Lamination Process of PVB Film

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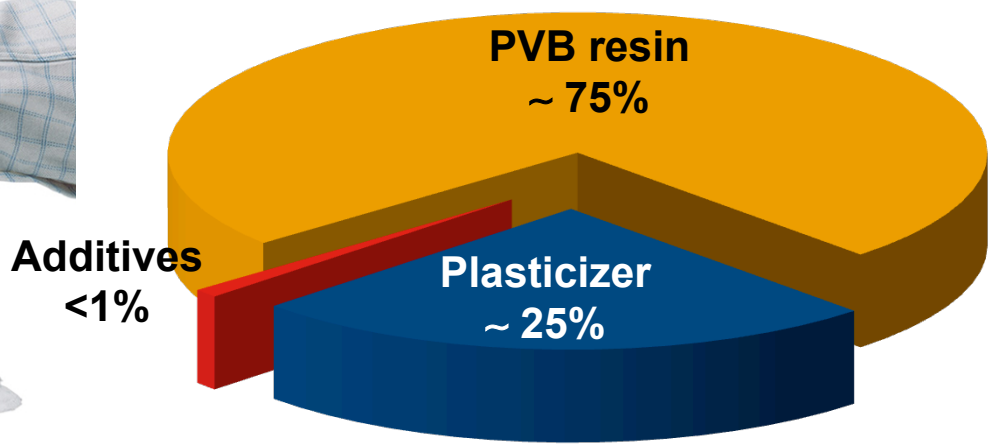
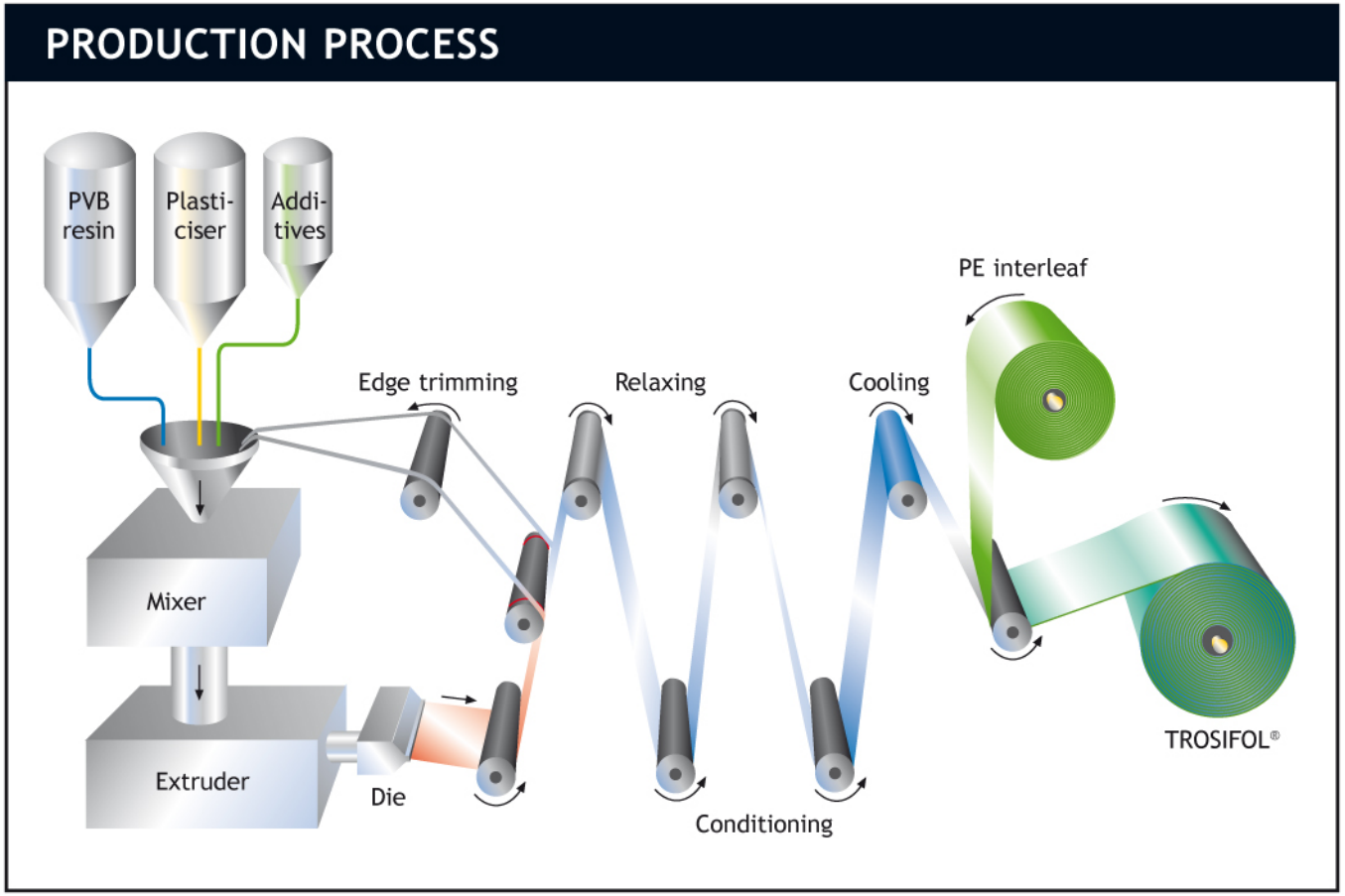
Chemical Composition of PVB Film

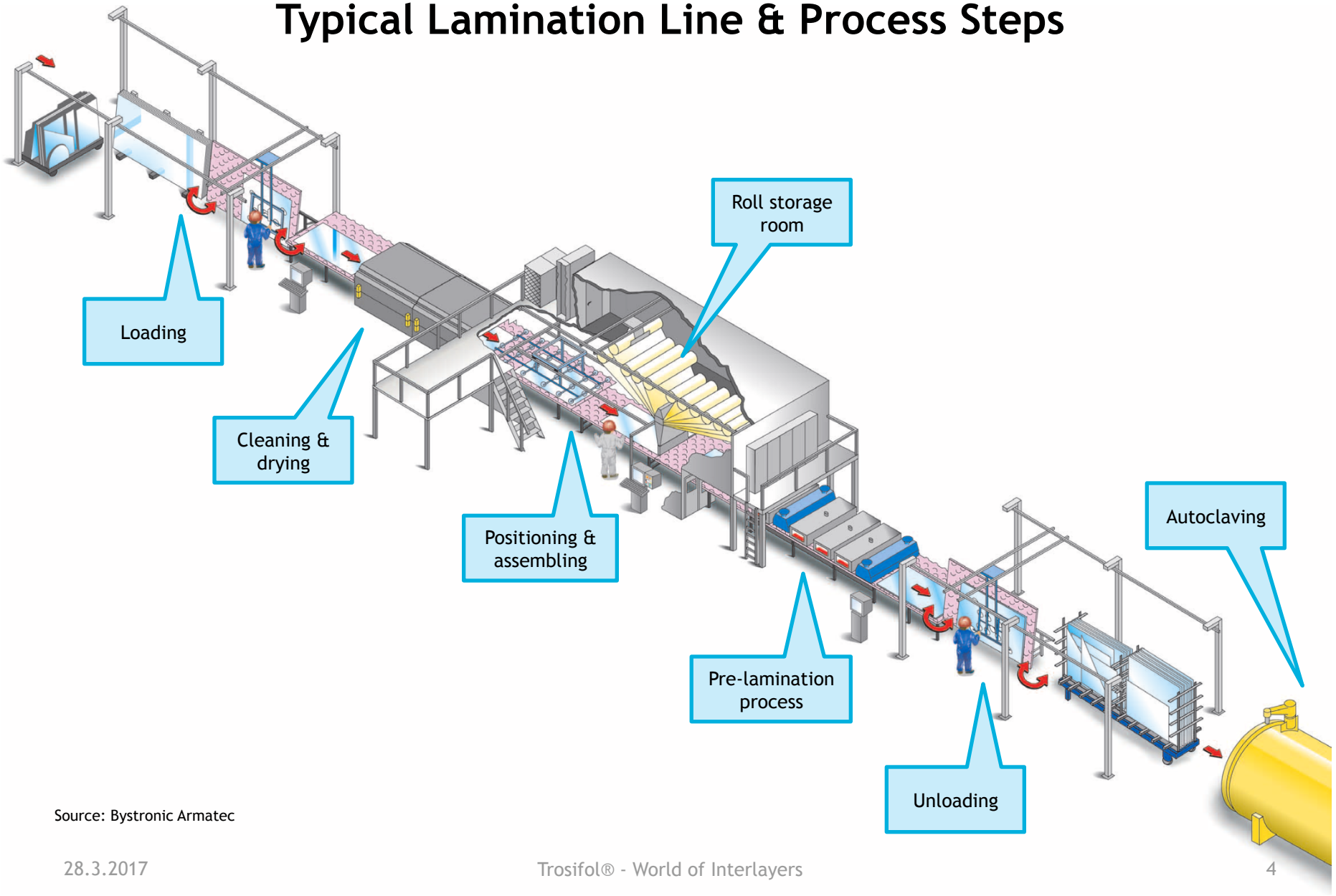
- Production of PVB film starts with the melting of PVB resin, plasticizer and additives in an extruder, where all the components are thoroughly mixed and plasticized.
- An accurate homogenization is very important in this context because inhomogeneity can have a negative influence on the mechanical and optical properties of the product



