

COTREP OPTICAL SORTING TEST PROCEDURE ASSESSING DARK PACKAGING DETECTABILITY IN OPTICAL SORTING PROCESSES

Background

- Dark packaging:

Black carbon pigment is commonly used to provide dark colours in packaging (intense, deep colours such as black, grey, green and purple) at competitive prices. However, optical separators at sorting centres are incapable of detecting and extracting packaging containing carbon black. This is due to carbon black absorbing the infrared light emitted by optical sorting equipment and sending back no signal. Consequently, unidentified recyclable dark single-resin packages are processed as sorting rejects and not sent to the appropriate recycling streams.

Alternative colorant solutions are being developed by colorant and packaging manufacturers to ensure that dark packaging is detectable in sorting centres and capable of recycling. This procedure has been specially devised to check the detectability of these alternatives and validate colorant solutions.

Any tests performed must be representative of sorting centres for household packaging waste in France. Most optical sorting machines used in the majority of sorting centres are supplied by two manufacturers – Pellenc St and Tomra. Tests should therefore be performed on the premises of these two companies.

- How optical sorting machines operate:

Optical separators operate by infrared spectroscopy (NIR–VIS). The machine scans and detects packaging that passes it on a fast conveyor belt supplying the equipment. The spectra of packages (linked to their composition) are analysed in milliseconds by the spectrometer, which compares them with reference spectra in a database. Packaging composition is determined based on the detected spectra and packaging is blown towards various chutes using compressed air.

Aims

Tests must be performed on the premises of Pellenc St and Tomra. They should be performed in two stages with packaging first undergoing a static test before being submitted for dynamic testing if it meets the criteria of the first test.

- **Static analysis:** This involves determining the capability of the optical sorting machines to detect dark packaging and identify its constituent resin. This resin will be referred to hereafter as the “**target resin**”.
- **Dynamic analysis:** This involves assessing separation performance (capture rates and purity) of dark packaging in a stream of household packaging waste.

Terms of reference

Companies wishing to perform detectability tests shall be referred to hereafter as “**requesters**”. Optical sorting machine manufacturers shall be referred to hereafter as “**O.S. manufacturers**”.

Preparation of samples by requesters

o Step 1: Contacting the O.S. manufacturers and COTREP.

Requesters must contact the two O.S. manufacturers and describe their requests using the document in [Appendix 1](#). Several such Appendix 1 documents should be submitted if requesters wish to test the detectability of several packaging types (different resins, shapes, colorant solution input ratios, etc.). The O.S. manufacturers' contact details are provided in the "[Practical information](#)" section of the document.

o Step 2: Preparing samples

The requester must submit samples for testing to the O.S. manufacturers:

- Packaging type:

Only formed packaging can be tested to ensure that the results are representative.

- Any type of plastic packaging can be tested (rigid packaging such as bottles, trays, pots, etc. as well as flexible packaging and film)¹.
- Packaging may be new or used but must be emptied of its contents.
- **If tested samples include associated elements** (labels, seals, caps, lids, etc.), requesters should also **provide a second batch of samples without the associated elements** so that optical separation performance can be assessed in both cases.
- If **packaging is sometimes manufactured from coloured production scrap** (which may itself contain carbon black) we strongly recommend testing this composition. This is because even small quantities of carbon black contained in production scrap may impact the detectability of such packaging during optical sorting.

- Number of packages to be submitted for testing for each type of tested packaging:

- Static test: **5 identical packages.**
- Dynamic test: 2 batches of packaging are required
 - **100 packaging units containing the tested colorant solution.**
 - **100 light-coloured packaging units made of the same resin** and of a similar weight, to be used as a control for testing.

For example, in order to test the detectability of a 20g black PP tray, the following must be provided:

- 100 x 20 g black PP trays.
- 100 x PP trays that are transparent, white or another light colour and weigh approximately 20g.

- Labelling samples:

Requesters should label each sample individually, ensuring that they use small paper labels to avoid any disruption to sorting that may be caused by these labels. The label should cover no more than 10% of packaging surface area.



