Sealing Barrier Films

No book with seven Seals!

Source: www.harzlife.de

MULTI-LAYER PACKAGING FILMS 2014

14-16 October 2014
Maritim Hotel, Cologne, Germany
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</table>
SIEGENBURG, Bavaria, Germany
Headquarters
Flexible films

INGOLSTADT, Bavaria, Germany
Rigid foil factory
Pilot Plant for thermoforming

NEUTRAUBLING, Bavaria, Germany
Centre of excellence
Printing and laminating
TECHNOLOGY / EXTRUSION MACHINES

• BLOWN-FILM EXTRUSION
  - Capacity: > 25,000 tons per year
  - 2 x 3 layer
  - 3 x 5 layer
  - 3 x 7 layer
  - 2 x 7 layer shrink-wrap film machines

• CAST FILM EXTRUSION (APET)
  - Capacity: > 30,000 tons per year
  - 3 machines

• PILOT PLANT for thermoforming: Multivac R530

• Printing • Laminating • Cutting/Winding • Pouch customising
APPLICATIONS / MARKETS

- FOODSTUFFS
- TECHNICAL APPLICATIONS
- MEDICAL PRODUCTS
- PET FOOD
- CHEMICAL INDUSTRY
- SPECIAL APPLICATIONS
PRODUCTS

- TUBULAR POUCHES, TOP FILMS AND BAGS
  - BUERGO.FLEX FLOW / TOP, BUERGO.BAG

- BOTTOM FILMS
  - BUERGO.FLEX BOTTOM

- TOP FILMS
  - BUERGO.FLEX TOP

- LAMINATES / RECLOSABLE
  - BUERGO.FLEX SPECIAL / BUERGO.RECLOSE

- RIGID FILMS / FOAMED RIGID FILMS
  - BUERGO.PET / BUERGO.PET EXPANDED

- SKIN FILMS
  - BUERGO.SKIN

- SHRINK FILMS
  - BUERGO.SHRINK

- SPECIALISED FILMS
  - BFCR
2. Sealing barrier films for food packaging

Materials and properties

Definitions:

- **Sealing** is the connection of thermoplastic film layers with temperature and pressure. The materials in the seal layers are normally not completely molten. Only the outer sealing layers of films are connected (inner layers are not affected).

  Used in processing films
  - to form and close bags
  - to close shells or cups with a lidding film
  - on Form, Fill & Seal packaging machines and in Flowpack process
  - to form Blister packages and tubes

- **Welding** is the connection of thermoplastic materials with temperature and with or without pressure. Plastic materials melt completely together. Connection is indestructible.

  Correct description would be “welding”, because by “sealing” the seal layers are also “welded”.

2. Sealing barrier films for food packaging

Materials and properties

Definitions:

**Hot Tack:** As defined by Terms of Packaging, hot tack is “the capability of a heat-seal joint to hang together when it is stressed, while still hot from the sealing operation.” A more technical definition states that hot tack is “the sum of the cohesive strength of a sealant material as well as its adhesive strength to the remaining elements of the multilayer structure while in the heat-seal temperature range.”

- High values for hot tack are usually necessary, especially on vertical form, fill and seal devices, because the seal joints are strained by filling with the product. Typical values are: 1 to 10 N/15 mm

**Seal Strength:** Measure for the stability of the seal joint. This is the force on the seal joint of a stripe with width 15 mm.

Seal strength depends on:

- Pressure of sealing
- Time of sealing
- Temperature of sealing (!!)
2. Sealing barrier films for food packaging

Materials and properties

Measurements:


- **DIN 55529 (2012):** Verpackung – Bestimmung der Siegelnhaftfestigkeit von Siegelungen aus flexiblen Packstoffen

- **ASTM F 88/F88M-09 (2009):** Standard Test Method for Seal Strength of Flexible Barrier Materials:
  Seal Strength testing, also known as Peel Testing, measures the strength of seals within flexible barrier materials. This measurement can then be used to determine consistency within the seal, as well as evaluation of the opening force of the package system. Seal strength is a quantitative measure for use in process validation, process control and capability. Seal strength is not only relevant to opening force and package integrity, but to measuring the packaging processes’ ability to produce consistent seals.

