

ADOPTED: 12 September 2023

doi: 10.2903/j.efsa.2023.8262

Safety assessment of the process ENVICCO, based on EREMA basic and Polymetrix SSP leaN technology, used to recycle post-consumer PET into food contact materials

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Abstract

The EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (CEP) assessed the safety of the recycling process ENVICCO (EU register number RECYC301), which uses the EREMA basic and Polymetrix SSP leaN technology. The input consists of hot caustic 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 pre-decontaminated in the EREMA reactor at high temperature under vacuum (step 2) before being extruded, pelletised and crystallised (step 3). The crystallised pellets are then preheated (step 4) and submitted to solid-state polycondensation (SSP) (step 5) at [REDACTED] temperature and under nitrogen flow. Having examined the challenge tests provided, the Panel concluded that step 2 as well as steps 4 and 5 are critical for determining the decontamination efficiency of the process. The operating parameters to control the performance of these critical steps are temperature, pressure and residence time for step 2 and temperature, residence time and gas velocity for steps 4 and 5. It was demonstrated that this recycling process is able to ensure that the level of migration of potential unknown contaminants into food is below the conservatively modelled migration of 0.1 µg/kg food. 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 hotfill. 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.

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Keywords: EREMA basic and Polymetrix SSP leaN, ENVICCO limited, food contact materials, plastic, poly(ethylene terephthalate) (PET), recycling process, safety assessment

Requestor: Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, Germany

Question number: EFSA-Q-2022-00188

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Declarations of interest: If you wish to access the declaration of interests of any expert contributing to an EFSA scientific assessment, please contact interestmanagement@efsa.europa.eu.

Suggested citation: EFSA CEP Panel (EFSA Panel on Food Contact Materials, Enzymes and Processing Aids), Lambré C., Barat Baviera, J. M., Bolognesi, C., Chesson, A., Coconcelli, P. S., Crebelli, R., Gott, D. M., Grob, K, Mengelers, M., Mortensen, A., Rivière, G., Steffensen, I-L., Tlustos, C., Van Loveren, H., Vernis, L., Zorn, H., Dudler, V., Milana, M. R., . . . Lampi, E. 2023. Safety assessment of the process ENVICCO, based on EREMA basic and Polymetrix SSP leaN technology, used to recycle post-consumer PET into food contact materials. *EFSA Journal*, 21(10), 1–16. <https://doi.org/10.2903/j.efsa.2023.8262>

ISSN: 1831-4732

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The EFSA Journal is a publication of the European Food Safety Authority, a European agency funded by the European Union.



† Deceased.

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1. Introduction

1.1. Background and Terms of Reference

1.1.1. 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 Article 5 of Regulation (EC) No 282/2008^{1,2} on recycled plastic materials intended to come into contact with foods and Articles 8 and 9 of Regulation (EC) No 1935/2004³ on materials and articles intended to come into contact with food.

According to this procedure, the industry submits 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 Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, Germany, for evaluation of the recycling process ENVICCO, European Union (EU) register No RECYC301. The request has been registered in EFSA's register of received questions under the number EFSA-Q-2022-00188. The dossier was submitted on behalf of ENVICCO Limited, Asia Industrial Estate (AIT), Huai Pong, Mueang, Rayong District, Rayong 21150, Thailand (see '[Documentation provided to EFSA](#)').

1.1.2. Terms of Reference

The Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, Germany requested the safety evaluation of the recycling process ENVICCO, in compliance with Article 5 of Regulation (EC) No 282/2008 and Articles 8, 9 and 10 of the Regulation (EC) No 1935/2004.

1.2. Interpretation of the Terms of Reference

According to Article 5 of Regulation (EC) No 282/2008 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 and deliver a scientific opinion on the recycling process examined.

According to Article 4 of Regulation (EC) No 282/2008, EFSA will evaluate whether it has been demonstrated in a challenge test, or by other appropriate scientific evidence, that the recycling process is able to reduce the contamination of the plastic input to a concentration that does not pose a risk to human health. The poly(ethylene terephthalate) (PET) materials and articles used as input of the process as well as the conditions of use of the recycled PET make part of this evaluation.