¹ Rigid packaging is defined as offering a certain degree of deformation resistance and stability when stacked on shelves. The main element of rigid packaging is generally over 300 micrometres thick. The definition of rigid packaging given here relates to its anticipated ballistic behaviour during sorting and recycling processes.

o Step 3: Sending samples:

After labelling, samples should be sent separately to the two O.S. manufacturers using the addresses provided in the “[Practical information](#)” section. [Appendix 2](#) should be completed and attached to each parcel. We recommend sending samples **10 days** prior to testing.

Preparation of tests by the O.S. manufacturers

- Preparing samples:

For the purpose of the two tests, packaging provided by requesters should be manually crushed by the O.S. manufacturers so that it is representative of the state of waste following collection processes. If the tested samples include associated elements (labels, seals, caps, lids, etc.) the O.S. manufacturers should simulate various usage scenarios (e.g. one sample with the seal half open, another with the seal completely open, another without a seal, etc.).

A stream of packaging waste² sampled from selective collection is required for dynamic testing. It should be sourced from sorting centres, provided by COTREP, and reused for several dynamic tests. This stream will be referred to hereafter as the “**SC stream**”. If required by the O.S. manufacturers, COTREP will provide a fresh SC stream at their request. Please note that a period of 15 days should be allowed between such requests and receipt of the SC stream. The first time, all steel and black packaging in the stream should be removed by the O.S. manufacturers.

- Equipment:

The same equipment should be systematically used for all tests. The machine settings should be representative of those currently used at sorting centres and have been defined in consultation with COTREP in a confidential appended document (see *Pellenc ST Confidential Appendix* and *Tomra Confidential Appendix*).

IMPORTANT:

- The aim is to perform tests that are **representative of procedures in modern sorting centres** in normal operating conditions.
- The machine settings should be **fixed and identical** for each test.

Tests to be performed

o Step 4: Static test

- Test procedure:

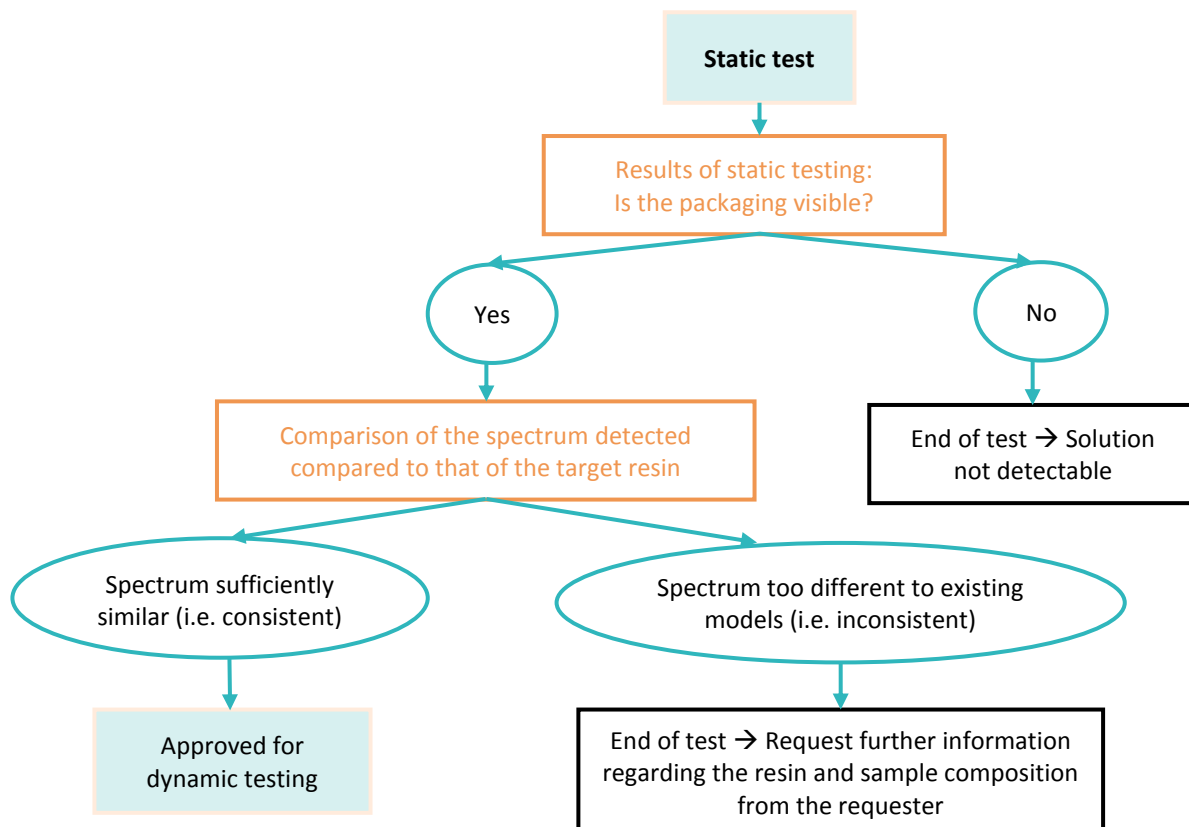
Samples should be positioned below the optical sensor to determine whether the optical sorting machine is able to detect the dark packages and identify their constituent resins, i.e. the target resins (specified by the requester in [Appendix 1](#)).

