

CHI-C8-BFPE

Preparation and Application Test of PE-based Blown-Films

Version 4.0

This CHI test method was developed by cyclos-HTP for application tests of LDPE-based recyclates for blown-films. The relevant application for sealed bags is also tested. and includes the following steps and criteria:

1. Evaluation of PE-based recyclates for blown film applications

- The tests can be carried-out on a lab scale blown film line capable to produce films of $35 \pm 5 \mu\text{m}$, with min 150 mm film bubble diameter, with at least 2 m/min film speed.
- The prepared recycle samples should be degassed and dried by demand.
- Blown film samples are produced by blending of 60% recycle sample with 20% PE-LLD and 20% PE-LD. The share of recycling compound in the film samples can be reduced by demand to 50% each or even to 40% each if no stable blown films can be produced with 60% REF05. The following blown film samples are produced:
 - F-REF05 (60% REF05 + 20% PE-LLD + 20% PE-LD)
 - F-CHI05 (60% CHI05 + 20% PE-LLD + 20% PE-LD)
 - F-REF30 (60% REF30 + 20% PE-LLD + 20% PE-LD)
 - F-CHI30 (60% CHI30 + 20% PE-LLD + 20% PE-LD)
- The virgin PE-LD and PE-LLD grades should be suitable for blown film applications (MFR $\leq 1.5 \text{ g}/10\text{min}$) without slip and anti-block additives to prevent sealing failures.

2. Parameter settings of blown film lab extrusion

Parameter	Unit	Suitable parameter settings
Extruder Temperatures	[°C]	depends on equipment, settings for "Standard PE-LD/LLD"
Melt Temperature	[°C]	$220 \pm 10 \text{ °C}$ (measured)
Melt Pressure	[bar]	depends on equipment, settings for "Standard PE-LD/LLD"
Film Speed	[m/min]	min. 2 m/min
Film Thickness	[μm]	$35 \pm 5 \mu\text{m}$
Film Diameter	[mm]	150 - 250 mm (typical for lab equipment)
Blow up ratio	[-]	2.0 – 3.0

3. Test of mechanical properties of the film samples

- Tensile test according to DIN ISO 527 in machine and cross direction
 - Specimen width: 15 mm | Specimen type 2 | Testing speed: 500 mm/min
 - Evaluation of the average value of min. 5 individual measurements per sample; in case of high deviations, further samples are tested.
- Dart Drop Impact test according to ASTM D 1709 (or DIN ISO 7765-2)
 - Drop height: 0.50 or 0.66 m | Dart diameter: 38 mm | Test speed: 3.6 m/s
 - Impact direction: from outside to inside
 - Evaluation of the average value of min. 5 individual measurements per sample (if the test is carried out with electronic data recording); in case of high deviations, further samples are tested.
 - Evaluation of the Impact failure weight relative to film thickness ($[\text{g}/\mu\text{m}]$ or $[\text{N}/\mu\text{m}]$)
- Puncture Resistance test, statical, according to ISO EN 14477
 - Dart diameter: 0.8 mm | Test speed: 100 mm/min
 - Impact direction: from inside to outside
 - Evaluation of the average value of min. 5 individual measurements per sample; in case of high deviations, further samples are tested.

Overview of mechanical tests:

Parameter	Unit
Tensile strength (σ_M) MD	[MPa]
Tensile strength (σ_M) CD	[MPa]
Elongation at break (ϵ_{tB}) MD	[%]
Elongation at break (ϵ_{tB}) CD	[%]
Dart Drop Impact Strength	[g/ μm]
Puncture Resistance	[N/ μm]

Evaluation criteria:

- The above listed mechanical properties are compared between the reference and the samples. To pass this test there should be **no significant negative deviation of the properties compared to reference.**

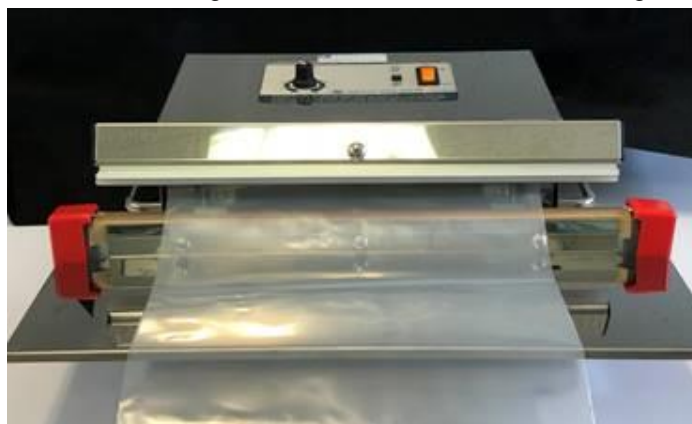
4. Test of film sealing properties

- Test of Sealing Properties according to DIN 55529: The **Seal Strength (Fmax) [N/15mm]** of the reference film and the recycle sample films is measured as a function of the sealing temperature.
- The obtained blown film samples are sealed vertical to the web direction with a heating jaw sealing device. The other sealing parameters pressure and sealing time are kept constant.
- Seam width: 10 mm | Test speed: 500 mm/min | Test angle: 90° (supported)
- Variation of heating temperature between 110 and 150°C and a constant sealing time of 0.5 seconds and a sealing pressure of 50 N/cm² to find the characteristic sealing parameter window for each sample
- Evaluation of the average value of the seal strength of min. 5 individual test series per sample
- Evaluation criteria:
 - The sealing window with the maximum seal strength is compared between the reference and the samples. To pass this test there should be **no significant negative deviation of the properties compared to reference.**

5. Seam tightness test

The purpose of this test is to check the integrity of the manufactured films with regard to the tightness of sealing seams.