2. Data and methodologies

2.1. Data

The applicant has submitted a confidential and a non-confidential version of a dossier following the 'EFSA guidelines for the submission of an application for the safety evaluation of a recycling process to produce recycled plastics intended to be used for the manufacture of materials and articles in contact with food, prior to its authorisation' (EFSA, 2008) and the 'Administrative guidance for the preparation of applications on recycling processes to produce recycled plastics intended to be used for manufacture of materials and articles in contact with food' (EFSA, 2021).

Additional information was provided by the applicant during the assessment process in response to a request from EFSA sent on 19 January 2023 (see '[Documentation provided to EFSA](#)').

¹ Commission Regulation (EC) No 282/2008 of 27 March 2008 on recycled plastic materials and articles intended to come into contact with foods and amending Regulation (EC) No 2023/2006. OJ L 86, 28.3.2008, pp. 9–18.

² Commission Regulation (EC) No 282/2008 was repealed by Commission Regulation (EU) 2022/1616 of 15 September 2022 on recycled plastic materials and articles intended to come into contact with foods, and repealing Regulation (EC) No 282/2008 (OJ L 243 20.9.2022, p. 3) which entered into force on 10 October 2022. Applications submitted to EU Member State competent authorities before the date of entry into force of Commission Regulation (EU) 2022/1616 are evaluated by EFSA in accordance with Commission Regulation (EC) No 282/2008.

³ Regulation (EC) No 1935/2004 of the European parliament and of the council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC. OJ L 338, 13.11.2004, pp. 4–17.

In accordance with Art. 38 of the Regulation (EC) No 178/2002⁴ and taking into account the protection of confidential information and the 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,⁵ the non-confidential version of the dossier has been published on Open.EFSA.⁶

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,⁷ EFSA carried out a public consultation on the non-confidential version of the application from 17 July to 17 August 2023, for which no comments were received.

The following information on the recycling process was provided by the applicant and used for the evaluation:

- General information:
 - general description,
 - existing authorisations.
- Specific information:
 - recycling process,
 - characterisation of the input,
 - determination of the decontamination efficiency of the recycling process,
 - characterisation of the recycled plastic,
 - intended application in contact with food,
 - compliance with the relevant provisions on food contact materials and articles,
 - process analysis and evaluation,
 - operating parameters.

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, 2008).

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 opinion developed by the EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (EFSA CEF Panel, 2011). The principle of the evaluation is to apply the decontamination efficiency of a recycling technology or 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 $\mu\text{g}/\text{kg}$ 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. 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 CEF Panel, 2011).

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

⁴ Commission 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.

⁵ Decision available at: <https://www.efsa.europa.eu/en/corporate-pubs/transparency-regulation-practical-arrangements>

⁶ The 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-2022-03911>

⁷ Decision available at: https://www.efsa.europa.eu/sites/default/files/corporate_publications/files/210111-PAs-pre-submission-phase-and-public-consultations.pdf

3. Assessment

3.1. General information⁸

According to the applicant, the recycling process ENVICCO is intended to recycle food grade PET containers using the EREMA basic and Polymetrix SSP leaN technology. The recycled PET is intended to be used at up to 100% by converters for the manufacture of materials and articles for direct contact with all kinds of foodstuffs such as bottles for mineral water, soft drinks, fruit juices, tea, milk, oil and alcoholic beverages for long-term storage at room temperature, with or without hotfill. The final articles are not intended to be used in microwave or conventional ovens.

3.2. Description of the process

3.2.1. General description⁹

The recycling process ENVICCO produces recycled PET pellets from PET materials originating from post-consumer collection systems (kerbside and deposit collection systems). It comprises the five steps below.

Input

- In step 1, the post-consumer PET is sorted and processed into hot caustic washed and dried flakes. This step is performed [REDACTED].

Decontamination and production of recycled PET material

- In step 2, the flakes are decontaminated under high temperature and vacuum.
- In step 3, the decontaminated flakes are extruded to produce pellets which are then crystallised.
- In step 4, the crystallised pellets are preheated to a high temperature under inert gas flow.
- In step 5, the pellets are decontaminated during solid-state polycondensation (SSP) under [REDACTED] temperature and inert gas flow.

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

Pellets, the final product of the process, are checked against technical requirements, such as intrinsic viscosity, colour and black spots and residual contaminants.