Where appropriate, tests should be performed with samples in different positions (side A up, side B up, packaging on its side, etc.).

² For rigid packaging, the stream should be collected at the ballistic outlet for hollow containers with a maximum of 2% residual film. Ferrous materials should be removed by the O.S. manufacturers. The stream should therefore consist of LPB, aluminium, rigid plastic, and potential rejects. For flexible packaging, the stream should be collected at the ballistic outlet for flat materials.

- Success criterion:

For the static test, packaging should be visible and the detected spectrum should be sufficiently similar to that of the target resin.



- Results analysis:

Results should be recorded in [Appendix 3](#):

- If the results meet the test criteria, a dynamic test should be performed.
- If the results do not meet the test criteria, a dynamic test is not necessary. Changes must be made to the alternative dark packaging solution.

o Step 5: Dynamic test

The purpose of the dynamic test is to assess packaging detectability in similar conditions to those in sorting centres. Tested samples are mixed in with a stream of packaging waste. The entire stream on the fast conveyor passes beneath the spectrometer. Packaging is blown and guided towards different outlet chutes depending on its composition and the spectrum detected.

- Test conditions:

Important:

- The parameters applied should be fixed and identical for all tests performed.
- They should be representative of genuine current conditions in sorting centres. **It is imperative that they are not optimised during testing.**

Machine settings (flow rate, belt width, sensor type, nozzle type, nozzle spacing, resolution, belt speed, ejection pressure) should be representative of those currently used at sorting centres and have been defined in consultation with COTREP in a confidential appended document (see *Pellenc ST Confidential Appendix* and *Tomra Confidential Appendix*). Only material sorting should be performed regardless of the target resin (PE, PP, PET or PS).

Important:

- Machine settings may be adapted for testing of flexible packaging. However, they must be the same for all tests performed on flexible packaging.

- Test procedure:

Dynamic tests should be performed in two steps:

1) Testing with control packaging:

- **Preparing the stream:** The 100 light packages should be used in this test. Once compacted, they should be mixed in evenly with the 100 kg SC flow upstream of the test.
- **Sorting:** Once the equipment is set (see previous section on *Test conditions*), packaging made of the target resin should be positively sorted. Other packaging should be negatively sorted as rejects.
- **Categorisation:** The two output streams (blown stream and non-blown stream) should be split into three categories:
 - Target resin: Control light packaging
 - Target resin: Other
 - Other resins/packaging
- **Analysis:** The results of this categorisation should be used to determine a benchmark separation performance:
 - Light control packaging capture rate: CR_{light}
 - Target resin capture rate: CR_1
 - Purity of the blown stream: P_1
- **Verification:** Check that the capture rates and purity are above 90%. If this is not the case, check the machine settings and repeat the control test.
- **Removal of packaging:** Once the capture rates and minimum purity are achieved, remove the 100 light control packages from the stream.

