP) are critical for the decontamination efficiency. The parameters to control the process efficiency are the pressure, the temperature, the residence time as well as the gas flow rate (air/PET ratio), as specified in Appendix C.

The Panel concluded that the recycling process. Starlinger recoSTAR PET iV+ is capable of reducing contamination of post-consumer food contact PET to a concentration that does not give rise to concern for a risk to human health if:

- it is operated under conditions that are at least as severe as those applied in the challenge test used to measure the decontamination efficiency of the process;
- the input material of the process is washed and dried post-consumer PET flakes originating from materials and articles that have been manufactured in accordance with the EU legislation on food contact materials and contain no more than 5% of PET from non-food consumer applications;
- the recycled PET is used at up to 100% for the manufacture of materials and articles for contact with all types of foodstuffs, including drinking water, for long-term storage at room temperature or below, with or without hot-fill.

The final articles made of this recycled PET are not intended to be used in microwave and conventional ovens, and such uses are not covered by this evaluation.

¹³Correction factors of 5 and 10 are applied for contaminants with molecular masses ≤ 150 and > 150 Da, respectively (EFSA CEP Panel, 2024).

5 | RECOMMENDATION

The Panel recommended periodic verification that the input to be recycled originates from materials and articles that have been manufactured in accordance with the EU legislation on food contact materials and that the proportion of PET from non-food consumer applications is no more than 5%. This adheres to good manufacturing practice and the Commission Regulation (EU) 2022/1616. Critical steps in recycling should be monitored and kept under control. In addition, supporting documentation should be available on how it is ensured that the critical steps are operated under conditions at least as severe as those in the challenge test used to measure the decontamination efficiency of the process.

6 | DOCUMENTATION AS PROVIDED TO EFSA (IF APPROPRIATE)

Dossier Starlinger recoSTAR PET IV+. January 2023. Submitted by lms consulting on behalf of Starlinger & Co GmbH.

Additional information. January 2025. Submitted by lms consulting on behalf of Starlinger & Co GmbH.

Additional information. May 2025. Submitted by lms consulting on behalf of Starlinger & Co GmbH.

ABBREVIATIONS

bw	body weight
CEP	Panel on Food Contact Materials, Enzymes and Processing Aids
C_{mod}	modelled concentration in PET
C_{res}	residual concentration in PET
PET	poly(ethylene terephthalate)
SSP	solid-state polycondensation

REQUESTOR

Austrian Competent Authority (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz)

QUESTION NUMBER

EFSA-Q-2023-00015

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WAIVER

In accordance with Article 21 of the Decision of the Executive Director on Competing Interest Management, a waiver was granted to an expert of the Working Group. Pursuant to Article 21(6) of the aforementioned Decision, the concerned expert was allowed to take part in the preparation and in the discussion of the scientific output but was not allowed to take up the role of rapporteur within that time frame. Any competing interests are recorded in the respective minutes of the meetings of the FCM Panel Working Group on Recycling Plastics.

LEGAL NOTICE

Relevant information or part of this scientific output have been blackened in accordance with the confidentiality requests formulated by the applicant pending a decision thereon by EFSA. The full output has been shared with the European Commission, EU Member States (if applicable) and the applicant. The blackening may be subject to review once the decision on the confidentiality requests is adopted by EFSA and in case it rejects some of the confidentiality requests.

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APPENDIX A

Specifications of the preprocessed input material* as provided by the applicant¹⁴

Parameter	Value
PVC content	< 200 ppm
PA content	< 200 ppm
PC	< 50 ppm
PS	< 100 ppm
Other plastics	< 500 ppm
Metal content	< 500 ppm
Dust	< 1.5%
Moisture	< 2.5%
Bulk density (average)	200–600 (kg/m ³) (≥ 260 kg/m ³)
Amount of non-food application PET	< 5%
Flake size	Up to 16 mm (> 95%)/main amount of material 1–14 mm (> 60%)
Thickness range	100 µm (wall) to 3 mm (neck)
Flakes containing glue	≤ 6000 mg/kg (measurement based on ISO 12418-2)