3.2.2. Characterisation of the input¹⁰

According to the applicant, the input material for the recycling process ENVICCO consists of hot washed and dried flakes obtained from PET materials e.g. bottles, previously used for food packaging, from post-consumer collection systems (kerbside and deposit systems). A small fraction may originate from non-food applications. According to the applicant, the proportion will be no more than 5%.

Technical data on the hot washed and dried flakes are provided, such as on physical properties and residual contents of moisture, poly(vinyl chloride) (PVC), polyolefins, glue, dust, paper, inorganics and metals (see Appendix A).

3.3. EREMA basic and Polymetrix SSP leaN technology

3.3.1. Description of the main steps¹¹

The general scheme of the EREMA basic and Polymetrix SSP leaN technology, as provided by the applicant, is reported in Figure 1. The steps are:

- Decontamination in the EREMA reactor (step 2):

The flakes are [REDACTED] fed into a reactor equipped with a rotating device, running under [REDACTED] temperature and vacuum for a predefined minimum residence time.

⁸ Technical dossier, sections 'Recycling process' and 'Intended application in contact with food'.

⁹ Technical dossier, sections 'Recycling process', 'Characterisation of the input' and 'Characterisation of the recycled plastic'.

¹⁰ Technical dossier, section 'Characterisation of the input'.

¹¹ Technical dossier, sections 'Recycling process' and 'Determination of the decontamination efficiency of the recycling process'.

- Extrusion of the decontaminated flakes (step 3):
The flakes, continuously introduced from the flakes reactor, are molten in the extruder. [REDACTED] before the melt is converted into pellets. The pellets are then crystallised.
- Preheating of the crystallised pellets (step 4):
The crystallised pellets are preheated under inert gas flow at [REDACTED] pressure and for a predefined residence time.
- SSP (step 5):
The pellets are [REDACTED] fed to a [REDACTED] reactor running under [REDACTED] temperature and inert gas flow at [REDACTED] pressure for a predefined residence time.

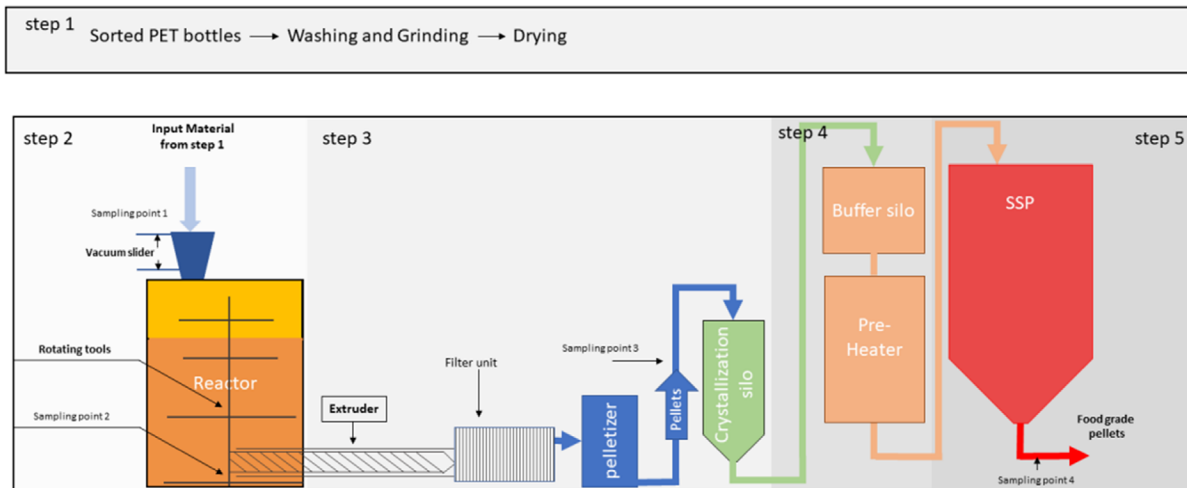


Figure 1: General scheme of the EREMA basic and Polymetrix SSP lean technology (provided by the applicant)

The process is run under defined operating parameters¹² of temperature, pressure, gas velocity and residence time.

3.3.2. Decontamination efficiency of the recycling process¹³

To demonstrate the decontamination efficiency of the recycling process ENVICCO, challenge tests on steps 2 as well as 4 and 5 were submitted to the EFSA.