2) Testing with the dark test packaging:

- **Preparing the stream:** The 100 dark test packages should be used in this test. Once compacted, they should be mixed in evenly with the 100 kg SC flow upstream of the test.
- **Sorting:** **Exactly the same conditions should be applied as in the control test** with the light packaging. Packaging composed of the target resin should be positively sorted. Other packaging should be negatively sorted as rejects.
- **Categorisation:** The two output streams (blown stream and non-blown stream) should be split into three categories:
 - Target resin: Dark packaging
 - Target resin: Other

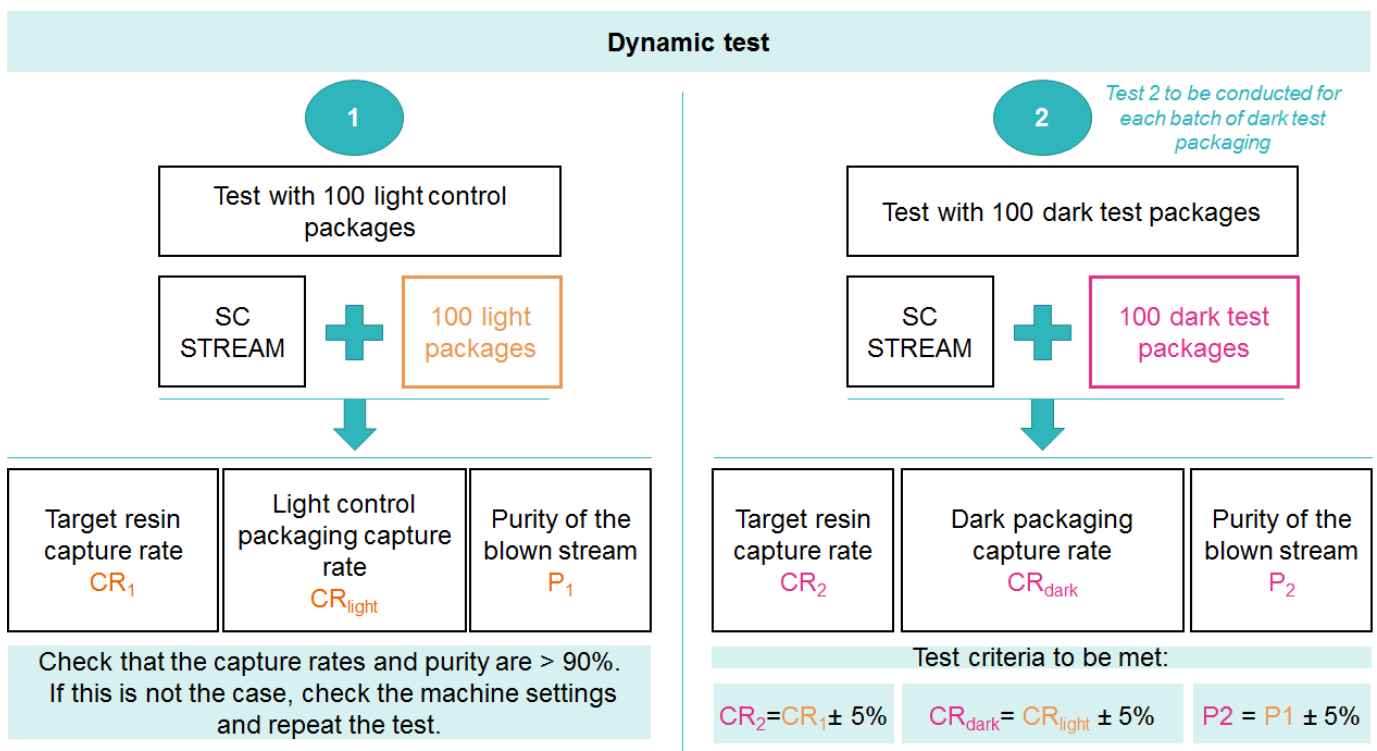
- Other resins/packaging
- **Analysis:** The results of this categorisation should be used to determine separation performance for the tested dark packaging:
 - Dark packaging capture rate: CR_{dark}
 - Target resin capture rate: CR_2
 - Purity of the blown stream: P_2
- **Success criteria:** In order for the test criteria to be met, the capture rates and purity for this test must equal those of the control test on light packaging, plus or minus 5%:
 - $CR_{dark} = CR_{light} \pm 5\%$
 - $CR_2 = CR_1 \pm 5\%$
 - $P_2 = P_1 \pm 5\%$

