Sealing Barrier Films

No book with seven Seals!

Source: www.harzlife.de

BUERGO.FOL

OUR QUALITY – YOUR SUCCESS

Dr. Kurt Stark

October 16th, 2014

Applied Market Information Ltd.

Multilayer Packaging Films 2014

14-16 October 2014
Maritim Hotel,
Cologne, Germany

Inhalt

1. BUERGO.FOL

   - Company
   - Markets/Applications
   - Product portfolio

2. Sealing barrier films for food packaging

   - Materials and properties
   - Sealing methods
   - Opening characteristics
   - Sealing measurements

3. Sealing in practice

   - Sealing on a flow pack machine
   - Sealing on a tray sealer
   - Contaminated sealing areas
   - Issues and solutions

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

1. BUERGO.FOL

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

COMPANY / BRIEF PROFILE

CORE COMPETENCY	40 years of experience in the co-extrusion of composite films
UNIQUE SELLING POINT	Development of film recipes to suit the application or customer request
SPECIALTY	**High-barrier EVOH-based films, printed and unprinted, as well as rigid films**
SITES	Siegenburg, Ingolstadt, Neutraubling
EMPLOYEES	About 300
CERTIFICATIONS	DIN EN ISO 9001:2008, HACCP, BRC/IoP Global Standard Version 4, ISO 50001

BUERGO.FOL

OUR QUALITY – YOUR SUCCESS

COMPANY / LOCATIONS

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

COMPANY

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

APPLICATIONS / MARKETS

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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".

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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 (!!)**

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Materials and properties

Measurements:

- ASTM F 2029 (2008): Standard Practices for Making Heatseals for Determination of Heatsealability of Flexible Webs as Measured by Seal Strength

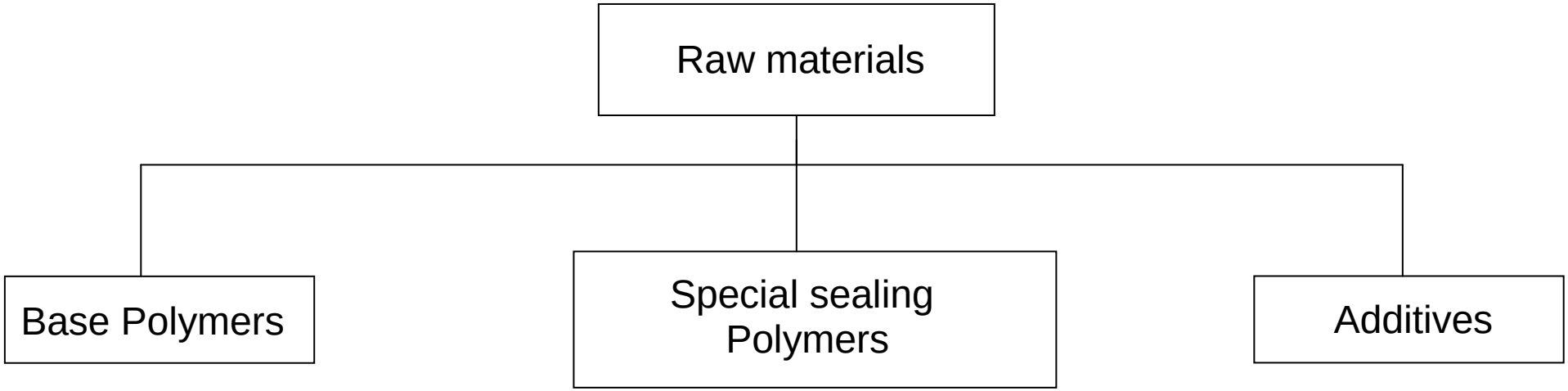
- DIN 55529 (2012): Verpackung – Bestimmung der Siegelnahtfestigkeit von Siegelungen aus flexiblen Packstoffen

- 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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Materials and properties



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

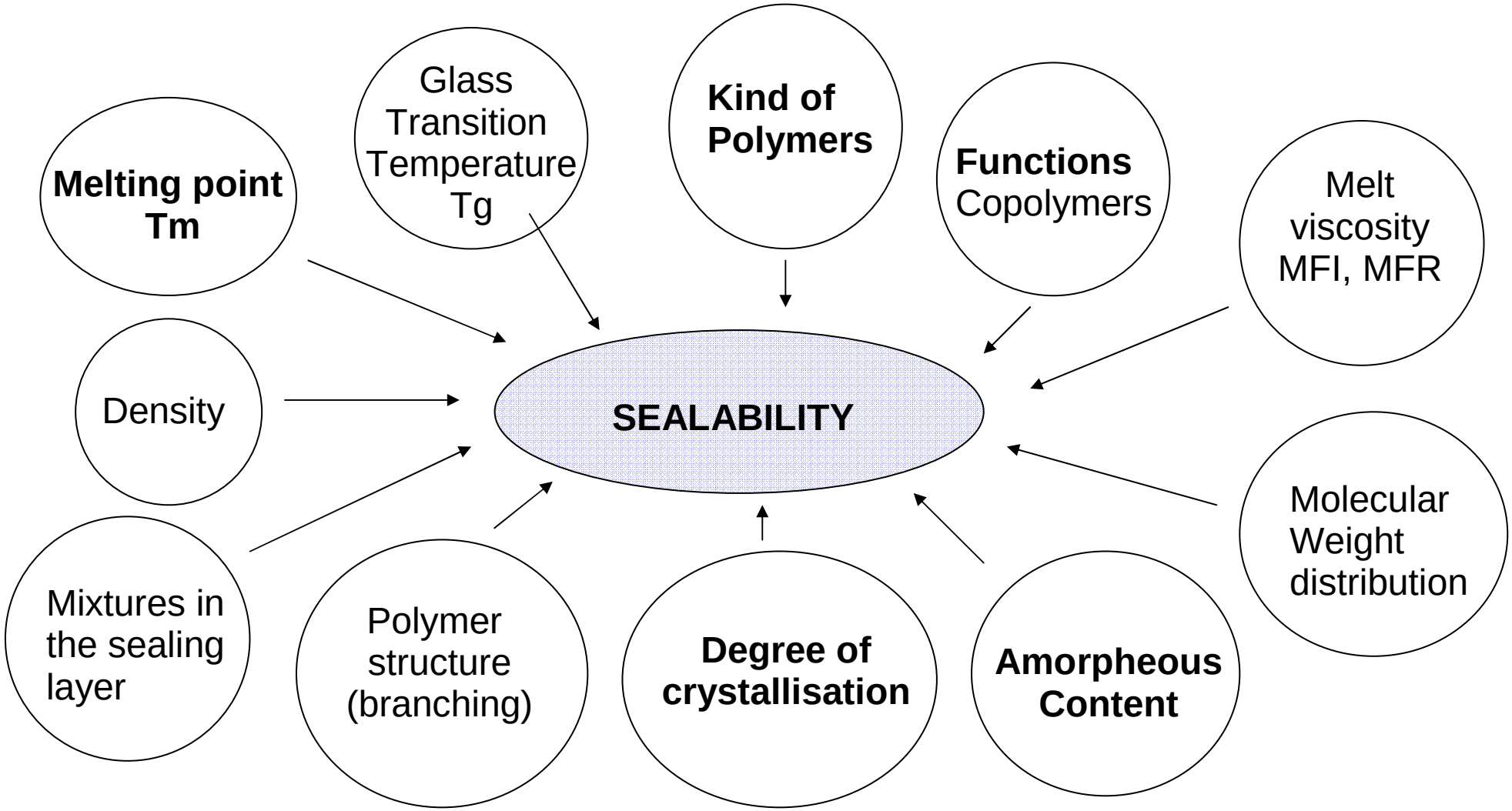
- LLDPE (C4, C6, C8)
- Metallocen based
  - ~ mPE-LLD C6, C8
  - ~ mPE-MD
  - ~ mPE-HD
- Ionomers
- EVAc
- „Specialties“

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

[C4, C6 and C8 are length of side chain branches of the polymer]

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Properties of the polymers influencing sealing behaviour:



BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Some properties of chosen polymers:

Polymer	Density g/cm^3	Melting point ℃	Degree of crystallisation %
LDPE	0,915 – 0,935	105 - 116	40 - 50
HDPE	0,94 – 0,98	125 - 135	60 - 80
LLDPE	0,86 – 0,96	100 - 128	10 - 50
Homo-PP	0,90 – 0,915	160 - 165	60 - 70
A-PET	1,335	- (Tg ca. 75)	amorpheous
PS	1,04	- (Tg ca. 105)	amorpheous
Hard-PVC	1,38 – 1,40	- (Tg ca. 79)	amorpheous

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Polypropylene PP (Types): [A: Propylene B: Ethylene]

PP-Homopolymers only with Propene.