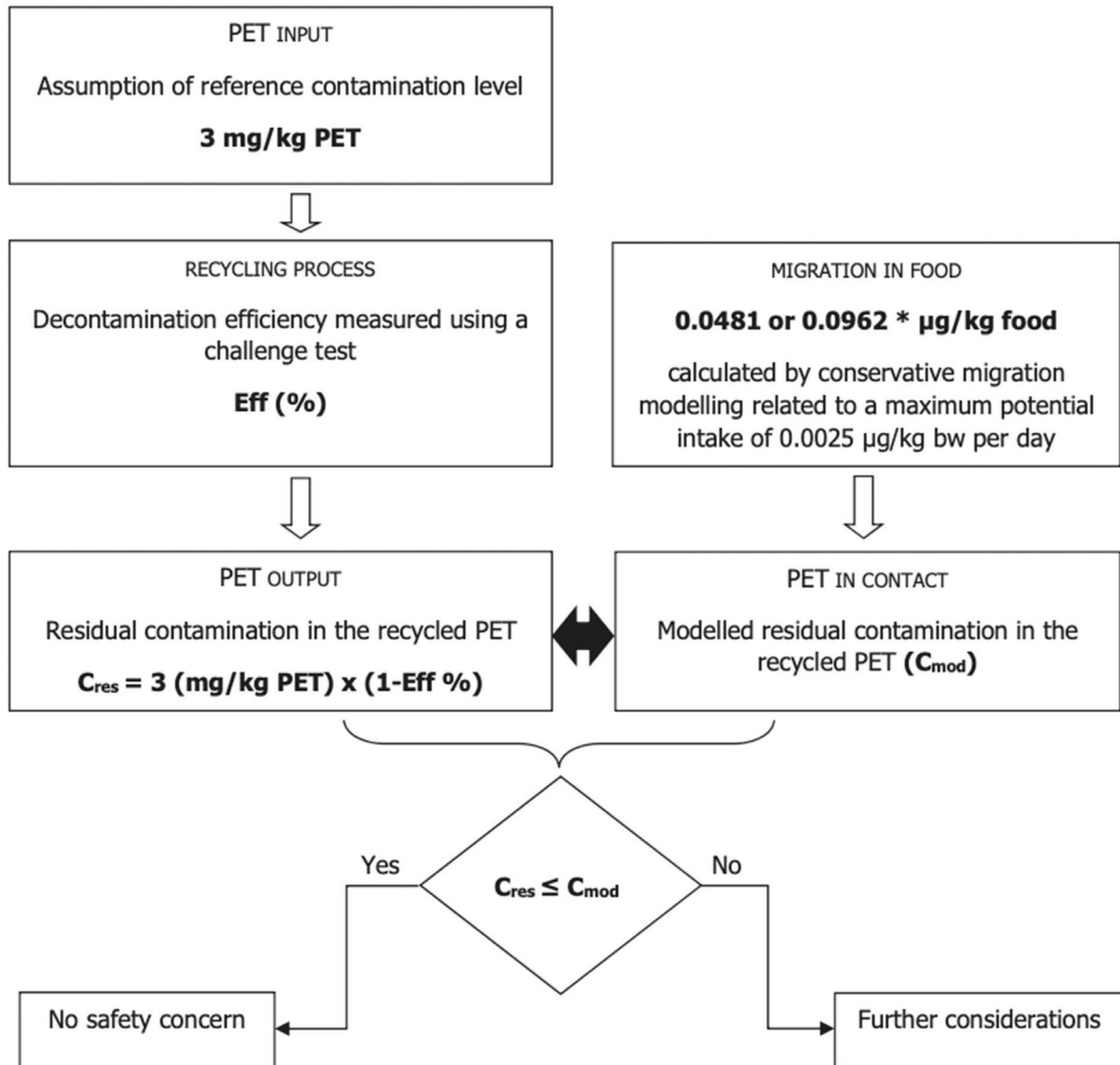
Abbreviations: PA, polyamide; PC, polycarbonate; PS, polystyrene; PVC, poly(vinyl chloride).

* Foreign polymers in the flakes were determined by the 'oven test'.

¹⁴Technical dossier, Section 'Characterisation of the input'.

APPENDIX B

Relationship between the key parameters for the evaluation scheme, based on the most conservative scenario A (EFSA CEP Panel, 2024)



*Depending on the molecular mass of the surrogate substance. The figures are derived from the application of the human exposure threshold value of 0.0025 µg/kg bw per day applying the factors of 5 and 10 related to the overestimation of modelling (most conservative Scenario A).

APPENDIX C

Table of operational parameters¹⁵

Although the operational parameters are reported for all the process steps, the critical steps and the corresponding parameters of the challenge test/process, considered for the evaluation of the process and for which it has been concluded that the process is safe, are highlighted in green.

The process should be operated at conditions at least as severe as the ones indicated in green in the table (e.g. lower pressures are more severe than higher, higher temperatures are more severe than lower, longer times are more severe than shorter, higher gas flows generally are more severe than lower).

The official enforcement control shall verify that the recycling plant is operating in a way that complies with its authorisation. Depending on the technology, some of the parameters are inter-related and changing one parameter to a more severe value may impact another parameter to a less severe value. Therefore, eventual deviations from the values of the parameters indicated as critical (marked in green in the table) should be demonstrated not impacting significantly on the safety assessment. The table does not necessarily report all the tolerances for the operational parameters.

Starlinger recoSTAR PET iV+										
Parameters	Step 2 Drying and crystallisation*				Step 3 Extrusion (1st line) Crystallisation (2nd line)			Step 4 Solid state polycondensation (SSP)**		
	t (min)	P	T (°C)	Air/PET ratio (m ³ air/kg PET)	t	P (mbar)	T (°C)	t (h)	P (mbar)	T (°C)
Challenge test PA-4603-07	■	Atmospheric	■	■	■ s ■ min	■ Atmospheric	■ ■	■	■	■
	Batch				Continuous Batch			Batch		
Process Starlinger recoSTAR PET iV+	≥ ■	Atmospheric	≥ ■	≥ ■	≥ ■ s ≥ ■ min	≤ ■ Atmospheric	≥ ■ ≥ ■	≥ ■	≤ ■	≥ ■
	Continuous				Continuous			Semi-continuous		

*Before Step 2, flakes might optionally be preheated in a different drier.

** Before the SSP, there is at least one preheater to warm the flakes up to ■°C.

¹⁵Technical dossier, Sections 'Table of operating Parameters' and 'Recycling process'.