If the difference between the results of the control test and the test with dark packaging is between 5 and 10%, the O.S. manufacturer may contact COTREP to discuss the test results and findings. They will decide on the next steps to be taken based on the evidence.

[Appendix 3](#) should be completed by O.S. manufacturers to enable COTREP to analyse the results.

- **Removal of packaging:** Once the capture rates and purity are calculated, remove the 100 dark packages from the stream.

Summary of the dynamic test:



Test report

Each O.S. manufacturer must draw up a test report including the following details:

- A description of samples received and tested including photographs. If several batches of samples have been tested, descriptions and results for each batch should be presented separately in the report.
- Details of the equipment used.
- A summary of the test parameters applied.
- The number of samples and procedures for each test.
- All Appendices should be appended to the report:
 - [Appendix 1](#) explaining the request.
 - [Appendix 3](#) summarising the results of the static and dynamic tests in terms of the success criteria set.
- The report should **include the following statements**:
 - “Tests have been conducted in accordance with the COTREP test procedure - Assessment of dark packaging detectability in optical sorting processes – Version 1 – January 2019”.
 - “This report does not constitute a COTREP opinion. In order for COTREP to issue an opinion on the detectability of an alternative dark solution, this test report must be submitted to COTREP.”
- O.S. manufacturers undertake to adhere to the entire procedure **and indicate any deviations from it in the test report.**

Reminder:

- The methodology used for testing all samples submitted for analysis should be strictly identical.
- Results presented in reports should relate **solely** to tests conducted with **machine settings that are representative of those used in modern sorting centres** in normal operating conditions.
- **No reference should be made in reports to results obtained with optimised settings.**

In order for a positive opinion to be issued on the detectability of an alternative dark solution, the two test reports must show that the procedure has been followed, demonstrate that test criteria have been met, and be submitted to COTREP.

Confidentiality

If required by requesters, a confidentiality agreement covering any details of requests and the content of reports (particularly results and observations) may be signed between the O.S. manufacturers, COTREP and requesters.

Practical information

○ Addresses and contact details of the O.S. manufacturers

	PELENC ST	TOMRA
Contact:	Marc Minassian Tel.: +33 4 90 09 47 90 m.minassian@pellencst.com	Sylvain Merhand Tel.: +33 6 79 57 69 34 Sylvain.merhand@tomra.com
Delivery address:	PELENC ST 125 Impasse François Gernelle 84120 Pertuis France.	TOMRA Sorting GmbH Test Center Otto-Hahn-Straße 6 D-56218 Mülheim-Kärlich Germany.

○ Cost of testing – to be borne by requesters

Requesters shall bear the costs of testing and discuss these directly with the O.S. manufacturers.

As a guideline, each test should cost between €250 and €2,000 before tax. Precise costings should be determined by each O.S. manufacturer based on the number of sample batches tested, whether tests are attended by the requester, and the number of static and/or dynamic tests conducted.

Requesters should also budget for:

- The cost of creating and labelling samples (to be performed by requesters)
- The cost of sending samples to the O.S. manufacturers
- Any costs for returning samples after testing.

Version number	Date	Author	Notes
1	15/01/2019	COTREP	Version 1

This procedure may be updated if another optical sorting manufacturer were to acquire more than 20% of the market for French household packaging waste sorting centres.