PVB Production Process



Typical Lamination Line & Process Steps



Source: Bystronic Armatec

PVB Roll Storage

- Why special storage conditions:
  - TROSIFOL is an adhesive
  - TROSIFOL is hydroscopic
  - TROSIFOL is a thermoplast

- Risk:
  - Blocking (= sticking of refrigerated PVB layers)
  - Moisture increase (= adhesion decrease, potential delamination and bubble formation)
  - Moisture decrease(= adhesion increase, ball drop test failure)

- Recommendations:
  - Open the original packaging in the air-conditioned unwinding area just before the usage
  - Check the integrity of the original moisture proof bag before the usage of the roll

PVB Roll Storage

- Kuraray recommendations for storage conditions of PVB rolls:


Source: Bystronic Armatec

Refrigerated rolls

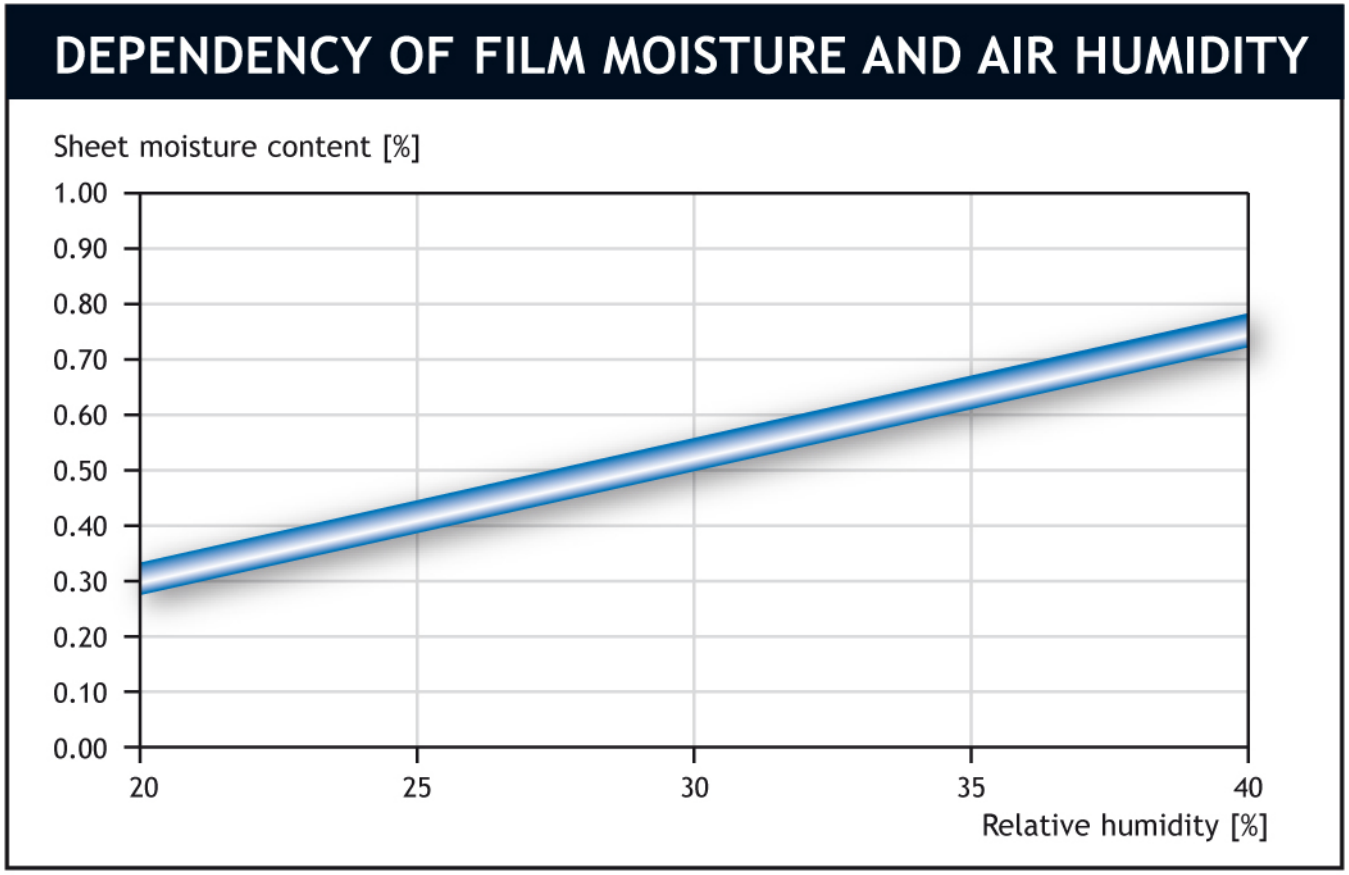
- originally sealed:
  ≤ 8°C
- opened:
  ≤ 8°C & 25 – 30% rel. humidity

Rolls with PE interleaving film

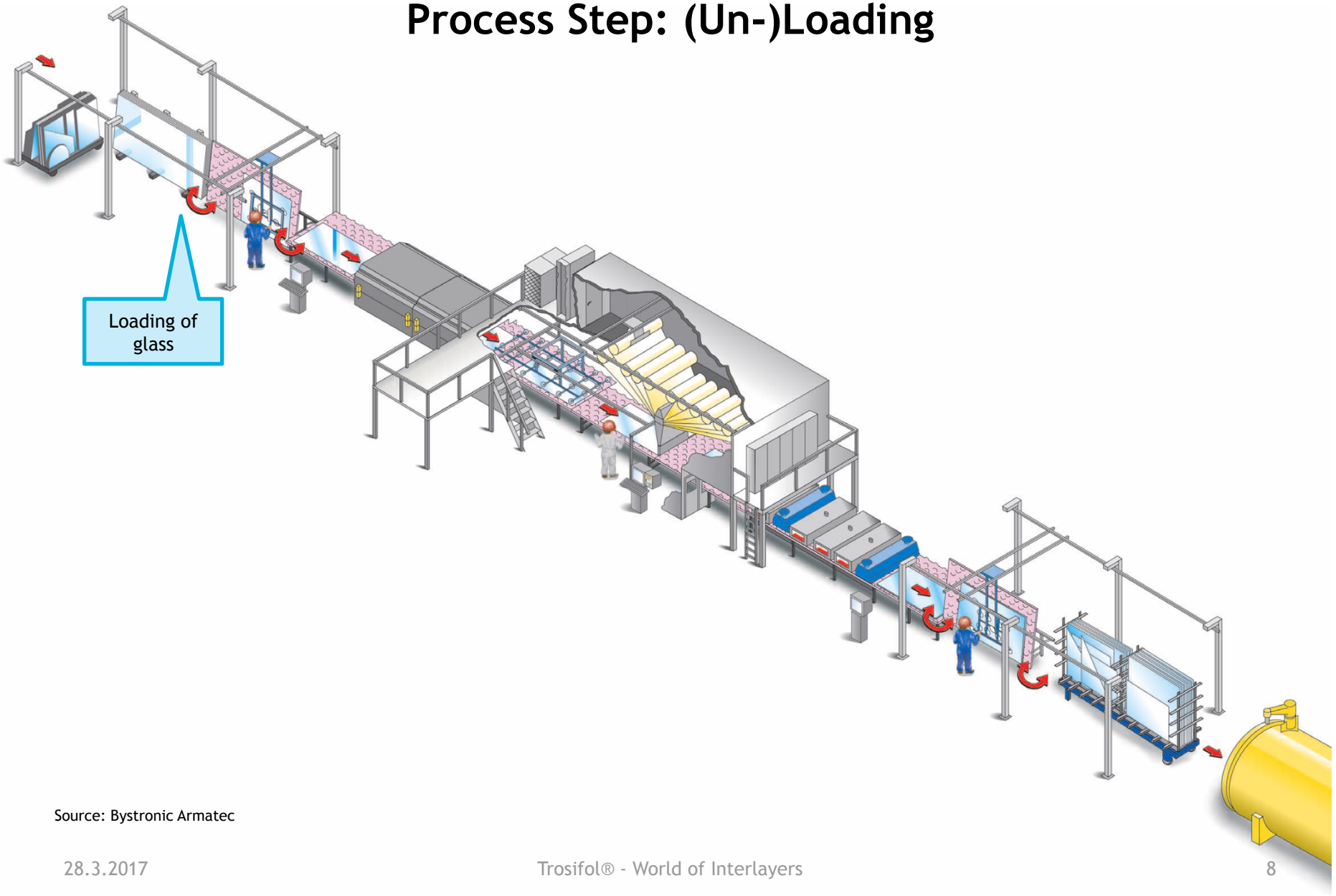
- originally sealed:
  ≤ 30°C for long-term storage
- opened:
  ≤ 18°C & 25 – 30% rel. humidity