A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A

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

A-A-A-B-B-B-B-A-A-A-A-A-A-A-B-B-B-B-A-A-A-A

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

A-A-A-B-A-B-A-A-A-B-A-A-A-B-A-A-B-A-A-A-A

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

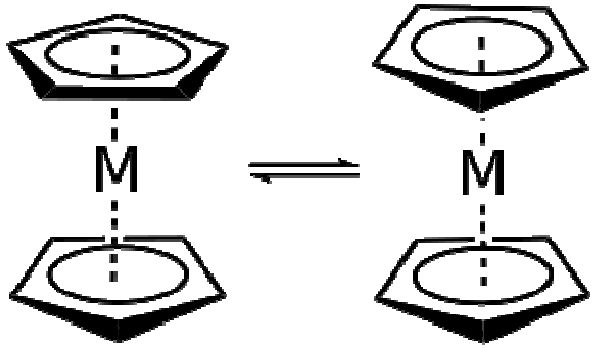
A-A-A-B-A-B-A-A-A-B-B-B-A-B-A-A-B-B-B-A-A

In addition: Metallocene catalyzed mPP

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Special sealing polymers: **PE-Metallocene**

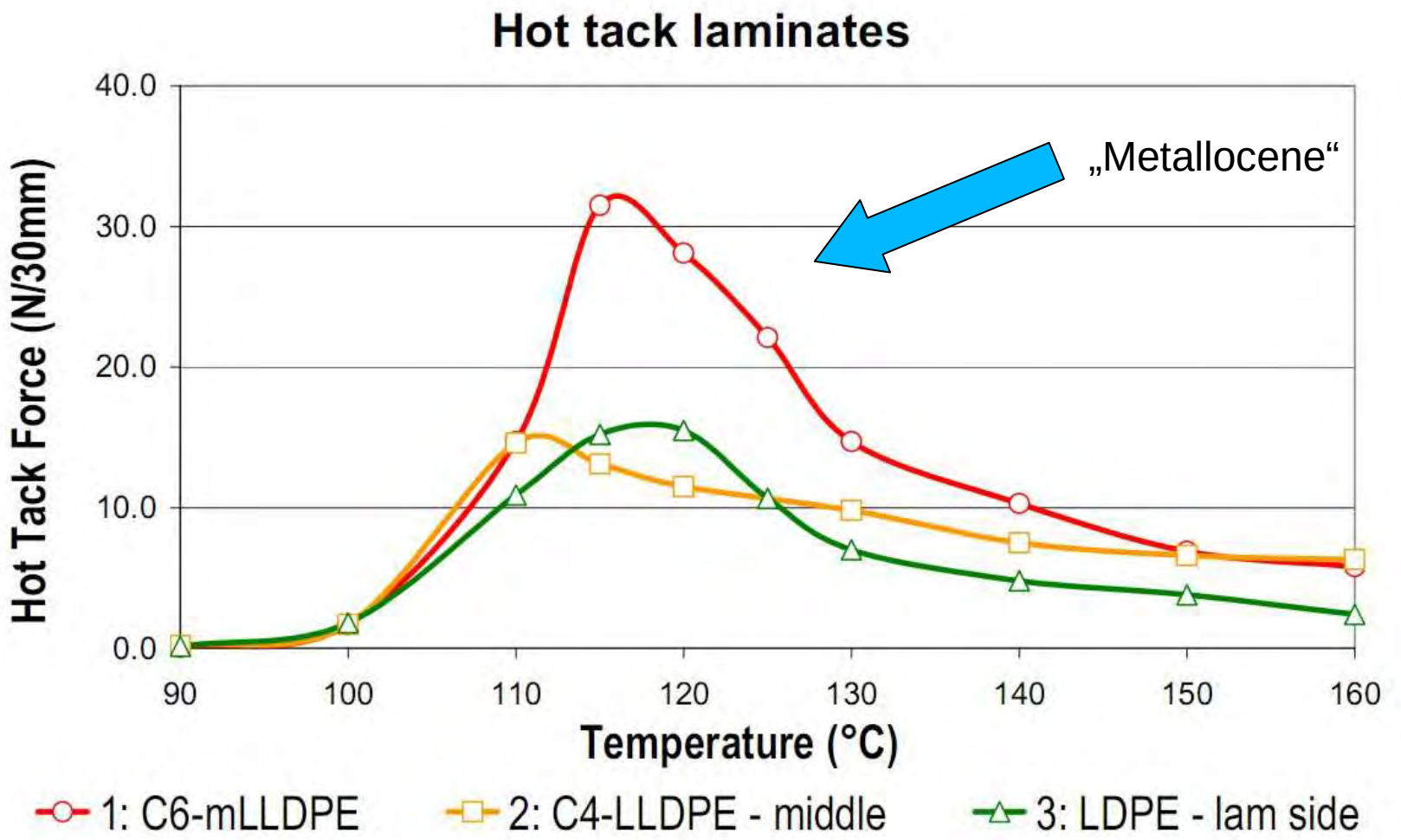
- Metallocen-catalyzed polymerisation
  of Ethylene with further α–Olefins like 1-Butene,
  1-Hexene and 1-Octene (→ C4, C6 and C8-branching)
- Minimal catalysator remains – low migration
- Excellent clarity and gloss
- Excellent to extrude
- Higher strengths
- Low gel content
- **Excellent sealability and high hot-tack**



Metallocene

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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“

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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**

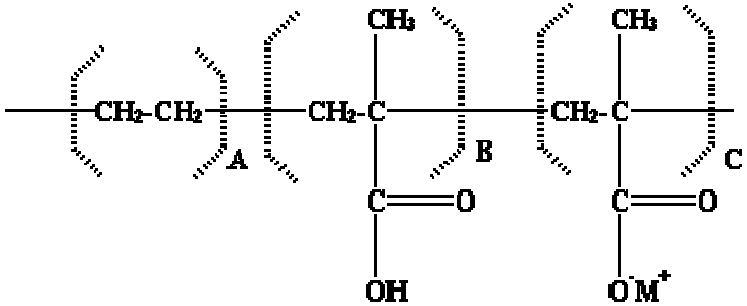
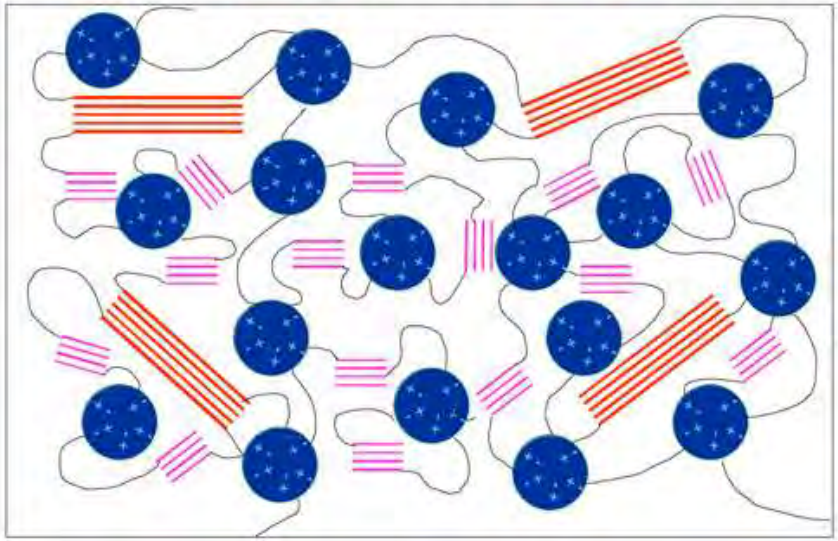