- The blown film samples are prepared on an impulse sealing equipment with 2.4 mm seam width (optional up to 3 mm) and sealing time of 0.3 – 2.0 seconds.
- The pressing mechanism of the sealing bars must ensure a uniform sealing seam:



- The one-side sealed film tubes are filled with water and hung on the open side so that the seam is under load. A soaking paper can be placed under the sample for the indication of water drops due to leakages.
- The amount of water to be filled into the sealed tube depends on the diameter of the film to ensure an equal force on the seam:

$$m_{Water} [kg] = 0.125 \left[\frac{kg}{cm} \right] \times L_{Seam} [cm]$$

Length (L)	cm	15	16	17	18	19	20	21	22	23	24	25
Water (m)	kg	1.875	2.000	2.125	2.250	2.375	2.500	2.625	2.750	2.875	3.000	3.125
Fill height *	cm	26.2	24.5	23.1	21.8	20.7	19.6	18.7	17.8	17.1	16.4	15.7

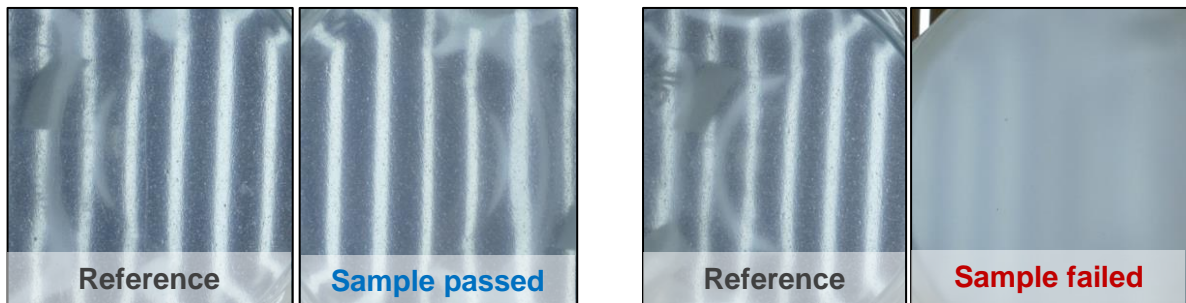
* Rough guide

- It is observed if any water is leaking through the seam within 5 minutes.



6. Test of optical appearance of the film samples

- This test has the purpose to compare the produced blown film samples containing the critical material component with the reference blown film samples according to transparency, opacity, black specks and gels.
- The film samples are evaluated with a visual method by which defects like gels and black specks and the transparency can be clearly detected.
- A practical method works in such a way that the film samples are placed above a flat light source with dark and light zones to obtain a high contrast. Other optical test methods or equipment are suitable to evaluate the optical properties.
- The sample F-REF05 with F-CHI30 and the sample F-REF30 with F-CHI30 are respectively contrasted and compared with each other and are documented photographically.
- Examples:



Evaluation criteria:

- The tightness of the sealed bags is evaluated according to the following criteria.
The sample has passed the test if ...
 - **no water penetrates through the seam within the 1st minute** after the sealed tube is filled.
 - **the seam of the sample is not breaking within 5 minutes** after the sealed tube is filled.
- The reference film REF05 is tested first with at least 3 samples. The sealing time is adjusted to be at the lower end of the window where all reference samples are still tight.
- A minimum of 3 samples per film variation is tested with the same parameters as the reference.
- The tightness of the bags produced is evaluated according to the following criteria:
 - If all 3 samples of a test film variant are tight, it can be assessed that the film variant has passed the test.
 - If one of the 3 samples shows significant leakage (water penetration or seam break), 2 further samples should be tested.
 - Assessment criteria: 3 out of 3 or at least 4 out of 5 samples must be tight (without leakages) to pass the test.
- If possible, the position with the leakage or break should be observed. The cause of the defect is documented in the test report. This can be a pinhole, a gel body, a thin area or an inhomogeneity in the film. Only failures and leakages caused by an insufficient sealing should be considered for the assessment. Leakages due to holes, gels or inhomogeneities should be taken out of the rating, as this criterion is not linked to the sealing integrity of a sample film.

Version history:

<i>Version No.</i>	<i>Date</i>	<i>Reason/Content of revision</i>
1.0	Oct 2019	First version of test method
4.0	May 2023	Reworked test parameters and criteria, test of optical appearance added.