PET flakes were contaminated with toluene, chlorobenzene, chloroform, methyl salicylate, phenylcyclohexane, benzophenone and methyl stearate, selected as surrogates in agreement with the EFSA guidelines (EFSA CEF Panel, 2011) and in accordance with the recommendations of the US Food and Drug Administration (FDA, 2006). The surrogates include different molecular masses and polarities to cover possible chemical classes of contaminants of concern and were demonstrated to be suitable to monitor the behaviour of PET during recycling (EFSA, 2008).

[REDACTED]. The concentrations of the surrogates in this material were determined.

Step 2 of the EREMA basic and Polymetrix SSP lean technology was challenged [REDACTED]

¹² In 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).

¹³ Technical dossier, Section 'Determination of the decontamination efficiency of the recycling process', Appendix E and F.

¹⁴ Conventional recycling commonly includes sorting, grinding, washing and drying steps and produces washed and dried flakes.

[REDACTED]. The Panel considered that the reactor ran at residence time, temperature and pressure conditions equal to or less severe than those foreseen for the industrial process. [REDACTED]

The decontamination efficiencies of step 2 (EREMA Basic reactor) were calculated from the concentration of the surrogates before and after the reactor (Table 1).

Table 1: Efficiency of the decontamination by the EREMA reactor in step 2 of the challenge test

Surrogates	Concentration of surrogates before step 2 (mg/kg PET)	Concentration of surrogates after step 2 (mg/kg PET)	Decontamination efficiency (%)
Toluene	357.0	57.0	84.0
Chloroform	165.6	78.0	52.9
Chlorobenzene	641.1	100.6	84.3
Phenylcyclohexane	588.2	140.1	76.2
Methyl salicylate	900.6	112.6	87.5
Benzophenone	852.1	171.4	79.9
Methyl stearate	1279.9	205.2	84.0

PET: poly(ethylene terephthalate).

The Polymetrix SSP technology (steps 4 and 5) were challenged [REDACTED]. Contaminated PET pellets were produced during extrusion by adding toluene, chlorobenzene, phenylcyclohexane, benzophenone and methyl stearate. [REDACTED]

The concentrations of the surrogates were determined in these crystallised pellets used as starting material for the challenge test.

The challenge test was performed on the preheating (step 4) and the SSP (step 5) [REDACTED]

The decontamination efficiencies of step 4 (preheating) and 5 (SSP reactor) were calculated from the concentration of surrogates before the preheater and after the reactor (Table 2).

¹⁵ 'Cross-contamination' (partitioning between clear and blue flakes), as meant in the Scientific Opinion on 'the criteria to be used for safety evaluation of a mechanical recycling process to produce recycled PET intended to be used for manufacture of materials and articles in contact with food', is the transfer of surrogate contaminants from the initially contaminated to the initially not contaminated material (EFSA CEF Panel, 2011).

Table 2: Efficiency of the decontamination of the Polymetrix SSP reactor in the challenge test (steps 4 and 5)

Surrogates	Concentration of surrogates before step 4 (mg/kg PET)	Concentration of surrogates after step 5 (mg/kg PET)	Decontamination efficiency (%)
Toluene	8.8	< 0.1 ^(a)	> 98.9
Chlorobenzene	71.5	2.6	96.4
Phenylcyclohexane	614.6	95.1	84.5
Benzophenone	565.0	68.6	87.7
Methyl stearate	623.1	58.1	90.7

PET: poly(ethylene terephthalate); SSP: solid-state polycondensation.

(a): Not detected at the limits of detection given.

A combined decontamination efficiency of the process was then calculated from the decontamination efficiencies of steps 2 as well as 4 and 5 (Table 3).

Table 3: Combined efficiency of decontamination by the EREMA basic and Polymetrix SSP lean technology in the challenge test

Surrogates	Decontamination efficiency (%) step 2	Decontamination efficiency (%) steps 4 and 5	Combined decontamination efficiency (%)
Toluene	84.0	> 98.9	> 99.8
Chlorobenzene	84.3	96.4	99.4
Phenylcyclohexane	76.2	84.5	96.3
Benzophenone	79.9	87.7	98.5
Methyl stearate	84.0	90.7	98.5

PET: poly(ethylene terephthalate).

As shown in Table 3, the decontamination efficiency ranged from 96.3% for phenylcyclohexane to > 99.8% for toluene.