- **ASTM F 1921 (2012):** Standard Test Methods for Hot Seal Strength (Hot Tack) of Thermoplastic Polymers and Blends Comprising the Sealing Surfaces of Flexible Webs
2. Sealing barrier films for food packaging

Materials and properties

Raw materials

- Base Polymers
  - LDPE
  - MDPE
  - HDPE
  - PP
  - PVC
  - A-PET
  - G-PET
  - C-PET
  - PLA
  - PS
  - Others

- Special sealing Polymers
  - LLDPE (C4, C6, C8)
  - Metallocen based
    - mPE-LLD C6, C8
    - mPE-MD
    - mPE-HD
  - Ionomers
  - EVAc
  - „Specialties“

- Additives
  - Polybutene
  - Reduction Tm
  - Softeners
  - „Impurities“
  - Others

[C4, C6 and C8 are length of side chain branches of the polymer]
Properties of the polymers influencing sealing behaviour:

- Melting point ($T_m$)
- Glass Transition Temperature ($T_g$)
- Kind of Polymers
- Functions Copolymers
- Melt viscosity MFI, MFR
- Molecular Weight distribution
- Degree of crystallisation
- Amorphous Content
- Polymer structure (branching)
- Mixtures in the sealing layer
- Density

2. Sealing barrier films for food packaging
2. Sealing barrier films for food packaging

Some properties of chosen polymers:

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Density g/cm³</th>
<th>Melting point °C</th>
<th>Degree of crystallisation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDPE</td>
<td>0,915 – 0,935</td>
<td>105 - 116</td>
<td>40 - 50</td>
</tr>
<tr>
<td>HDPE</td>
<td>0,94 – 0,98</td>
<td>125 - 135</td>
<td>60 - 80</td>
</tr>
<tr>
<td>LLDPE</td>
<td>0,86 – 0,96</td>
<td>100 - 128</td>
<td>10 - 50</td>
</tr>
<tr>
<td>Homo-PP</td>
<td>0,90 – 0,915</td>
<td>160 - 165</td>
<td>60 - 70</td>
</tr>
<tr>
<td>A-PET</td>
<td>1,335</td>
<td>- (Tg ca. 75)</td>
<td>amorphous</td>
</tr>
<tr>
<td>PS</td>
<td>1,04</td>
<td>- (Tg ca. 105)</td>
<td>amorphous</td>
</tr>
<tr>
<td>Hard-PVC</td>
<td>1,38 – 1,40</td>
<td>- (Tg ca. 79)</td>
<td>amorphous</td>
</tr>
</tbody>
</table>
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Polypropylene PP (Types): [A: Propylene  B: Ethylene]

**PP-Homopolymers** only with Propene.


**PP-Blockcopolymers** are heterophase. Polymerization of Ethylene and Propylene.


**PP-Randomcopolymers** contain Propylene, Ethylene and Butene in a statistic distribution.


**PP-Randomblockcopolymers** are Randomcopolymers, with Ethene-Propene-Rubber


In addition: Metallocene catalyzed mPP
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Special sealing polymers: **PE-Metallocene**

- Metalloccen-catalyzed polymerisation of Ethylene with further α–Olefins like 1-Butene, 1-Hexene and 1-Octene (→ C4, C6 and C8-branching)
- Minimal catalyst remains – low migration
- Excellent clarity and gloss
- Excellent to extrude
- Higher strengths
- Low gel content
- **Excellent sealability and high hot-tack**
2. Sealing barrier films for food packaging

Special sealing polymers: **PE-Metallocene** compared to “common” polymers

Source: Simone Viganò, ExxonMobil Chemical Europe; “The Use of Metallocen Polyethylene in Co-Extruded Lamination Film”
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Special sealing polymers: Ionomers

- Ionomers are synthesized by copolymerisation of an unpolar monomer like Ethylene with a polar monomer like (Meth)Acrylic acid
- Neutralisation with base leads to ionic groups
- The polar bonds reduce crystallisation and result in “ionic networks”
- Excellent sealability, even with contaminated sealing areas
- Low sealing temperatures
- High Hot Tack
- High temperature range for sealing
- High seal strength

Figure 1: Ionomer Morphology Model
(Sphere: ionic domain; Long stack: primary crystal; Short stack: secondary crystal)

Source: John C. Chen, Han-II Lee, Donna Visioli; DuPont Company
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Special sealing polymers: **Ethylene-Vinylacetate-Copolymers (EVAc)**

**Figure 2: Influence of VA content on morphology**

Source: LANXESS, Levapren-brochure
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Methods for sealing/welding

**Plastic welding** is a process of uniting softened surfaces of materials (films) generally with the aid of heat (except solvent welding).

Welding of thermoplastics is accomplished in three sequential stages, namely

- surface preparation,
- application of heat and pressure, and
- cooling.

Numerous welding methods have been developed for the joining of semifinished plastic Materials and films. Based on the way of heat generation mechanism at the welding interface, welding methods for thermoplastics can be classified as external and internal heating methods, as shown in the figure.

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Methods for sealing/welding

Source: http://en.wikipedia.org/wiki/Plastic_Sealing/Welding_Technologies
Methods for sealing

**Direct Contact Thermal Sealing**: Hot bar sealers - have heated tooling kept at a constant temperature. They use one or more heated bars, iron, or dies which contact the material to heat the interface and form a bond. The bars, irons, and dies have various configurations and can be covered with a release layer or utilize various slick interposer materials (i.e. Teflon films) to prevent sticking to the hot tooling.