Figure 1: Ionomer Morphology Model

(Sphere: ionic domain; Long stack: primary crystal; Short stack: secondary crystal)

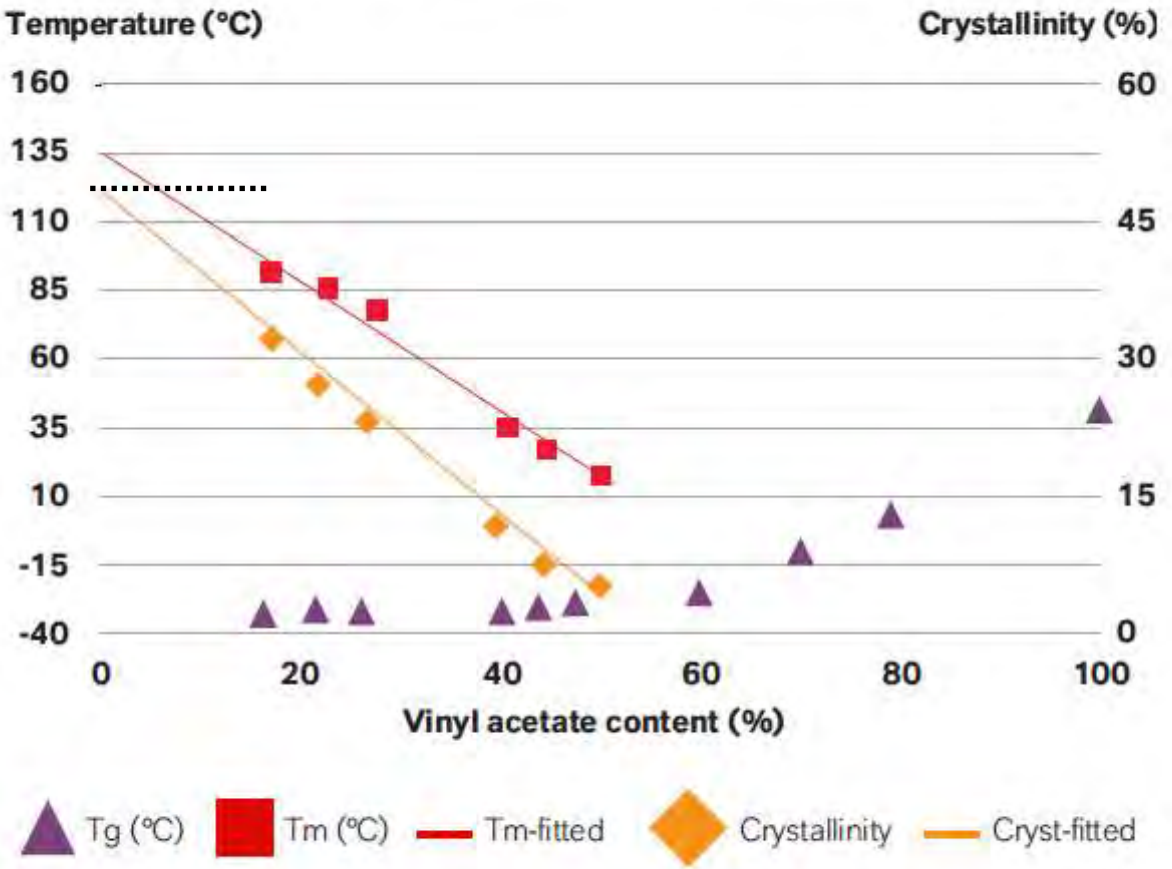


Source: John C. Chen, Han-Il Lee, Donna Visioli; DuPont Company

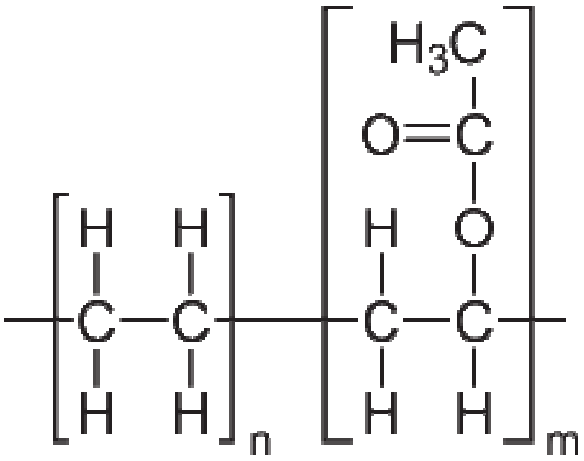
BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Special sealing polymers: **Ethylene-Vinylacetate-Copolymers (EVAc)**

Figure 2: Influence of VA content on morphology



Source: LANXESS, Levapren-brochu



BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

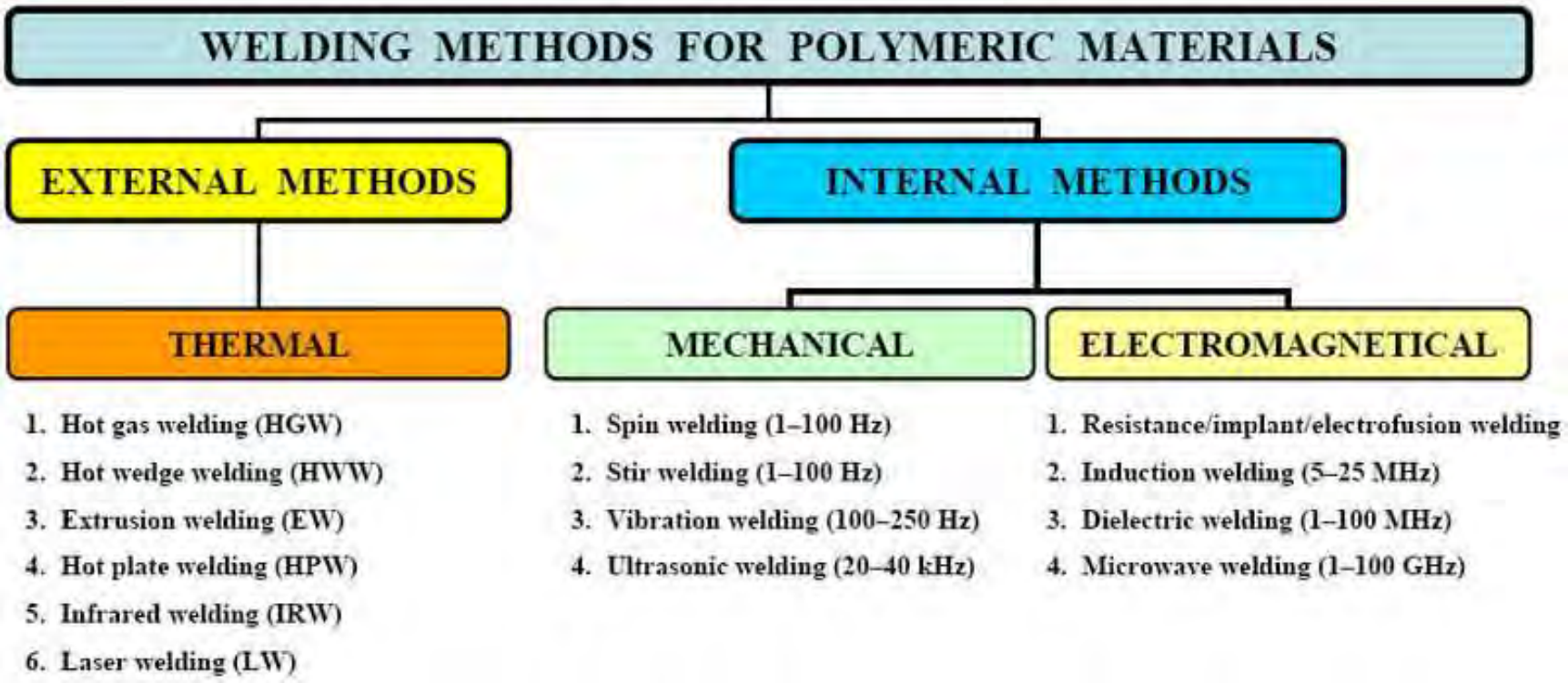
- surface preparation,
- application of heat and pressure, and
- cooling.