Shelf life for both types refrigerated and PE interleaved: 3 to 4 years

PVB Roll Storage



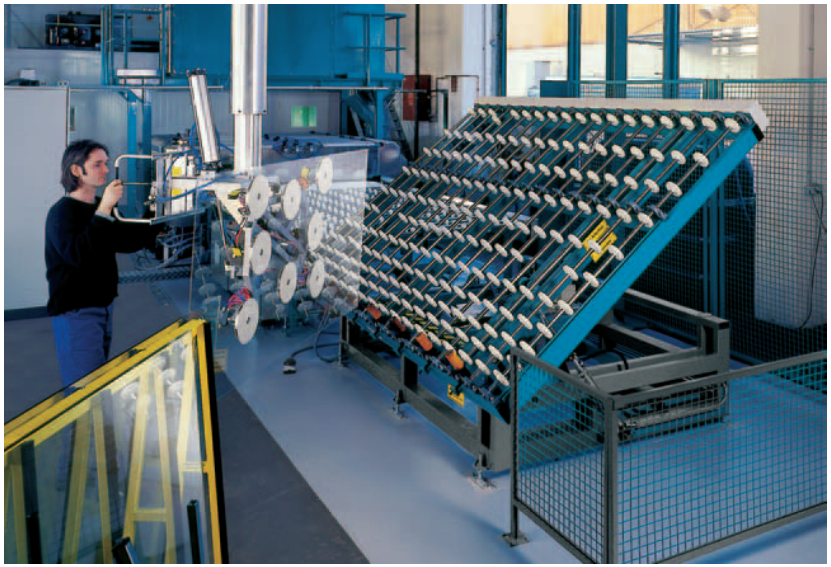
Process Step: (Un-)Loading



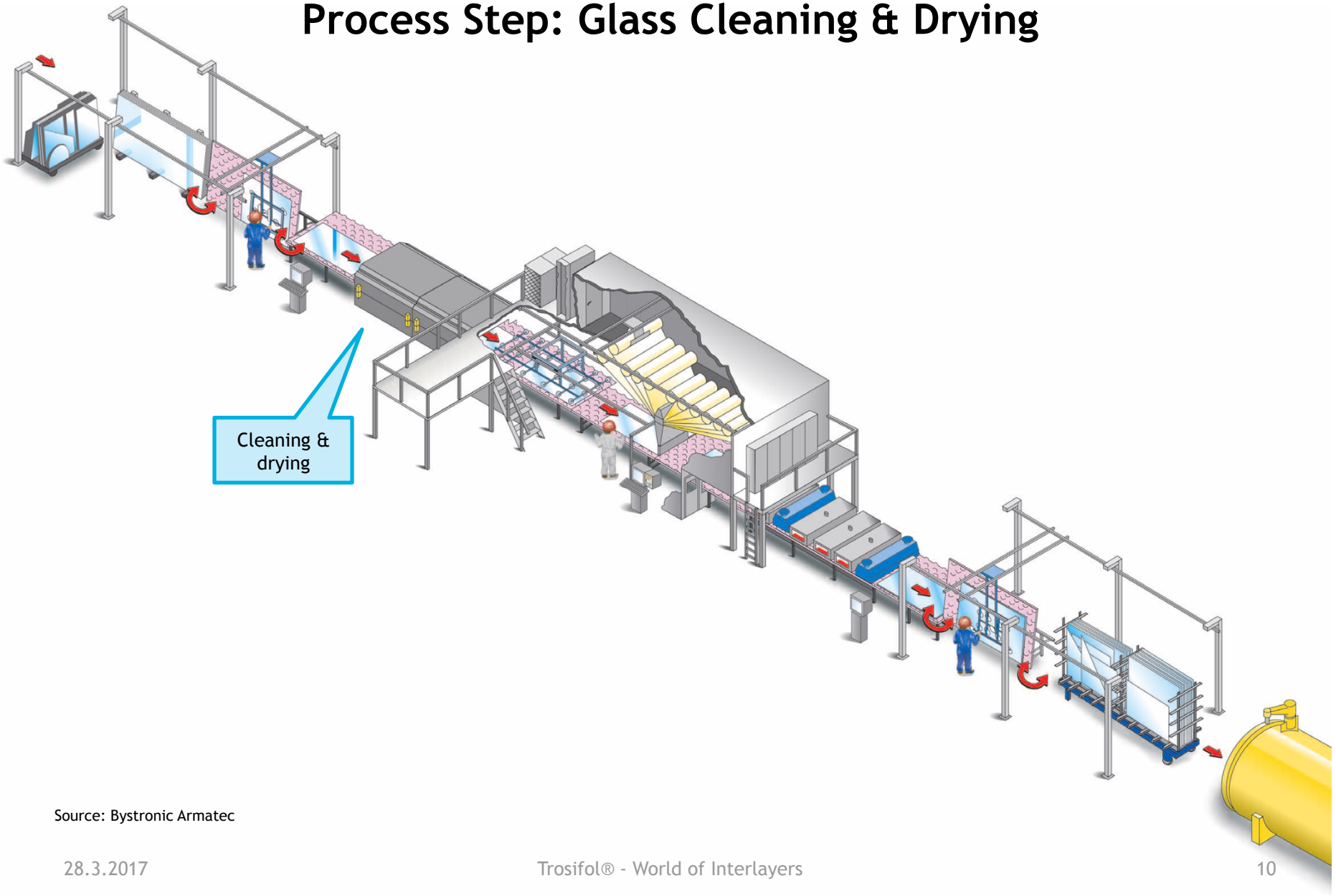
Source: Bystronic Armatec

Process Step: Loading & Unloading

- Gantry stackers with suction cups are used for loading /unloading of the glass and prepressed laminates.
- Automatic stackers for jumbo sizes or manual stackers for smaller sizes are used.



Process Step: Glass Cleaning & Drying



Source: Bystronic Armatec

Glass Cleaning and Drying

- Why:
  - Eliminate grease, dust and cutting oil on the glass surface
  - Achieve the specified adhesion level for each product

- Risk:
  - Contamination
  - Adhesion variability
    - → delamination
    - → bubbles
  - Remaining water drops on glass surface

Source: Bystronic Armatec

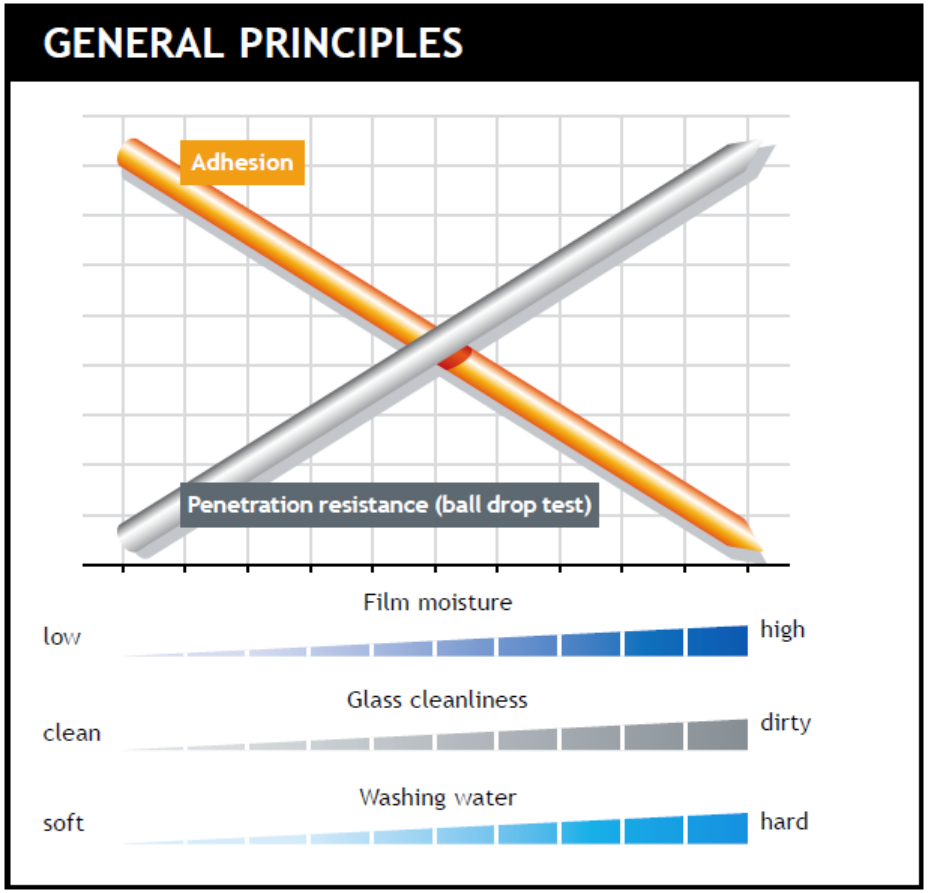
Glass Cleaning and Drying

- Kuraray recommendations:
  - Washing demineralized water conductivity in the last washing step ≤ 15 µS (architectural glass) and ≤ 5 µS (windscreens) to get perfect adhesion between PVB and glass surface.
  - Temperature of the water in the first washing step at least 45°C.
  - Regular check of the drier efficiency.