APPENDIX 1: COTREP sorting test request form

Requester:

- Company:
- First name/Last name
- Position:
- Email:
- Telephone:

Description of tested packaging:

- Packaging type (bottle, pot, tray, tube, film, etc.):
- Packaging colour and weight:
- Forming process:
- Packaging structure (if multi-layer, describe the layers):
- Majority resin:
- Colorant solution:
 - Trade name:
 - Description:
 - Input ratio in the packaging:
 - Size of pigments (where applicable):
- Does the packaging contain coloured production scrap (which may itself contain carbon black): YES/NO
- Does the packaging contain any mineral loads (TiO₂, etc.)? If so, what percentage:
- Other components:
 - Barriers/other resins:
 - Other additives:
- Marketed volume:

Requester's undertakings

I hereby confirm the following:

- I wish to conduct tests in accordance with the **standard procedure** set out by COTREP.
- I confirm that I will conduct tests **on the premises of the two O.S. manufacturers** (Pellenc St and Tomra).
- I agree that **results will be sent to COTREP** for its analysis and opinion.
- I agree to bear the entire cost of testing, which I will arrange directly with the O.S. manufacturers.
- I certify that the tested colorant solution:
 - Meets the essential requirements of the Packaging and Packaging Waste Directive (94/62/EC).
 - Does not alter the density of the packaging: the density of packaging mainly consisting of PP or PE must be < 1 and > 1 for packaging mainly consisting of PET or PS.

COTREP can only issue an opinion once it has received this document and the test reports from the two O.S. manufacturers.

Company stamp:

Date:

Last name, first name and signature:

O.S. manufacturers should append this document to their test reports for COTREP.

Document to be completed and attached to each package of samples

Purpose of testing: Standard sorting procedure for dark packaging

Requester:

- Company:
- First name/Last name

O.S. manufacturer contact:

Test date:

Reminder of target resin:

What should be done with samples after testing?

- Please destroy samples after testing.
- Please return samples after testing. The return address is:
 - Name:
 - Street:
 - Post code/city:
 - Country:

APPENDIX 3: Results analysis table – Excel file provided

o **Results of static tests:** 1 row per batch of tested samples

Reference number of tested samples	Photo of the sample	Target resin indicated by the requester	Photo of samples during the static test	Results of static detection	Comparison of spectrum detected compared to that of target resin	Conclusion	Comments
				Visible or not visible	Sufficiently similar or too different	GO / NO GO for dynamic testing	
E.g.: Tray-PP-NIROK-1		PP		Visible	Sufficiently similar	GO for dynamic testing	Both sides of the tray were tested

o **Results of dynamic tests:** 1 row per batch of tested samples

Reference number of tested samples	Number of packages included in the SC stream	Target resin indicated by the requester	Photo of sorted containers after categorisation		Categories to apply after dynamic testing	Packaging blown by OS			Packaging not blown by OS		
			Packaging blown by OS	Packaging not blown by OS		Number	kg	%	Number	kg	%
E.g.: Tray-PP <i>light</i>	100	PP			Target resin (light pkg)	95	4,75	15%	5	0,25	0%
					Target resin (other pkg)		24,50	80%		1,00	1%
					Other (different to target resin)		1,50	5%		68,00	98%
					TOTAL		30,75			69,25	
					Target resin purity - P ₁	95%	verif	> 90%		OK	
					Target resin capture rate - CR ₁	96%	verif	> 90%		OK	
					Target resin capture rate light pkg - CR _{light}	95%	verif	> 90%		OK	
E.g.: Tray-PP <i>dark</i>	100	PP			Packaging blown by OS			Packaging not blown by OS			
					Number	kg	%	Number	kg	%	
					Target resin (dark pkg)	90	4,50	14%	10	0,50	1%
					Target resin (other pkg)		24,00	76%		1,50	2%
					Other (different to target resin)		3,00	10%		69,50	97%
					TOTAL		31,5			71,5	
					Target resin purity - P ₂	90%	verif	+/- 5%	95%	OK	
					Target resin capture rate - CR ₂	93%	verif	+/- 5%	96%	OK	
					Target resin capture rate dark pkg - CR _{dark}	90%	verif	+/- 5%	95%	OK	
					Test conclusion OK / NOK						OK
Observations/Comments											