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.

Source: http://en.wikipedia.org/wiki/Plastic_Sealing/Welding_Technologies

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Methods for sealing/welding



Source: http://en.wikipedia.org/wiki/Plastic_Sealing/Welding_Technologies

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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.

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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.

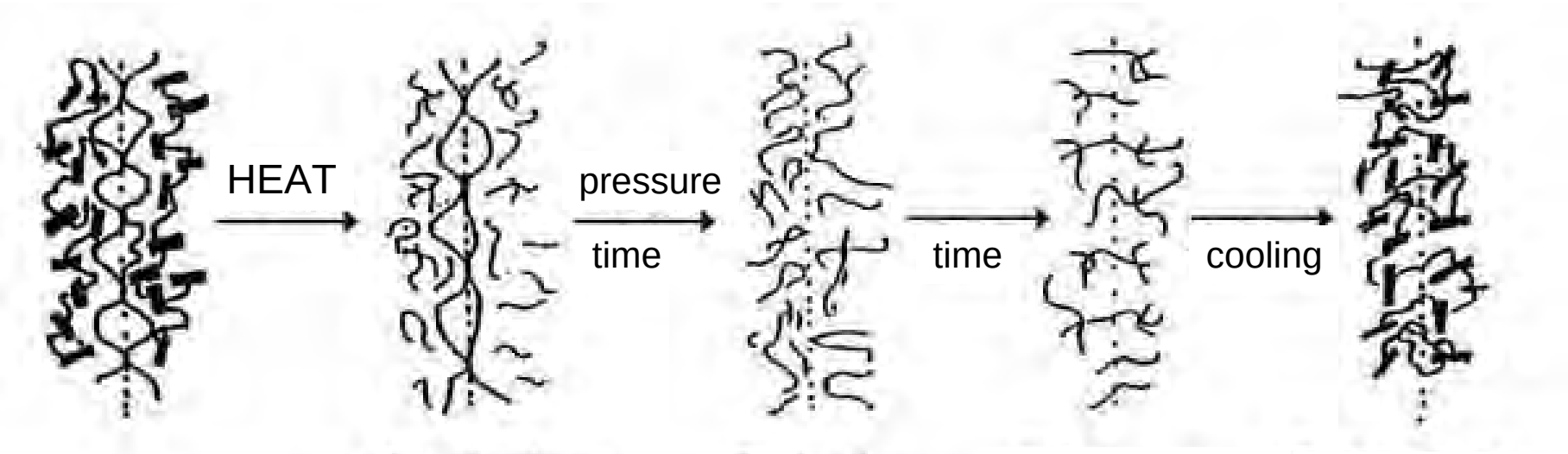
Hot wire sealing – involves a heated wire that both cuts the surfaces and joins them with a molten edge bead. This is not usually employed when barrier properties are critical.

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.

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Sealing methods – What happens?

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



Semi-crystalline Polymers in two film surfaces

(Partially) Molten Contact areas

Entanglements are loosened

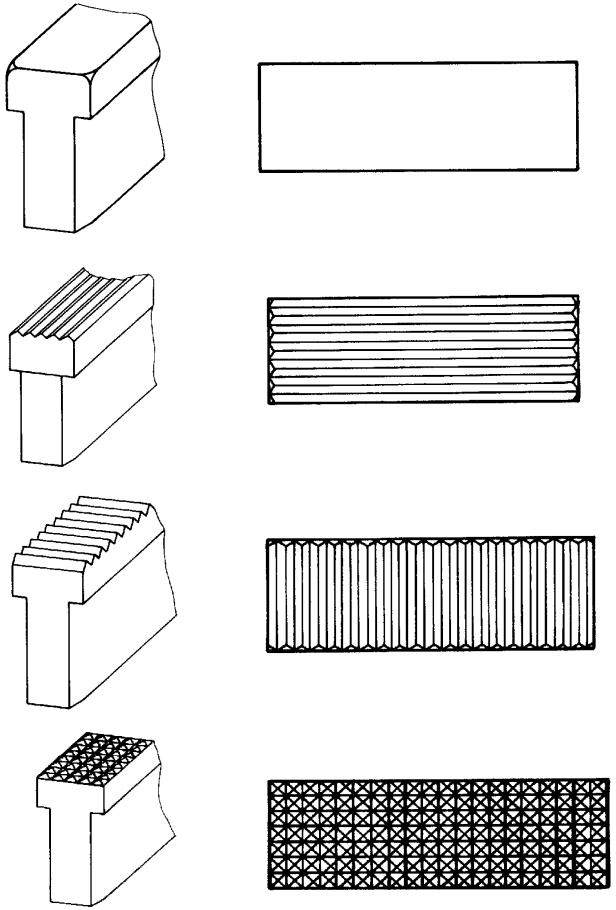
Diffusion of macromelcules and forming of new entanglements

Re-crystallisation, Tightened.

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

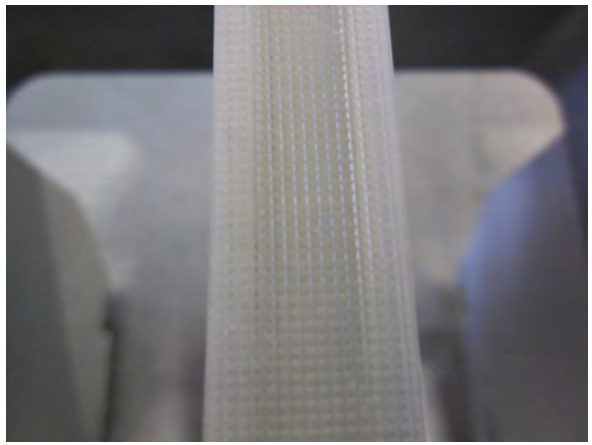
Sealing tools – Sealing bars

- **smooth**
- **grooved (longitudinal)**
- **grooved (cross)**
- **waffle-weave pattern**