- Typical adjustments at the washing machine:
  - Distance of the washing brushes
  - Type of washing brushes
  - Water temperature
  - Water conductivity at water treatment unit
  - If applicable, detergent

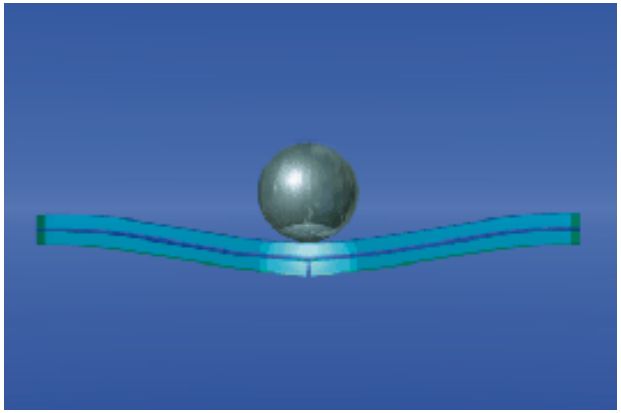
Adhesion to Glass

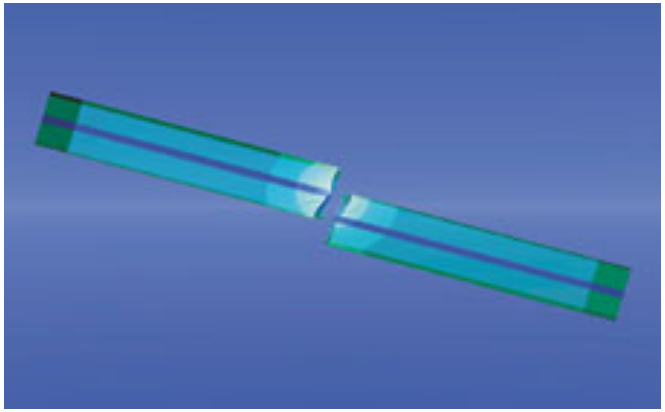
- Relation between adhesion and penetration resistance