**Continuous heat sealers** - (also known as Band type heat sealers) utilize moving belts over heating elements.

**Impulse heat sealers** - have heating elements (one or two) of Nichrome placed between a resilient synthetic rubber and a release surface of film or fabric. The heating elements are not continuously heated; heat is generated only when current flows. When the materials are placed in the heat sealer, they are held in place by pressure. An electric current heats the heating element for a specified time to create the required temperature. The Jaws hold the material in place after the heat is stopped, sometimes with cooling water: this allows the material to fuse before stress can be applied. Impulse: 0.1 to 1 s.
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Methods for sealing

**Ultrasonic welding** uses high-frequency ultrasonic acoustic vibrations to workpieces being held together under pressure to create a weld. In ultrasonic welding, high frequency (15 kHz to 40 kHz) low amplitude vibration is used to create heat by way of friction between the materials to be joined. The interface of the two parts is specially designed to concentrate the energy for the maximum weld strength. Ultrasonic can be used on almost all plastic material. It is the fastest heat sealing technology available.

**Induction sealing**, otherwise known as cap sealing, is a non-contact method of heating a metallic disk to hermetically seal the top of plastic and glass containers. This sealing process takes place after the container has been filled and capped.

**Hot wire sealing** – involves a heated wire that both cuts the surfaces and joins them with a molten edge bead. This is not usually employed when barrier properties are critical.

**Hot melt adhesive** can be applied in strips or beads at the point of joining. It can also be applied to one of the surfaces during an earlier manufacturing step and reactivated for bonding.
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Sealing methods – What happens?

Scheme of the molecular process for sealing of two semi-crystalline films:

- **HEAT**
- Pressure for time
- Entanglements are loosened
- Diffusion of macromolecules and forming of new entanglements
- Cooling
- Re-crystallisation, Tightened.

Semi-crystalline Polymers in two film surfaces

(Partially) Molten Contact areas

Re-crystallisation, Tightened.
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Sealing tools – Sealing bars

- smooth

- grooved (longitudinal)

- grooved (cross)

- waffle-weave pattern

Source: Rubber with waffle-weave pattern
2. Sealing barrier films for food packaging

Packaging – Area sealing

Transparent sealing without bubbles

Complete sealing to the product: Meat has no chance to lose blood or fat
### Opening characteristics – peel / easy peel / tight sealing - definitions

<table>
<thead>
<tr>
<th>Range</th>
<th>Name</th>
<th>Opening characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) – 4 – 6 N/15 mm</td>
<td>soft peel</td>
<td>Seal joint is weak and very easy to open</td>
</tr>
<tr>
<td>6 – 10 N/15 mm</td>
<td>easy peel</td>
<td>Seal joint is opened easily</td>
</tr>
<tr>
<td>10 – 15 N/15 mm</td>
<td>peel</td>
<td>Seal joint is opened without material breaks</td>
</tr>
<tr>
<td>&gt; 15 N/15 mm</td>
<td>tight</td>
<td>Material breaks, not to open without destruction</td>
</tr>
</tbody>
</table>
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Opening characteristics – peel / easy peel: Surface Peel

Suitable for: PVC, PS, PP, PET, HDPE

Source: Neue Verpackung 04/2002: „Vielseitige“ Peel und Siegelmedien
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Opening characteristics – peel / easy peel: cohesive peel or Polybutene-Peel

Source: H. Rist, Neue Verpackung 04/2005; Leicht und ruckfrei aufreißen
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Opening characteristics – peel / easy peel: cohesive peel or Polybutene-Peel – peel process

Perfect!  
Longitudinal disruption

Bad!  
Cross disruption

Source:  
http://wiki.polymerservice-merseburg.de/index.php/Peelvorgang
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Opening characteristics – Burst peel - Safety peel

Advantages:

- Crack happens in a coextruded layer – specially designed
- Absolutely tight package – but very easy to open
- Best for critical packed goods, like fish with oil
2. Sealing barrier films for food packaging

Opening characteristics - Reclose

**Principle:** Lidding film contains an adhesive (green layer). By opening, the adhesive layer breaks and allows easy opening with peel. The adhesive is transferred to the surface of the bottom film. After the product has been taken, the package can be reclosed. The adhesive is still sticky.

**Packages:** Tray packaging, thermoformed packages

Quelle: http://www.multivac.de
## Tailor made barrier sealing films of BUERGO.FOL (choice) – suitable for every application!