Source:

kopp
Verpackungssysteme



Rubber with waffle-weave pattern

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Packaging – Area sealing

Transparent sealing without bubbles

Complete sealing to the product: Meat has no chance to lose blood or fat

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

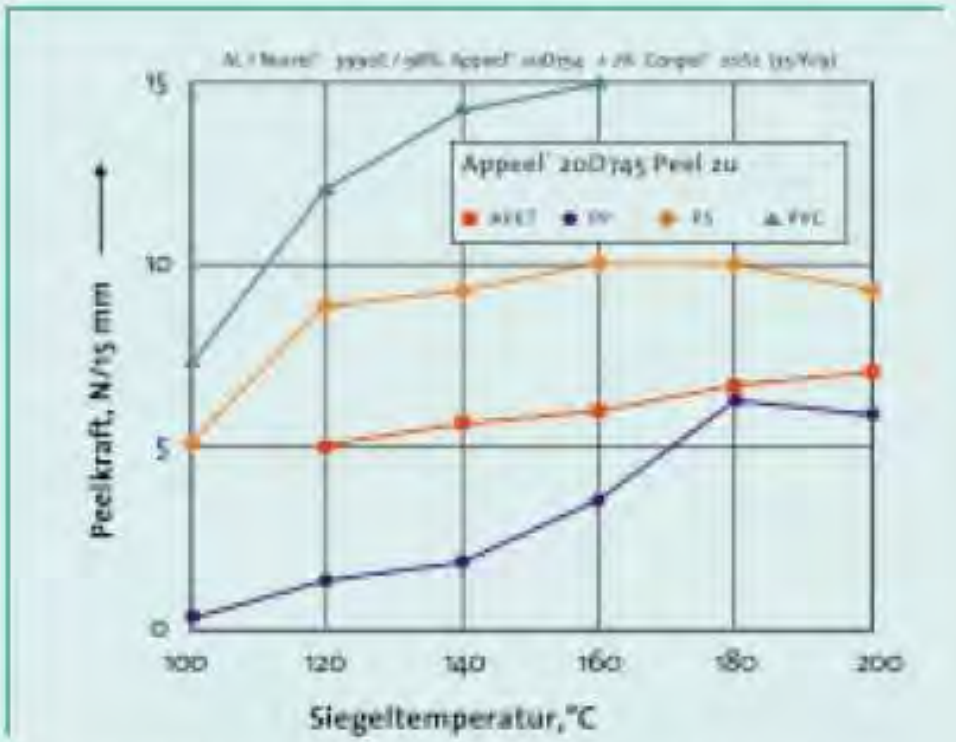
Opening characteristics – peel / easy peel / tight sealing - definitions

Range	Name	Opening characteristics
(1) – 4 – 6 N/15 mm	soft peel	Seal joint is weak and very easy to open
6 – 10 N/15 mm	easy peel	Seal joint is opened easily
10 – 15 N/15 mm	peel	Seal joint is opened without material breaks
> 15 N/15 mm	tight	Material breaks, not to open without destruction

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Opening characteristics – peel / easy peel: Surface Peel

Beim Grenzflächen-Peel trennt sich der Deckel/Siegelschicht-Verbund sauber von dem Kunststoff-Substrat, aus dem die Becher oder Schalen hergestellt sind.



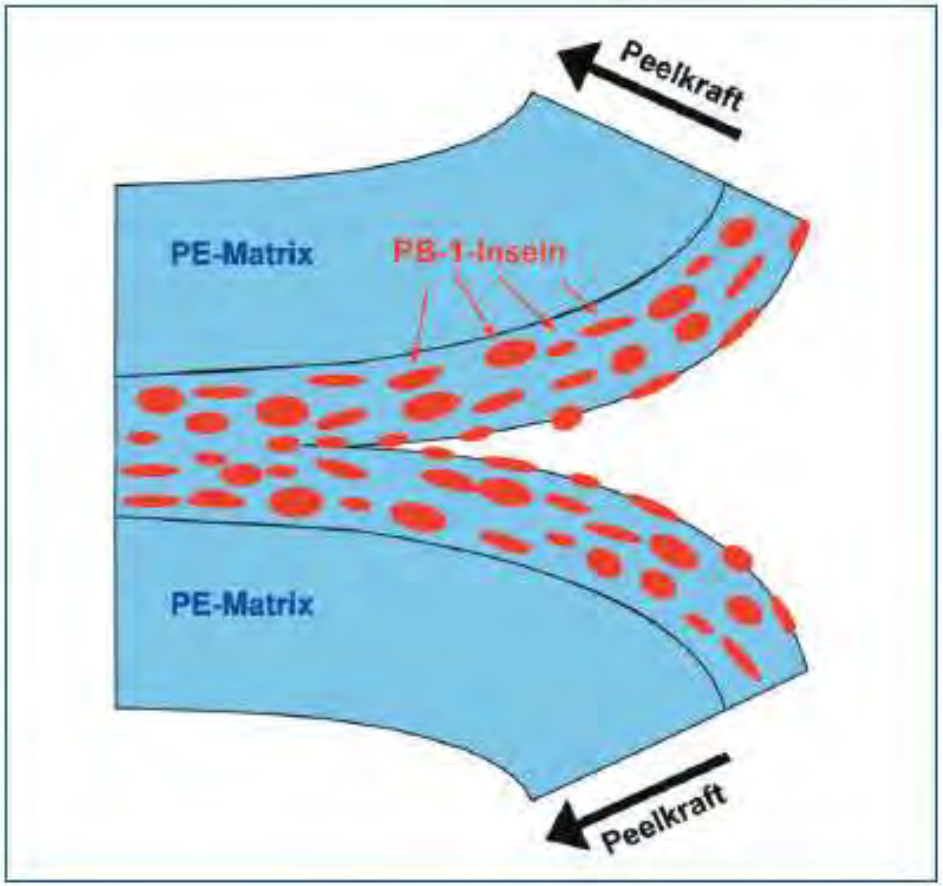
Peelverhalten von „Appeel" 20D745 zu unterschiedlichen, für Lebensmittelbehälter eingesetzten Kunststoffen. Neu: Für PET-A optimiert

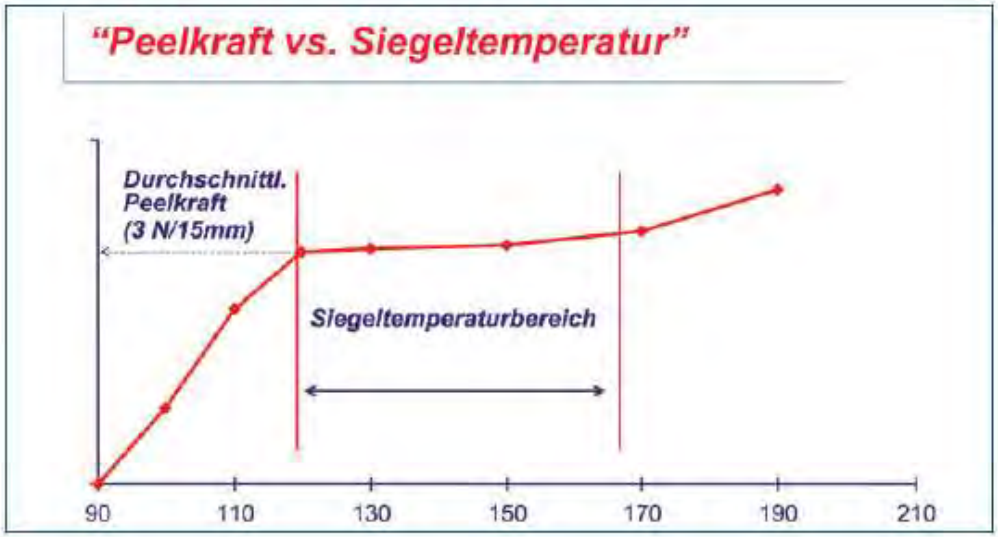
Suitable for: PVC, PS, PP, PET, HDPE

Source: Neue Verpackung 04/2002: „Vielseitige" Peel und Siegelmedien

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Opening characteristics – peel / easy peel : cohesive peel or Polybutene-Peel