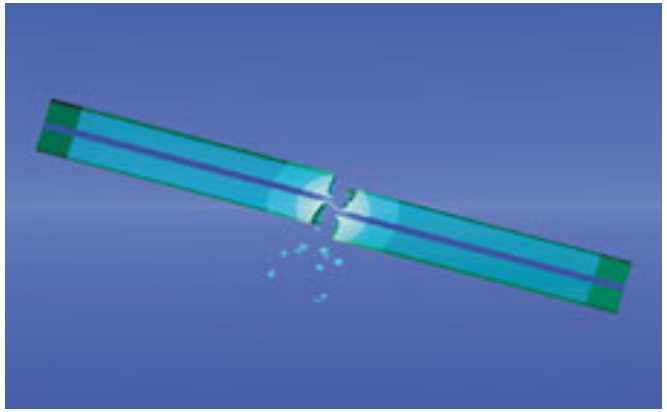
Adhesion to Glass

- Adhesion and its impact on the penetration resistance



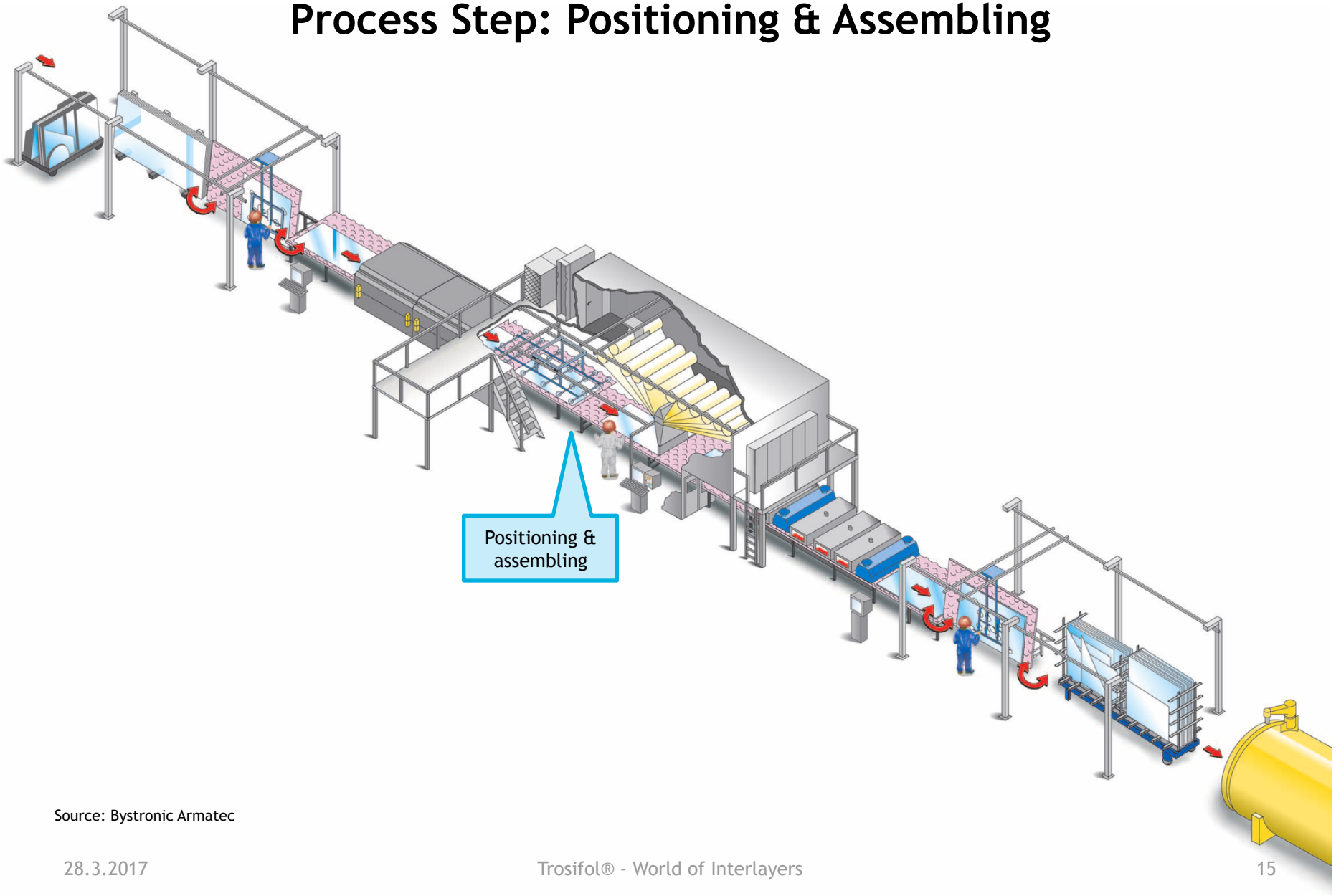


High adhesion



Medium adhesion

Process Step: Positioning & Assembling

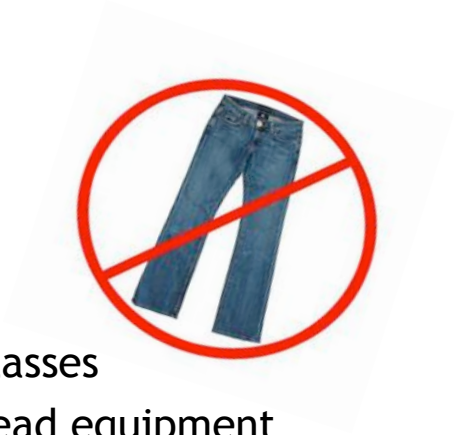


Source: Bystronic Armatec

Assembly Room

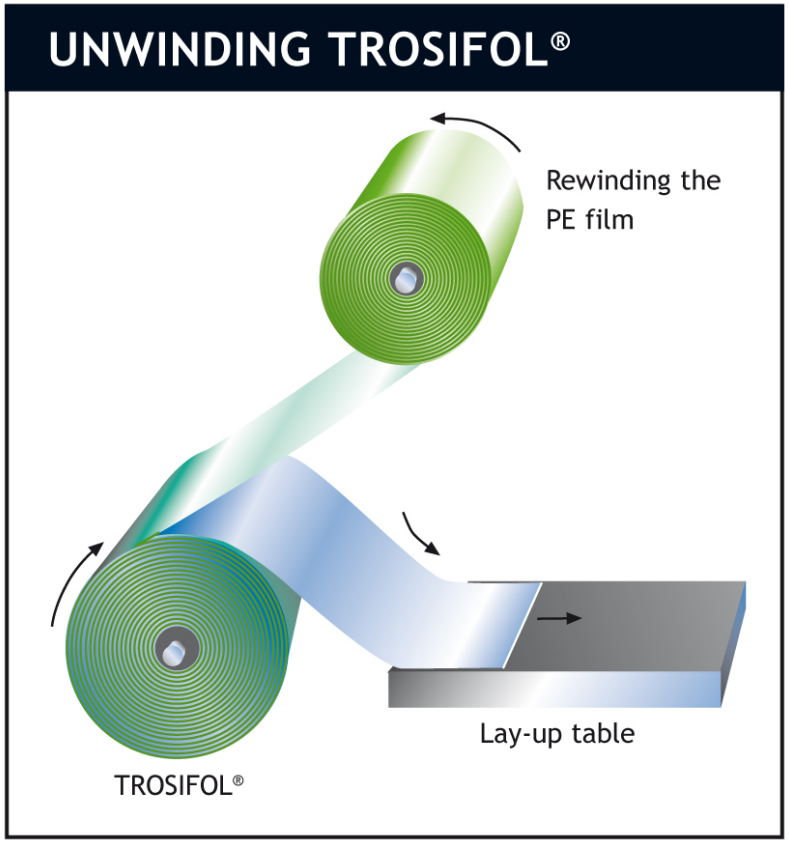
- Risk:
  - Contamination from hair, clothing lint, dust and other foreign
  - Low adhesion due to too high air humidity

- Kuraray recommendations:
  - Correct humidity (25-30% rh) plus cleanliness
  - Air temperature approx. 18 to 20°C
  - Lint free clothes, gloves and hair nets
  - Room over pressurized to force dirt to stay outside
  - Double door entrance and limited access
  - Antistatic doormats
  - Assembly room well illuminated – also below the glasses
  - Routine cleaning of floor, conveyor rolls and overhead equipment
  - Do not use solvents for cleaning



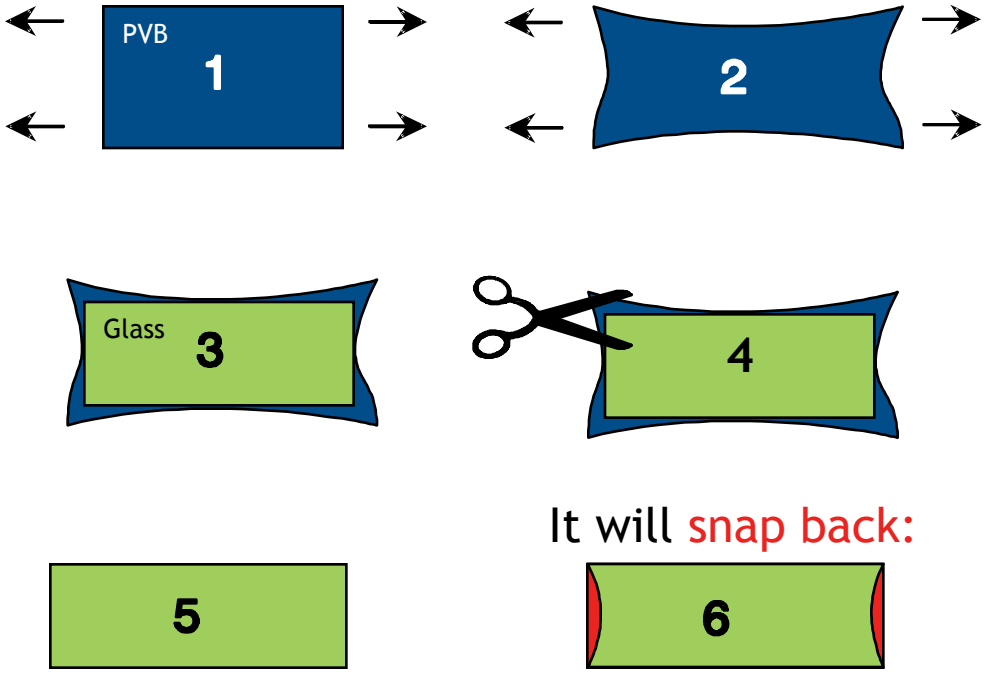
Assembly Room

- TROSIFOL with PE interleaving film



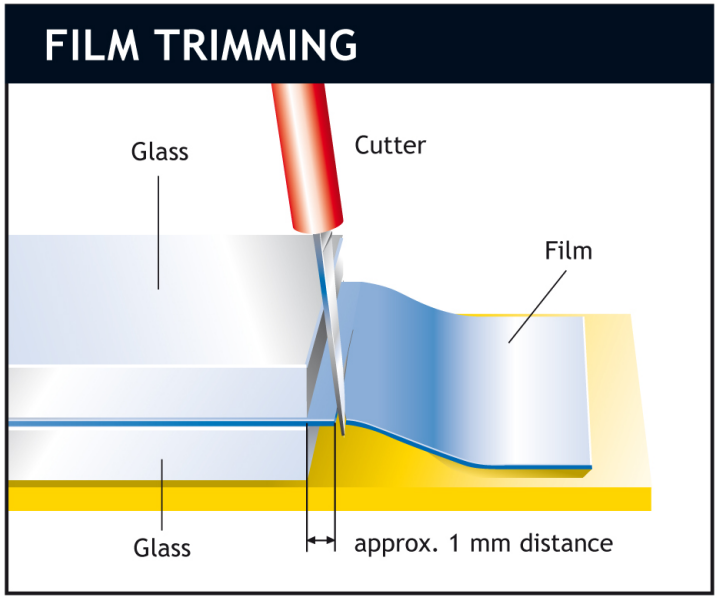
Assembly Room

- Do not pull TROSIFOL too much when unrolling !
- Do not pull out TROSIFOL while cutting !

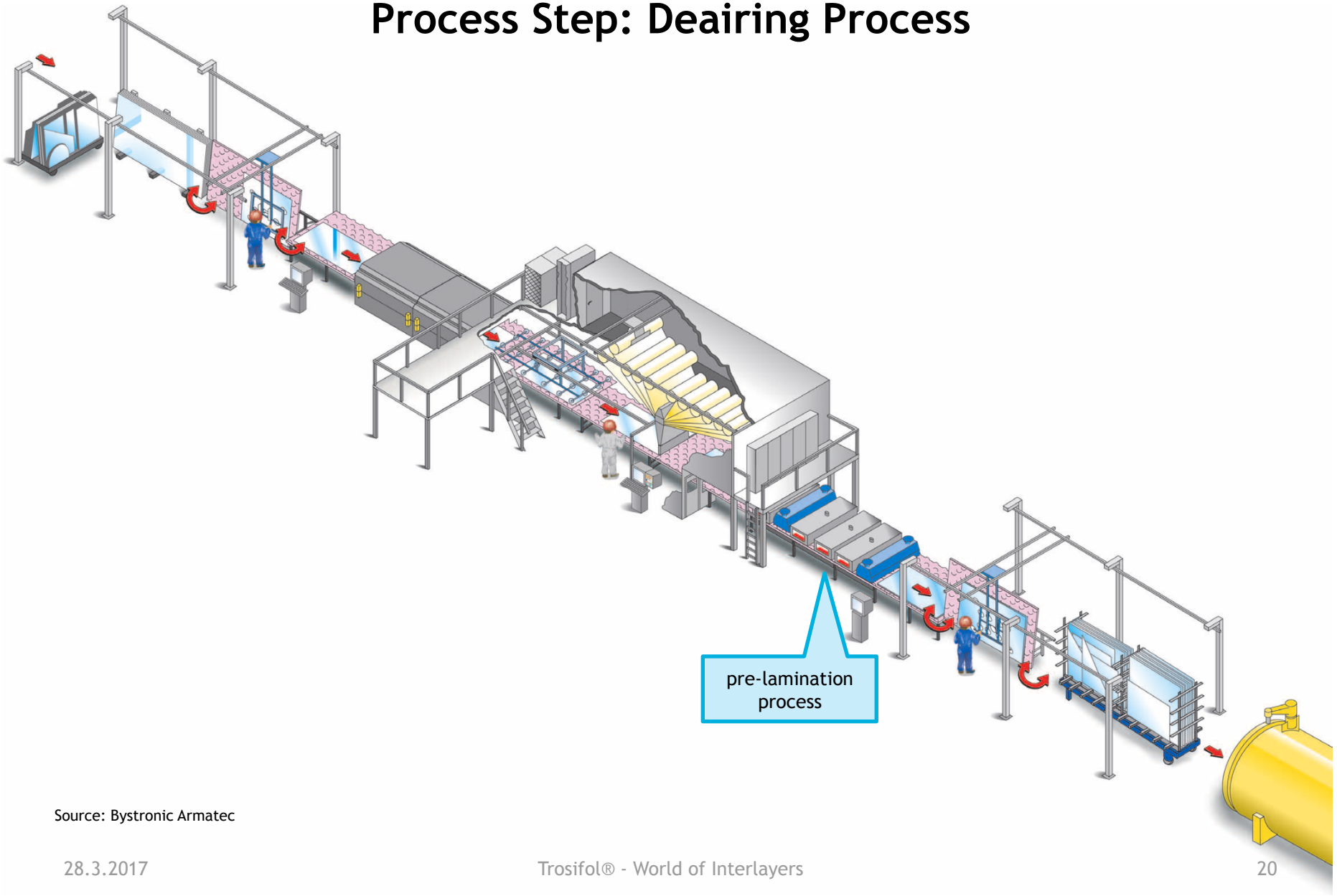


Assembly Room

- Placing of the PVB on the glass – ideally with an overlap about 1 cm on all sides.
- Automatic or manual trimming with sharp blade under the little angle – approx. 1 to 2 mm against the glass edge.