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.

Technical data, such as on physical properties and residual contents of moisture, poly(vinyl chloride) (PVC), polyolefins, glue, cellulose and metals, are provided for the input materials (i.e. washed and dried flakes, step 1). 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 process are managed in such a way that this fraction will be no more than 5% in the input stream, as recommended by the EFSA CEF Panel in its 'Scientific opinion on the criteria to be used for 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' (EFSA CEF Panel, 2011).

The process is adequately described. The washing and drying of the flakes from the collected PET containers (step 1) is conducted [REDACTED] and, according to the applicant, this step is under control. The EREMA basic and Polymetrix SSP lean technology comprises the decontamination in the EREMA reactor (step 2), extrusion and crystallisation (step 3), preheating (step 4) and decontamination in the SSP reactor (step 5). The operating parameters of temperature, pressure, residence time and gas velocity have been provided to EFSA.

The challenge tests to measure the decontamination efficiency were conducted in a small industrial scale EREMA reactor (step 2) and a pilot plant Polymetrix SSP reactor (steps 4 and 5). The reactors were operated under pressure, temperature and gas velocity conditions as well as residence times equivalent to those of the commercial process. [REDACTED]

The Panel considered that this challenge test was performed correctly according to the recommendations of the EFSA guidelines (EFSA, 2008) and that steps 2, 4 and 5 are critical for the decontamination efficiency of the process. Consequently, temperature, pressure and residence time in step 2 as well as temperature, residence time and gas velocity in steps 4 and 5 of the process should be controlled to guarantee the performance of the decontamination (Appendix C).

The decontamination efficiencies obtained for each surrogate, ranging from 96.3% to > 99.8%, have been used to calculate the residual concentrations of potential unknown contaminants in PET (C_{res}) according to the evaluation procedure described in the 'Scientific opinion on the criteria to be used for safety evaluation of a mechanical recycling process to produce recycled PET' (EFSA CEF Panel, 2011; Appendix B). By applying the decontamination efficiency percentage to the reference contamination level of 3 mg/kg PET, the C_{res} for the different surrogates was obtained (Table 4).

According to the evaluation principles (EFSA CEF Panel, 2011), 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. Because 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 (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 0.1 $\mu\text{g}/\text{kg}$ of a contaminant substance into the infant's food and has been used to calculate C_{mod} (EFSA CEF Panel, 2011). C_{res} reported in Table 4 is calculated for 100% recycled PET, for which the risk to human health is demonstrated to be negligible. The results of these calculations are shown in Table 4. The relationship between the key parameters for the evaluation scheme is reported in Appendix B.

Table 4: Decontamination efficiencies from the challenge test (from the combined steps 2, 4 and 5), 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 0.1 $\mu\text{g}/\text{kg}$ food after 1 year at 25°C

Surrogates	Decontamination efficiency (%)	C_{res} for 100% rPET (mg/kg PET)	C_{mod} (mg/kg PET)
Toluene	> 99.8	< 0.01	0.09
Chlorobenzene	99.4	0.02	0.09
Phenylcyclohexane	96.3	0.11	0.14
Benzophenone	98.5	0.05	0.16
Methyl stearate	98.5	0.04	0.32

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 ENVICCO using the EREMA basic and Polymetrix SSP leaN technology 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 0.1 $\mu\text{g}/\text{kg}$ 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, for long-term storage at room temperature or below, with or without hotfill.

The Panel noted that the input of the process originates from Thailand. In the absence of data on misuse contamination of this input, the Panel used the reference contamination of 3 mg/kg PET (EFSA CEF Panel, 2011) that was derived from experimental data from an EU survey. Accordingly, the recycling process under evaluation using the EREMA basic and Polymetrix SSP leaN technology is able to ensure that the level of unknown contaminants in recycled PET is below a calculated concentration (C_{mod}) corresponding to a modelled migration of 0.1 $\mu\text{g}/\text{kg}$ food.

5. Conclusions

The Panel considered that the process ENVICCO, using the EREMA basic and Polymetrix SSP lean technology, 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 tests provided, the Panel concluded that temperature, pressure and residence time in the continuous reactor of step 2 as well as temperature, inert gas velocity and residence time in steps 4 and 5, are critical for the decontamination efficiency.