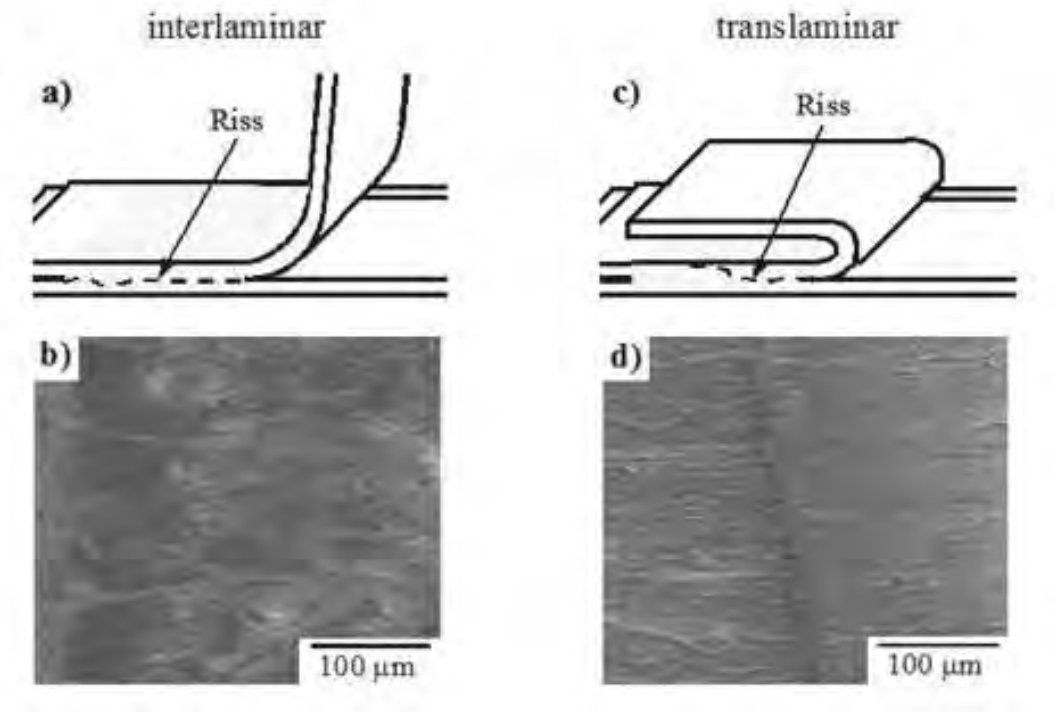
Aufreißkraft einer Peelfolie in Abhängigkeit von der Siegeltemperatur.

Aufreißmechanismus: Beim Aufreißen setzt sich der Riss nur innerhalb der Siegelnaht von PB-1-Insel zu PB-1-Insel fort. Dadurch lässt sich die Verpackung leicht und mit gleich bleibendem Kraftaufwand öffnen.

Source: H. Rist, Neue Verpackung 04/2005; Leicht und ruckfrei aufreißen

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Opening characteristics – peel / easy peel : cohesive peel or Polybutene-Peel – peel process



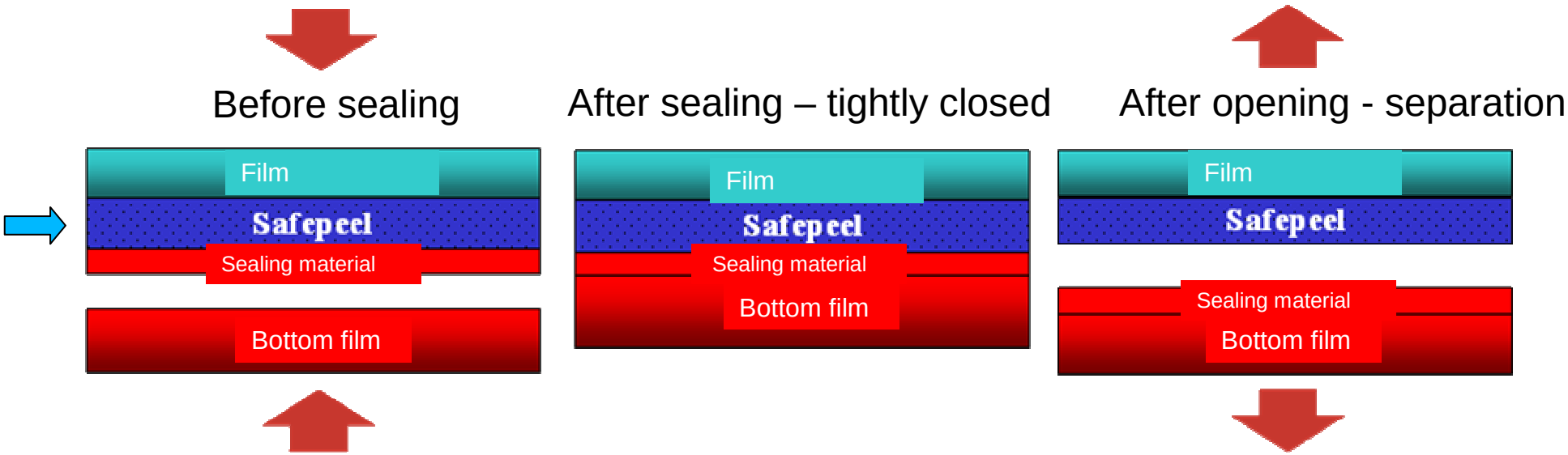
Source:
http://wiki.polymerservice-merseburg.de/index.php/Peelvorgang

Perfect!
Longitudinal disruption

Bad!
Cross disruption

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Opening characteristics - Reclose

Adhesive layer breaks easily

Quelle: http://www.multivac.de

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Tailor made barrier sealing films of BUERGO.FOL (choice) – **suitable for every application!**

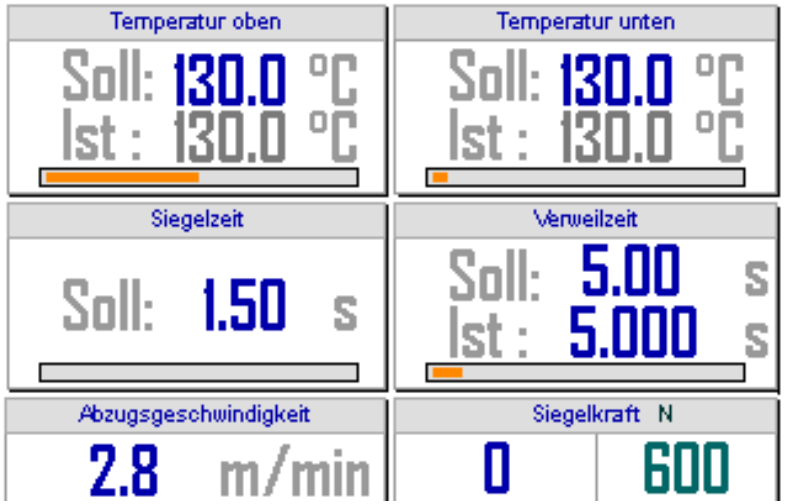
Product	Thickness µ	Property	Sealing material Specialty	Modifications
T 900	25 to 140	High Barrier	PE, PP Multipeel APET, PP, PS (mono) Safety peel, Easy peel Reclose (RC)	Laminating films transparent or coloured
KF 02 KF 03	25 to 140	High Barrier	High hot tack Flowpack	antistatic
KF 08	25 to 140	High Barrier	Safety peel	UV-Blocker
T 678	40 to 150	High Barrier	Tight sealing, APET; RC	antifog
T 713	35 to 100	High Barrier	PP homo, random, Copo	combinations