Process Step: Deairing Process



Source: Bystronic Armatec

Deairing Process

- Why:
  - Get max. air out of PVB/glass sandwich
  - Tacking the glass to the interlayer to avoid separation prior to
  - Sealing the edges to avoid air penetration during autoclaving

- Risk:
  - Bubbles
  - Delamination
  - Bad thermal stability

- Methods:
  - Nip rollers – Arch / Auto
  - Vacuum rings - Auto
  - Vacuum bags – Arch / Auto

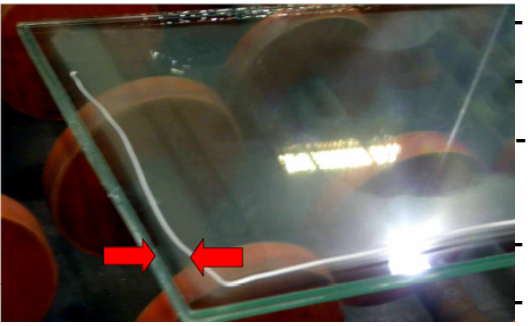
Source: Forel

Nip Roller De-airing Process – Arch.

- Recommendations:

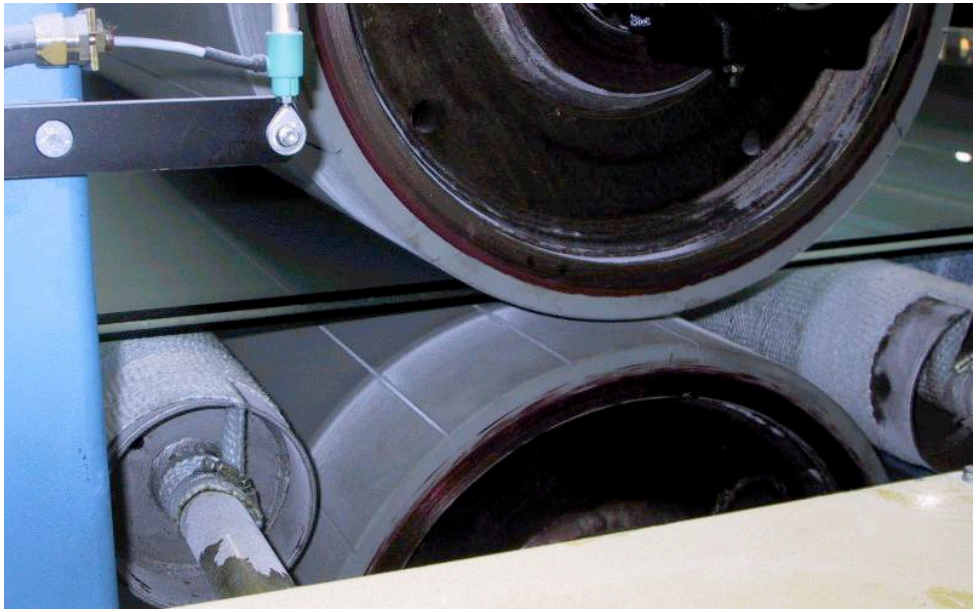
1th niproller:
- Mainly deairing,
- Glass surface temperature 25 – 37 °C,
- Uniform translucent appearance without any air pockets and without edge sealing,
- Roller gap: 1mm less than total laminate thickness, multilaminates or ESG laminates may need smaller gap,
- Pressure 3 - 6 bar (other pressure units also common e.g. kN/m).

2nd niproller:
- Mainly edge sealing,
- Glass temperature 55 – 70°C,
- Slightly translucent appearance in the center,
- Few cm clear strip around the edges – indication of good edge sealing,
- No remaining air pockets,
- Roller gap: 2 to 3 mm less than total laminate thickness,
- Pressure: 4 – 7 bar (other pressure units also common e.g. kN/m



Adjustment of the Nip Roller Line

- Typicall adjustments of the nip roller line:
  - Line speed
  - Number and type of the heaters
  - Power of the heaters
  - Oven temperature
  - Gap between rollers
  - Nip roller pressure
  - Number of the ventilators



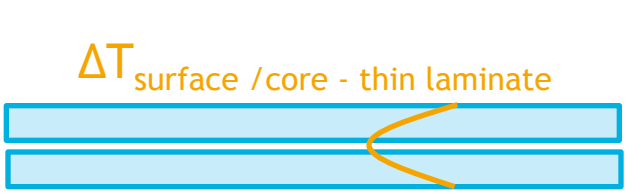
Source: Bottero

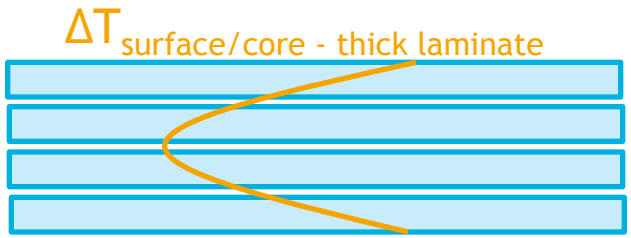
Nip roller line process – typical issues

- Laminate too hot:
  - Premature edge sealing & air pockets especially at the end of the laminates
  - Bubbles or „burned“ edges

- Laminate too cold:
  - No or only partial melting of the PVB causes too much air in the laminates
  - no edge sealing

- Glass surface temperature can mislead especially in combination with thick multipe laminates