<table>
<thead>
<tr>
<th>Product</th>
<th>Thickness µ</th>
<th>Property</th>
<th>Sealing material</th>
<th>Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 900</td>
<td>25 to 140</td>
<td>High Barrier</td>
<td>PE, PP</td>
<td>Laminating films</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multi peel APET, PP, PS (mono)</td>
<td>transparent or coloured</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Safety peel, Easy peel</td>
<td>antistatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reclose (RC)</td>
<td>UV-Blocker</td>
</tr>
<tr>
<td>KF 02</td>
<td>25 to 140</td>
<td>High Barrier</td>
<td>High hot tack</td>
<td>antifog</td>
</tr>
<tr>
<td>KF 03</td>
<td></td>
<td></td>
<td>Flowpack</td>
<td></td>
</tr>
<tr>
<td>KF 08</td>
<td>25 to 140</td>
<td>High Barrier</td>
<td>Safety peel</td>
<td></td>
</tr>
<tr>
<td>T 678</td>
<td>40 to 150</td>
<td>High Barrier</td>
<td>Tight sealing, APET; RC</td>
<td></td>
</tr>
<tr>
<td>T 713</td>
<td>35 to 100</td>
<td>High Barrier</td>
<td>PP homo, random, Copo</td>
<td></td>
</tr>
</tbody>
</table>
2. Sealing barrier films for food packaging

Measurement of Seal strength – sealing curves

KOPP Labormaster 3000

<table>
<thead>
<tr>
<th>Temperature Top</th>
<th>Temperature Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soll: 130.0 °C</td>
<td>Soll: 130.0 °C</td>
</tr>
<tr>
<td>Ist: 130.0 °C</td>
<td>Ist: 130.0 °C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seal Time</th>
<th>Hold Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soll: 1.50 s</td>
<td>Soll: 5.00 s</td>
</tr>
<tr>
<td>Ist: 5.000 s</td>
<td>Ist: 5.000 s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extraction Speed</th>
<th>Seal Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8 m/min</td>
<td>600 N</td>
</tr>
</tbody>
</table>

Time/area chart
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Measurement of Seal strength – sealing curves

Test according to DIN 55529

Quelle: www.easy-opening.info

Source: http://wiki.polymerservice-merseburg.de
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Measurement of Seal strength – sealing curves

Sealing device: Laborsiegelgerät SGPE 20, Sealing conditions: 1s, 300N
Test device: Zugprüfmaschine Fa.Frank according to DIN 55 529,
Speed: 100mm/min

sealing chart AA1000/TKF03EP, 250:50µm against Buergofol-Standard-PE

![Diagram showing sealing force along and across at different temperatures.](chart.png)
2. Sealing barrier films for food packaging

Measurement of Seal strength – Closeness

- Package with protective gas is put into water: If bubbles, not closed!
- Package with protective gas is put into water and vacuum is applied: How much pressure can the closed package withstand, until it breaks?
- Protective gas (gas analyzer)

→ Also for detection of barrier properties

- Test ink:

Quelle: www.pbi-dansensor.de
3. Sealing in practice

Film:

Packing and Sealing on a Flow Pack Machine (PFM Shamal)
3. Sealing in practice

What happens in the sealing device of a Thermoformer or Traysealer?

1. Open package
   ... In the sealing tool. Air is evacuated.

2. Sealing plate
   ... is closed. Pressure and heat weld lidding and bottom film to a closed and airtight package.

Source: http://www.multivac.com/com/Vakuum.187.0.html
3. Sealing in practice

Contaminated sealing areas – poor sealing

Very disadvantageous for sealing are:

- **Corona Treatment** (Raise of glass transition point $T_g$ and melting point $T_m$, Oxydation!)

- **Migration**, of adhesives and additives, from the film
  - Sealability can be given by „washing off“ the film surface

- **Contamination** of the sealing areas with contaminants from packed product
  - Fat and oil from packed product $\rightarrow$ Release agents!
  - Fine powders (flour, sugar powder) $\rightarrow$ are embedded!
  - Coarse grained products (sugar, salt, cerealia) $\rightarrow$ damage the film!
3. Sealing in practice

What happens because of Corona treatment? Why is the sealing behaviour badly influenced?

Source: AFS; http://www.afs.biz/

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ATR-Spectra of PP before and after Corona treatment, incl. differential spectrum.

After Corona treatment, a chemically different material results!!
3. Sealing in practice

Sealing on contaminated areas

Solutions

- **Machine**: Suitable sealing tools

- Use of a special sealing layer

  → Proper choice of a suitable sealing film:

  - Use of excellent sealing polymers (EVAc, Ionomers, metallocene catalyzed)

  - Use of safety peel

- **Get help from the film supplier!**
3. Sealing in practice

Sealing on contaminated areas

BUERGO.FOL is not only a film supplier. Service is given: Advices, application technology, adjustments of the machines.
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