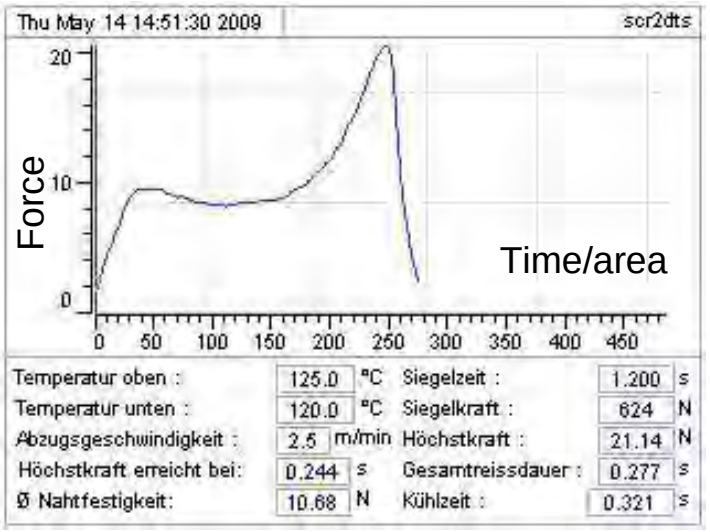
BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Measurement of Seal strength – sealing curves

KOPP Labormaster 3000

kopp
Verpackungssysteme



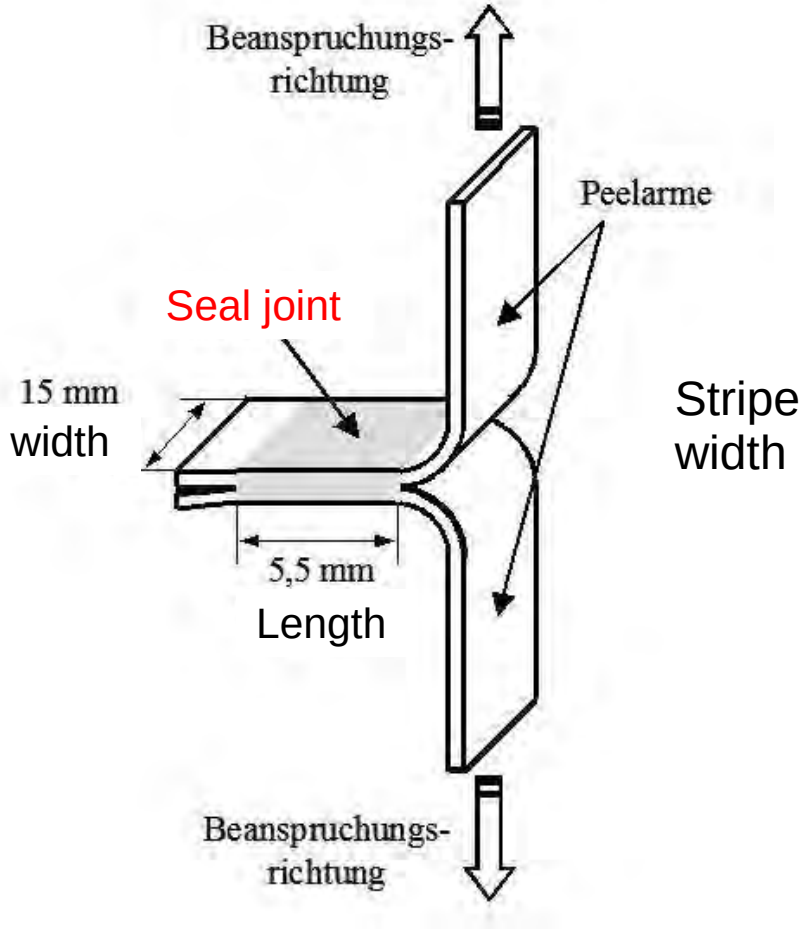


BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Measurement of Seal strength – sealing curves

Test according to DIN 55529

Quelle: www.easy-opening.info



Stripe with
width 15 mm

Source: http://wiki.polymerservice-merseburg.de

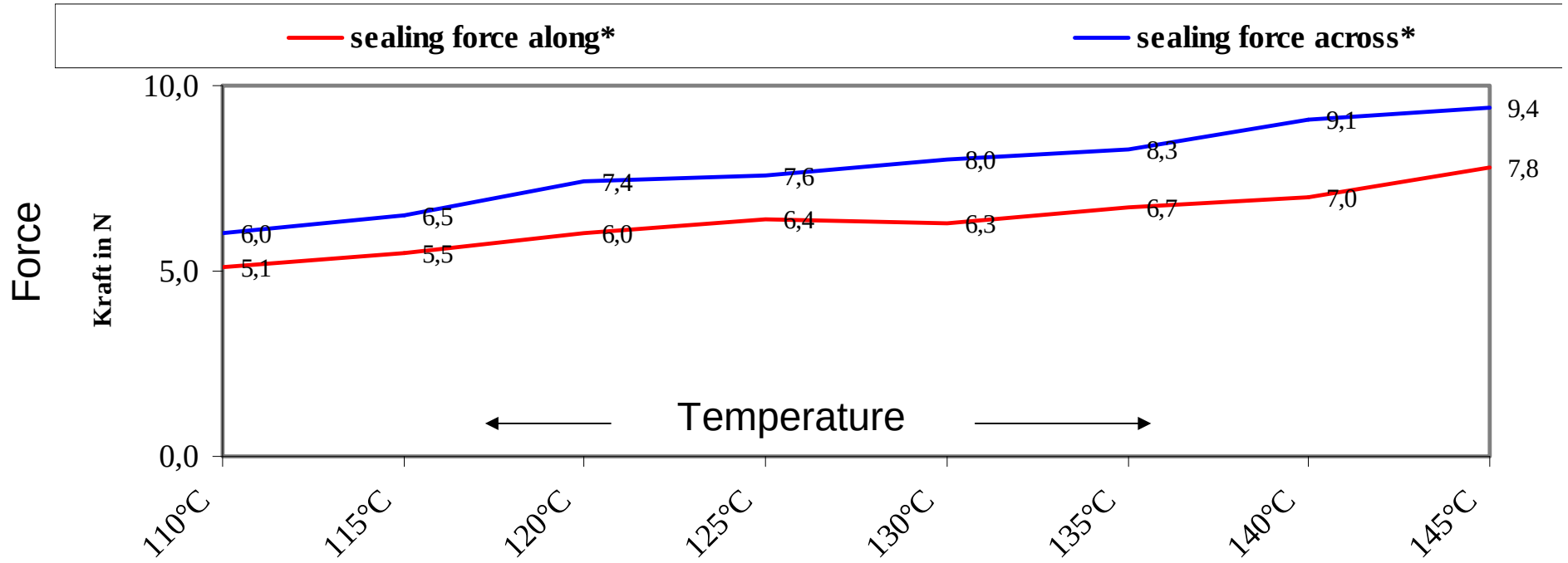
BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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



BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

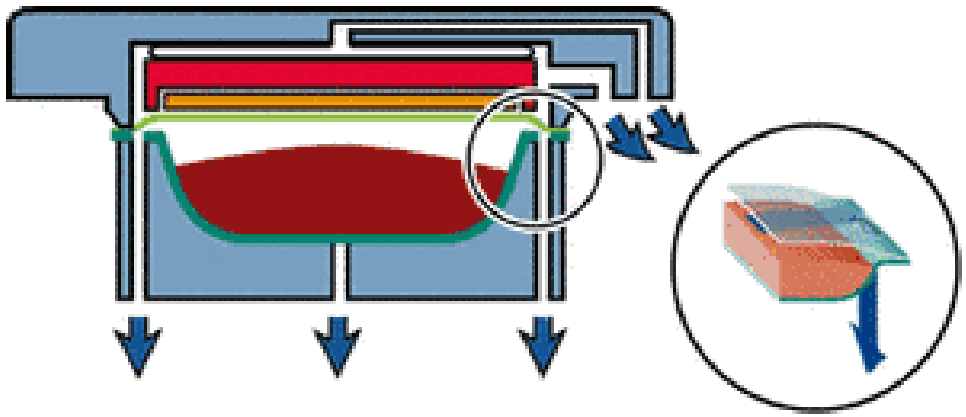
BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Film:

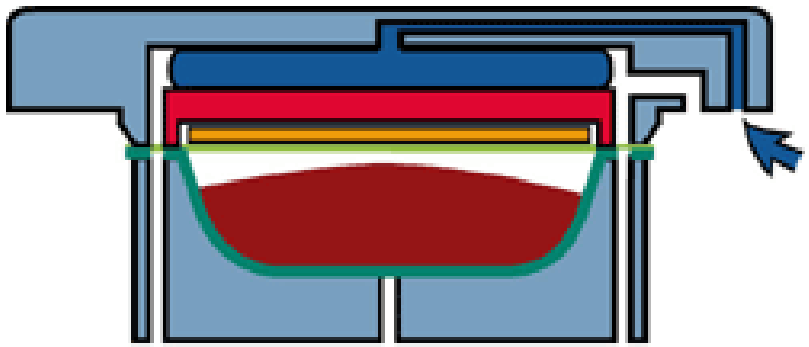
Packing and Sealing on a Flow Pack Machine (PFM Shamal)

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Contaminated sealing areas – poor sealing

Very disadvantageous for sealing are:

- **Corona Treatment** (Raise of glass transition point Tg and melting point Tm, Oxydation!)

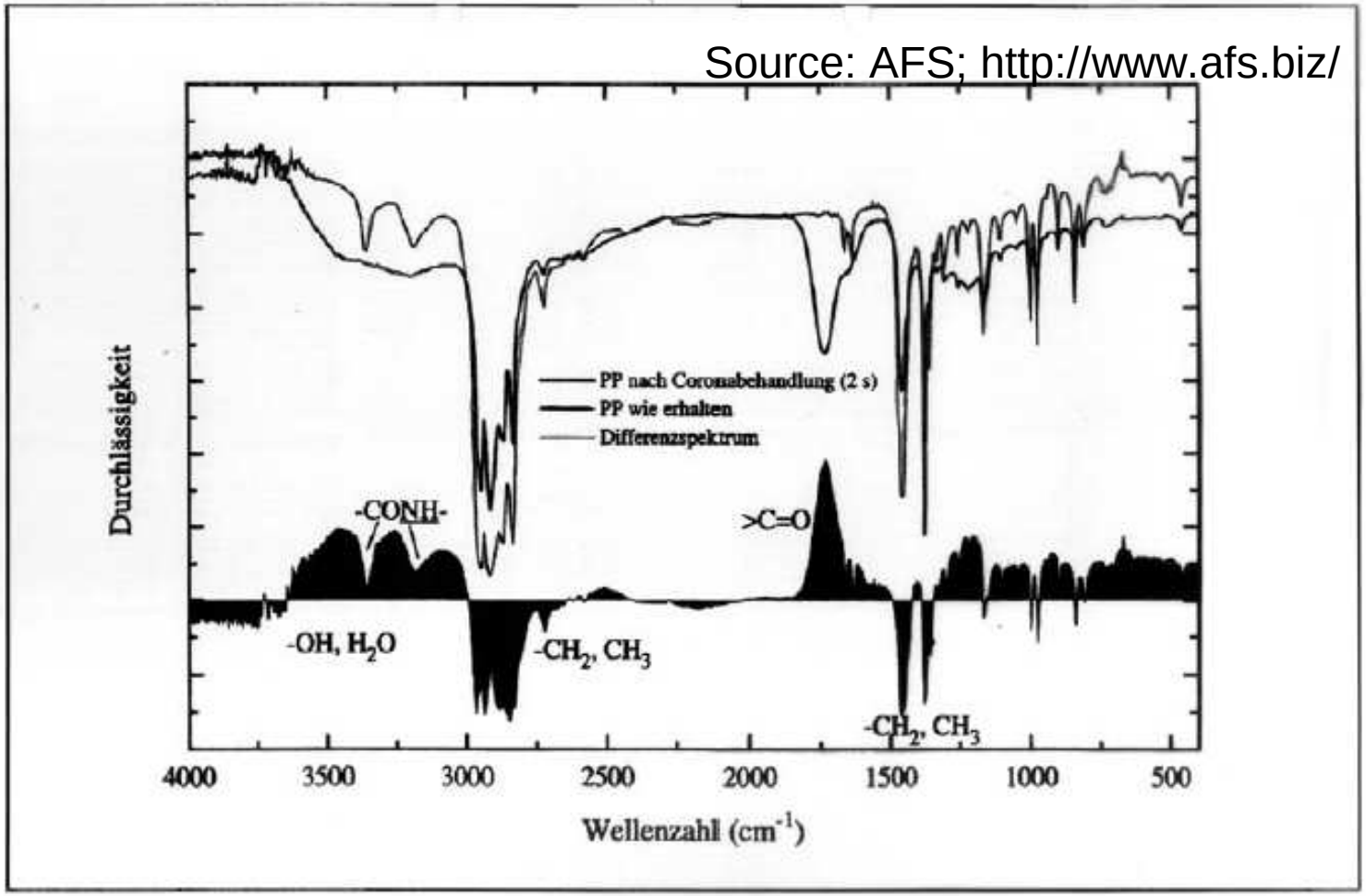
- **Migration**, of adhesives and additives, from the film
  - Sealability can be given by „washing off“ the film surface

- **Contamination** of the sealing areas with contaminants from packed product
  - Fat and oil from packed product → Release agents!
  - Fine powders (flour, sugar powder) → are embedded!
  - Coarse grained products (sugar, salt, cerealia) → damage the film!

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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

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



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

After Corona treatment, a chemically different material results!!

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

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**!

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Sealing on contaminated areas

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

QUESTIONNAIRE

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

Customer requirement questionnaire is DIN-EN-ISO-9001, BRC-IoP and HACCP-certified. Appendix: A1/01_VA_7.2.0_02/01.
Questionnaire created by QM on 01.03.2012.

CUSTOMER INFORMATION

Customer: _____

Person responsible: _____ Date: _____

FILM DESCRIPTION / TECHNICAL REQUIREMENTS

Material, Composite, System: _____

Nominal thickness: _____
(Tolerances)

Layer structure: _____

Mechanical requirements: _____
(e.g. tear coefficients, friction coefficients, elongation at break, shrinkage, etc.)

Sealing properties: _____
(Substrate, sealing parameters, tight seal, peel, sealing window, etc.)

BUERGO.FOL
OUR QUALITY – YOUR SUCCESS

CONTACT

BUERGOFOL GmbH

Jahnstraße 10-14
93354 Siegenburg
Germany

Fon +49 (0) 94 44 / 97 91-110
Fax +49 (0) 94 44 / 97 91-55

kurt.stark@buergofol.de

contact@buergofol.de
www.buergofol.de