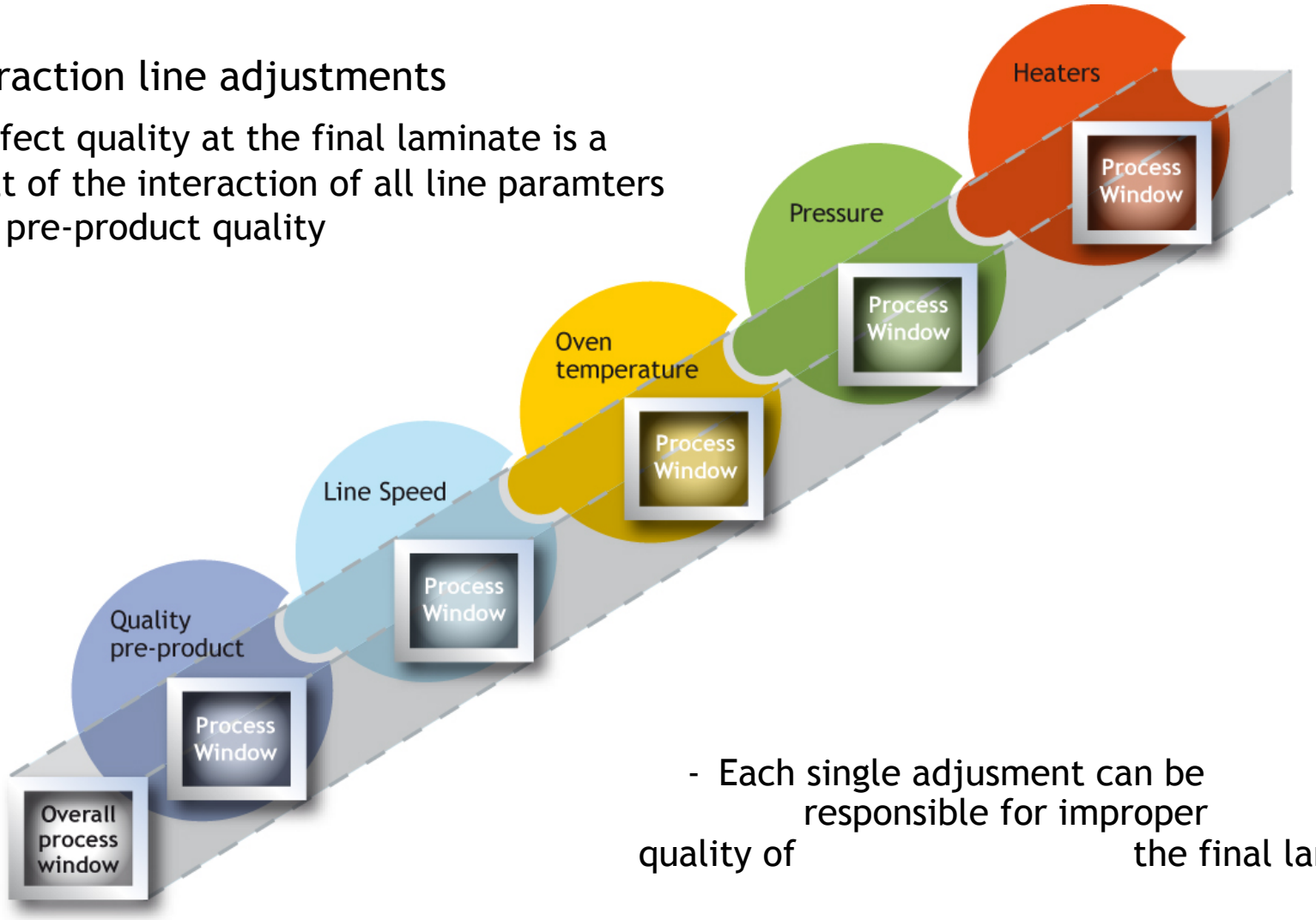




Deairing Process – Nip Roller

- Interaction line adjustments

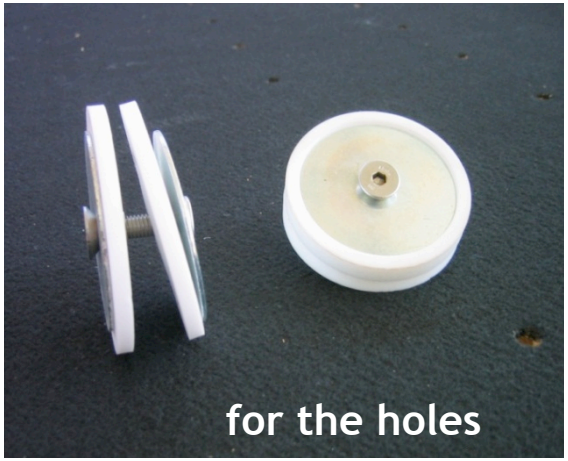
  - Perfect quality at the final laminate is a result of the interaction of all line paramters incl. pre-product quality



- Each single adjusment can be responsible for improper quality of the final laminate

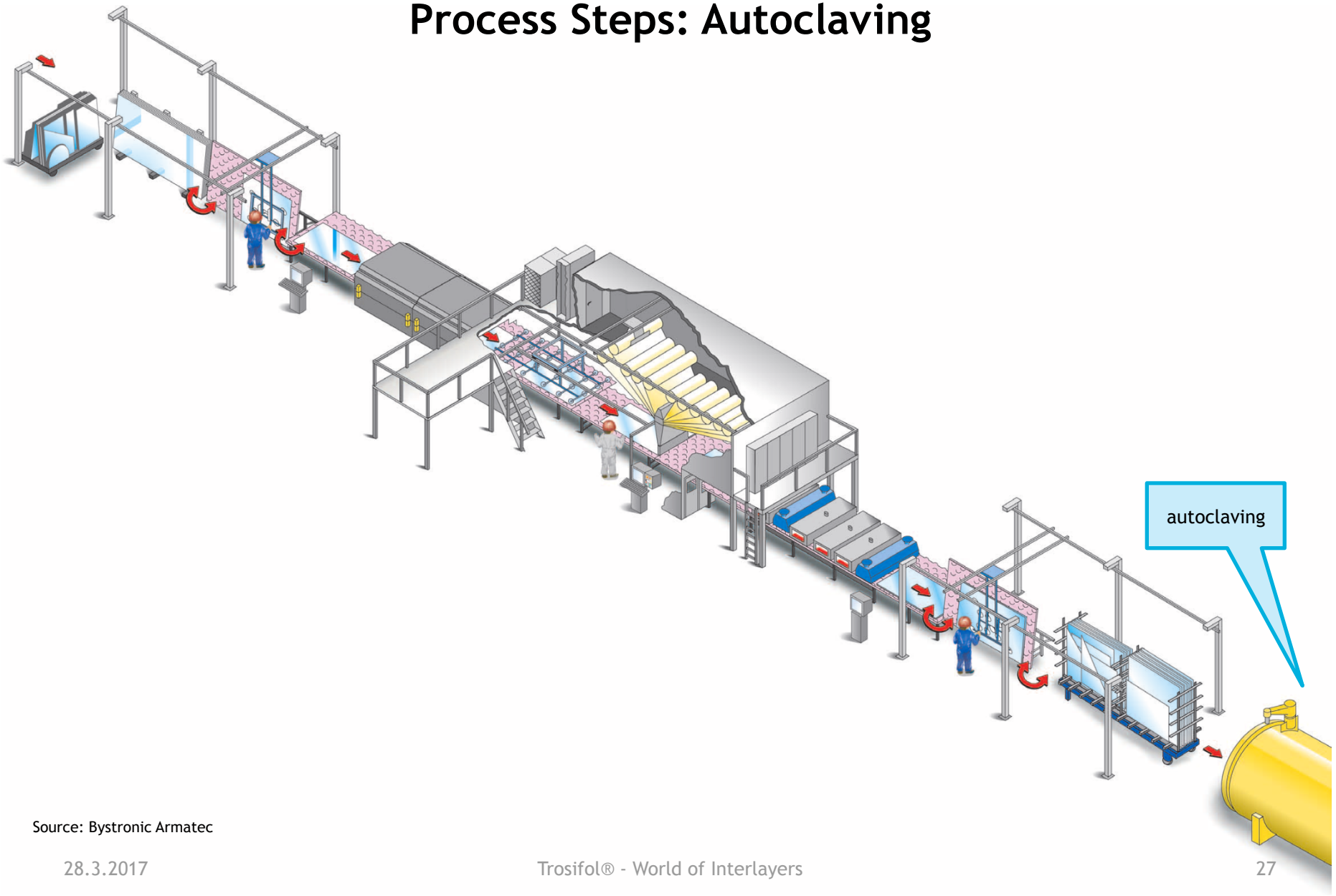
Deairing Process – Nip Roller

- **Lamination of tempered glasses**



- Clips and clamps are sometimes used but not recommended
- „Success“ might be a short-term effect
- Recommended flatness of tempered glass ≤ 0,15mm/300mm (local bow)
- PVB is able to absorb the glass flatness imperfection of max. 10% of PVB thickness

Process Steps: Autoclaving



Source: Bystronic Armatec

Autoclaving

- Why:

  - To dissolve the remaining air left from the deairing step under heat and pressure,

  - Allow for viscous flow of the interlayer resulting in intimate contact, between the interlayer and the glass

  - To achieve the desired adhesion level between glass and interlayer.

- Risk:

  - Poor optical quality

  - Not sufficient performance properties

  - Limited durability

  - Glass breakage

Autoclaving

- Recommendations:
  - Loading for the autoclaving should take place as soon as possible after
  - Not more than 145°C max. temperature,
  - Adjustment of the 3 stages of the autoclave cycle,

