SUPER-CLEAN RECYCLING PROCESS.
PET DECONTAMINATION FOR DIRECT FOOD CONTACT.
With the IR-CLEAN® system, KREYENBORG offers an attractive and cost-effective alternative for the direct reprocessing of PET post-consumer flakes for food packaging - without using any vacuum technology and as a retrofit solution for existing extrusion lines. The efficiency of the cleaning process has been verified by a Letter of Non-Objection from the US Food and Drug Administration (FDA). Similarly, several challenge tests have demonstrated compliance with the criteria established by the European Food Safety Authority (EFSA) for the use of recycled materials for direct food contact packaging.

**High-Performance Decontamination**
Efficient decontamination of recycled PET for re-use in direct food contact packaging.

**FDA & EFSA Approvals**
FDA Letter of Non-Objection granted, EFSA thresholds attained for up to 100% recycled material.

**Continuous Process**
Continuous processing from the product-feed to the extruder inlet.

**Drying Up to 50 ppm**
Crystallization and drying in a single process.

**First-in / First-out**
Rotary drum with internal helix guarantees a defined flow of materials.

**Easy Retrofitting**
A problem-free upgrade of a non-EFSA or -FDA-approved extrusion line is possible.

**Easy Start-Stop Process**
No long pre-heating processes are necessary. System can be started directly with cold material.

**Easy and Cost-Effective Maintenance**
Maintenance is uncomplicated and not time-consuming.

**High Energy Efficiency**
High efficiency through direct heat input.

**Small Footprint**
Horizontal system layout does not require high plant ceilings.

**No Vacuum**
No maintenance-intensive and expensive vacuum system is required.

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### FDA & EFSA Approvals

<table>
<thead>
<tr>
<th>Type of Heat Treatment / Storage</th>
<th>Temperature Limits</th>
<th>Criteria Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: High temperature heat-sterilized</td>
<td>&gt; 100 °C (&gt; 212 °F)</td>
<td>No</td>
</tr>
<tr>
<td>B: Boiling water sterilized</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>C: Hot filled or pasteurized</td>
<td>&gt; 65 °C (&gt; 150 °F)</td>
<td>Yes</td>
</tr>
<tr>
<td>D: Hot filled or pasteurized</td>
<td>&lt; 65 °C (&lt; 150 °F)</td>
<td>Yes</td>
</tr>
<tr>
<td>E: Room temperature filled and stored</td>
<td>No thermal treatment</td>
<td>Yes</td>
</tr>
<tr>
<td>F: Refrigerated storage</td>
<td>No thermal treatment</td>
<td>Yes</td>
</tr>
<tr>
<td>G: Frozen storage</td>
<td>No thermal treatment</td>
<td>Yes</td>
</tr>
<tr>
<td>H: Frozen or refrigerated storage</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>I: Irradiation (Microwave)</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>J: Cooking at high temperatures</td>
<td>&gt; 120 °C (&gt; 250 °F)</td>
<td>No</td>
</tr>
</tbody>
</table>

**FDA Criteria**
40 days 6 °C (43 °F)

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### PER FDA DEFINITION.

- **Process**: Baby
  - **PCR Bottle Flake (%)**: 37
  - **Virgin / Inhouse (%)**: 63
- **Process**: Toddler
  - **PCR Bottle Flake (%)**: 55
  - **Virgin / Inhouse (%)**: 45
- **Process**: Adult
  - **PCR Bottle Flake (%)**: 100
  - **Virgin / Inhouse (%)**: 0
- **Process**: All ages
  - **PCR Bottle Flake (%)**: 100
  - **Virgin / Inhouse (%)**: 0

### PER EFSA DEFINITION.

- **Process**: Bottle to bottle
  - **EFSA criteria**: Bottle to bottle
    - **Duration**: 365 days
    - **Temperature**: 25 °C (77 °F)
  - **EFSA criteria**: Thermoform packaging
    - **Duration**: 30 days
    - **Temperature**: 6 °C (43 °F)
**IR-CLEAN** STEP

The PET recycling material is conveyed to the metering hopper of the IR-CLEAN system and introduced into the rotary drum via a volumetric metering system. The internal helix welded into the rotary drum ensures a homogeneous mass flow with a defined residence time (the first-in / first-out principle). Due to the rotation of the rotary drum and mixing elements integrated in the coils, the material is continuously mixed with simultaneous, constant surface exchange.

The infrared module installed above the material bed heats the material quickly and directly to a high temperature level.

The moisture-laden air is discharged from the IR-CLEAN through a constant air stream. After minutes, rather than hours, the material exits the IR-CLEAN and is available for the next process step.

**IR-CLEAN+ STEP**

The combination of the IR-CLEAN system with a finisher in the form of a desiccant dryer enables a further reduction of contamination, and has the added benefit of reduction to < 50 ppm of residual moisture.

The IR-CLEAN+ system also includes all necessary system components, including conveying equipments, filter units, de-misters and a comprehensive control package including on-going process documentation.

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**STEP 1**

- Assorted PET bottles / packaging
- Washing / grinding: 75°C / 15 min. in 1% NaOH lye
- Rinsed in cold water
- Pre-dried in centrifugal dryers

**STEP 2**

- IR-CLEAN® processing
  - Internal helix of the rotary drum, in detail.

**SUPER-CLEAN STEPS**

- Processing by the supplier
- IR-CLEAN® processing
- Extruder
  - Single screw extruder
  - Twin screw extruder
  - Multi-rotating screw extruder
  - Ring extruder
  - Planetary extruder
- IR-CLEAN®
  - temperature
  - residence time
  - surface exchange
  - FDA C-G
  - EFSA
  - 50 ppm moisture content

**IR-CLEAN+**

- temperature
- residence time
- surface exchange
- FDA C-G
- EFSA
- 50 ppm moisture content

**EFSA**

+ 50 ppm moisture content