The Panel concluded that the recycling process ENVICCO is able to reduce foreseeable accidental contamination of post-consumer food contact PET to a concentration that does not give rise to concern for a risk to human health if:

- i) 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;
- ii) 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 contains no more than 5% of PET from non-food consumer applications;
- iii) the recycled PET obtained from the process ENVICCO 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 hotfill.

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.

6. 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 Regulation (EC) No 282/2008, Art. 4b. 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.

Documentation provided to EFSA

Dossier 'Envicco Limited'. March 2022. Submitted on behalf of ENVICCO Limited, Thailand.
Additional information, April 2023. Submitted on behalf of ENVICCO Limited, Thailand.

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Abbreviations

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

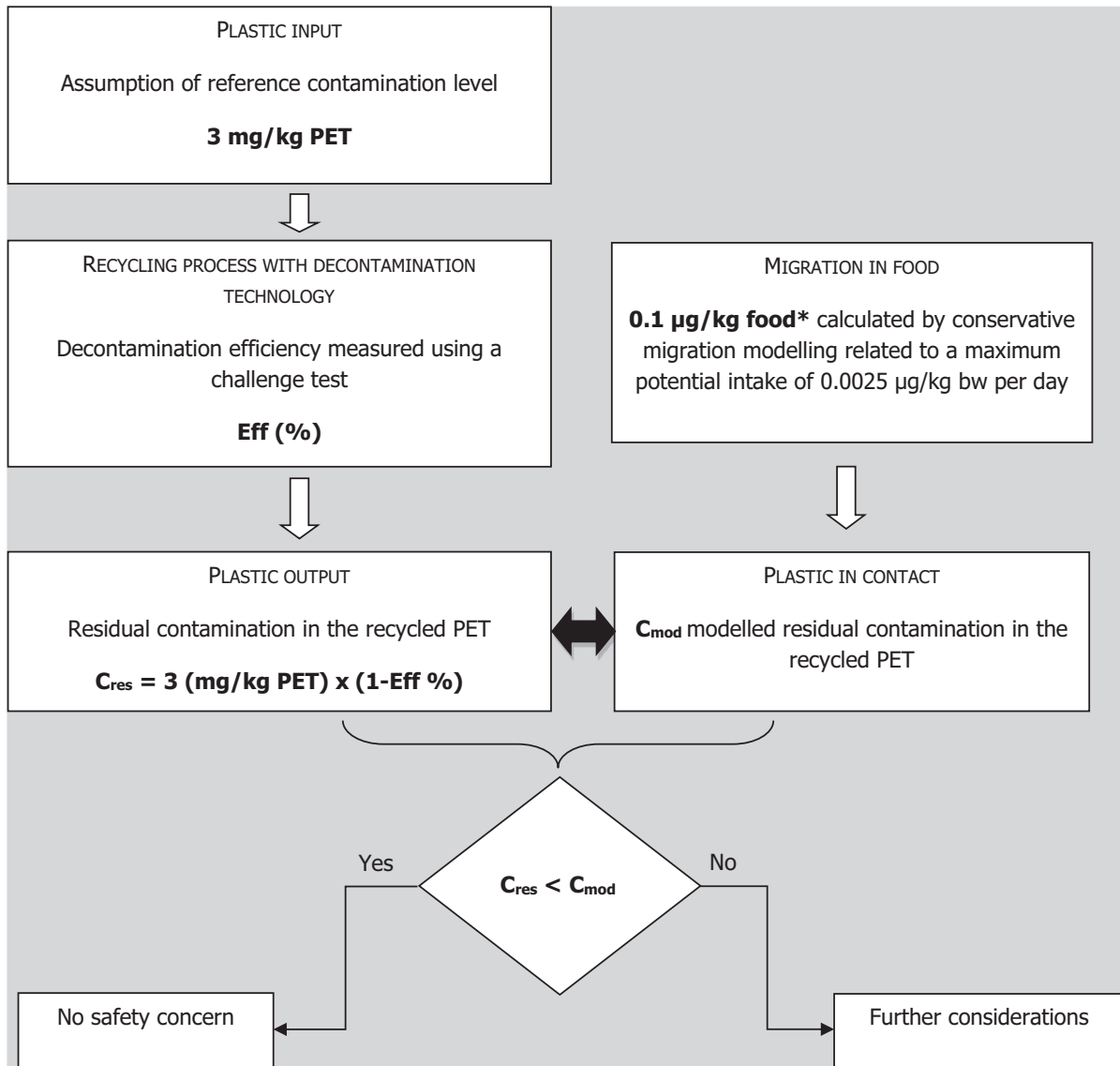
Appendix A – Technical data of the washed flakes as provided by the applicant¹⁶

Parameter	Value
PVC	0–10 mg/kg
Polyolefin	0–10 mg/kg
Paper	0–20 mg/kg
Glue	0–10 mg/kg
Metals	0–10 mg/kg
Moisture	0.5–0.7%
Coloured flakes	0–20 mg/kg
Inorganics	0–10 mg/kg
Bulk density	220–350 kg m ⁻³
Size	Max. 12 mm
Dust (< 0.6 mm)	Max. 0.5%

PVC: poly(vinyl chloride).

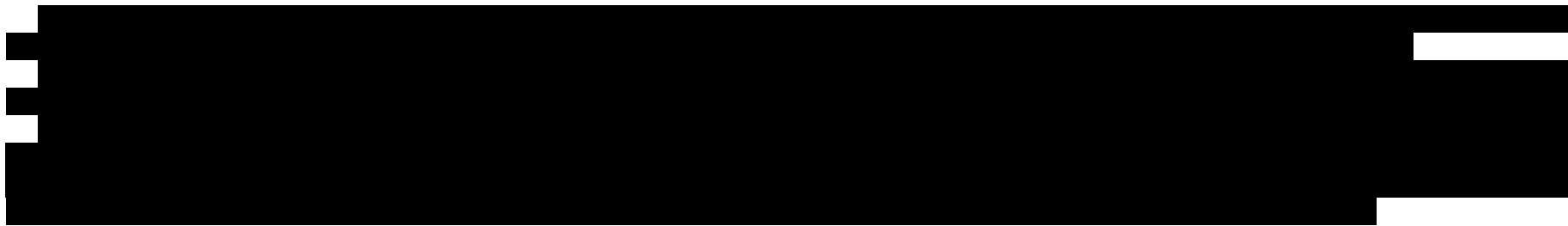
¹⁶ Technical dossier, section 'Characterisation of the input'.

Appendix B – Relationship between the key parameters for the evaluation scheme (EFSA CEF Panel, 2011)



*Default scenario (infant). For adults and toddlers, the migration criterion will be 0.75 and 0.15 µg/kg food, respectively. The figures are derived from the application of the human exposure threshold value of 0.0025 µg/kg bw per day applying a factor of 5 related to the overestimation of modelling.

Appendix C – Table on operational parameters¹⁷



Process ENVICCO (RECYC301) based on the EREMA basic and Polymetrix SSP leaN technology

Parameters	Step 2 EREMA Reactor			Step 3 Extrusion & crystallisation		
	t [min]	P [mbar]	T [°C]	t [s]	P [mbar]*	T [°C]
Challenge test (Fraunhofer report PA/4111a/19)	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]
Process	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]

¹⁷ Technical report, Section 'Recycling process' and 'Table of Operating Parameters'.

Process ENVICCO (RECYC301) based on the EREMA basic and Polymetrix SSP leaN technology

Parameters	Step 4 Preheating				Step 5 SSP			
	t [min]	P [mbar]	T [°C]	Gas velocity** [m/s]	t [h]	P [mbar]	T [°C]	Gas velocity** [m/s]
Challenge test (Fraunhofer report PA/4632/09)	█	█	█	█	█	█	█	█
Process	█	█	█	█	█	█	█	█

*: █

** : There is experimental evidence (Huang and Walch 1998, Polymer, 93, p. 6991–9; Solid State Polymerisation, ed. C. Papaspyrides and N. Vouyiouka, J. Wiley & Sons Inc., 2009) that above a minimal gas flow, the gas velocity has no more influence on the rate of SSP process. Taking into account the gas flow in plant and the size of pellets, the gas flow used in the challenge test is considered representative of the one used in the plant.

The gas velocity values of █ m/s (challenge test) and > █ m/s (process) correspond to gas flows of █ Nm³/h (challenge test) and █ Nm³/h (process, █ kg capacity reactor).