heat-up: Time to get temperature and pressure to the recommended level,

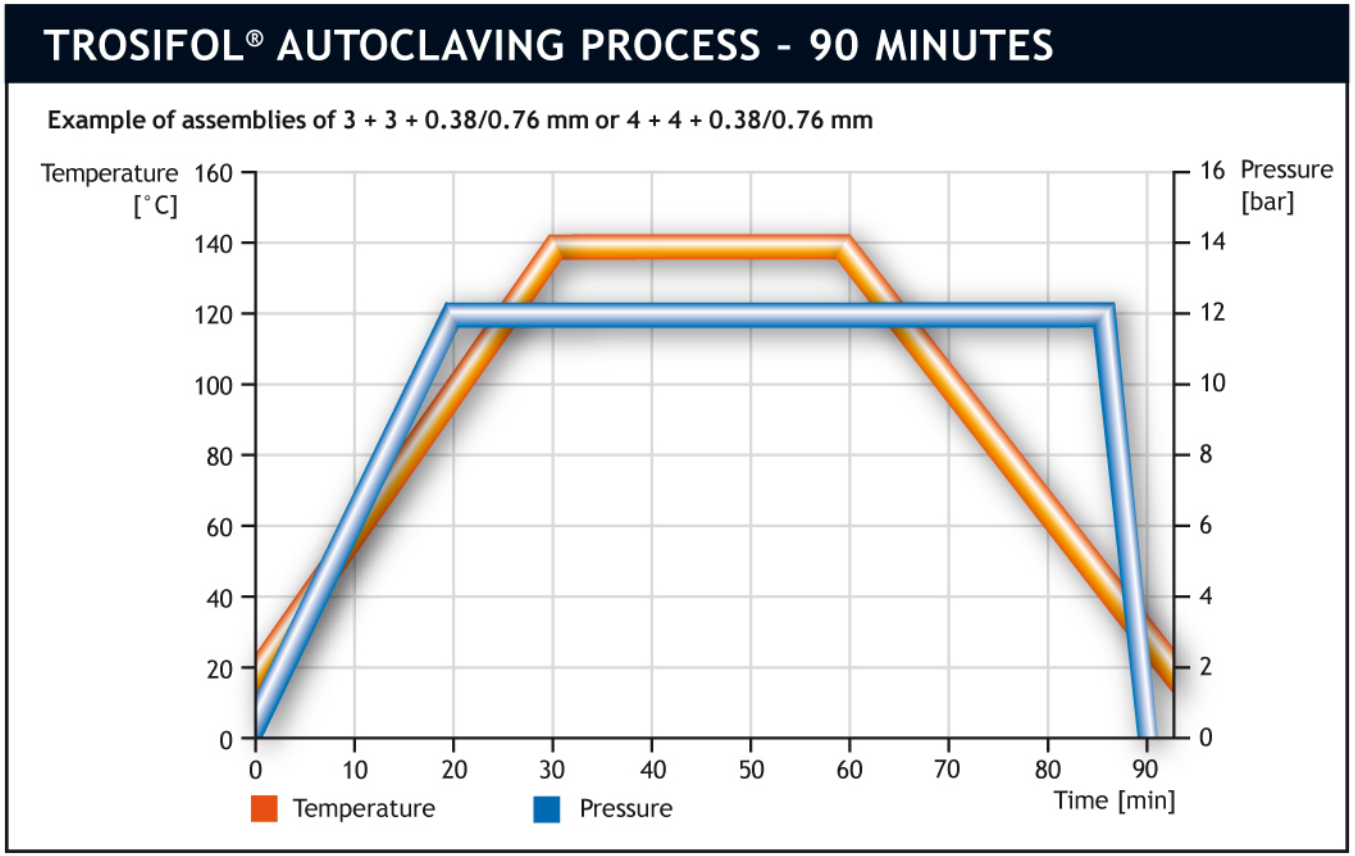
holding time: Once the pressure and temperature reached the recommended level, the conditions need to be maintained for sufficient time to obtain the viscou

cooling: During this step, temperature and pressure are reduced to the initial level. Pressure release not before 50°C glass (!) temperature is reached. Risk of tiny edge bubbles, cracks or bending of the glasses,

  - Total time depends on the equipment, amount of glass, thickness of laminates and packing,
  - To prevent the accumulation of plasticizer within the autoclave/internal insulation/glass spacers – regular use of a cleaning cycle is needed.

Autoclaving

- Recommendations for autoclave cycles:



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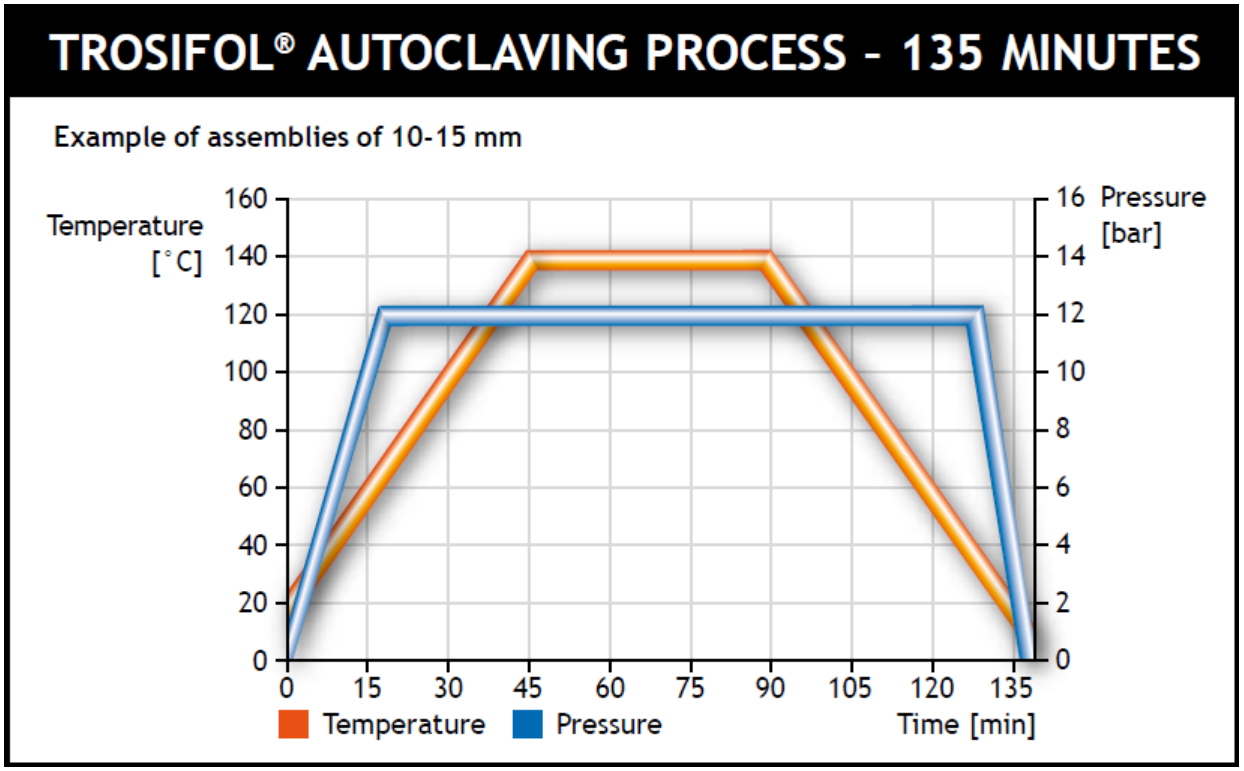

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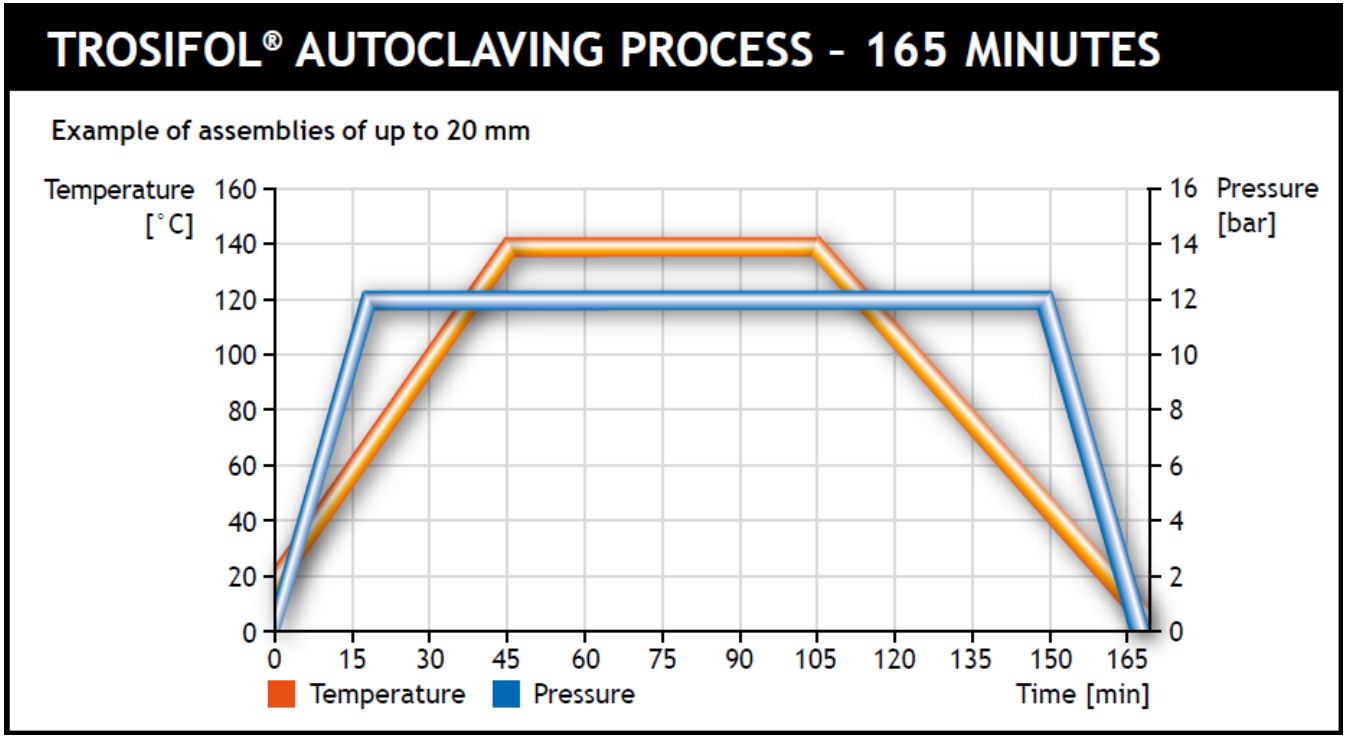

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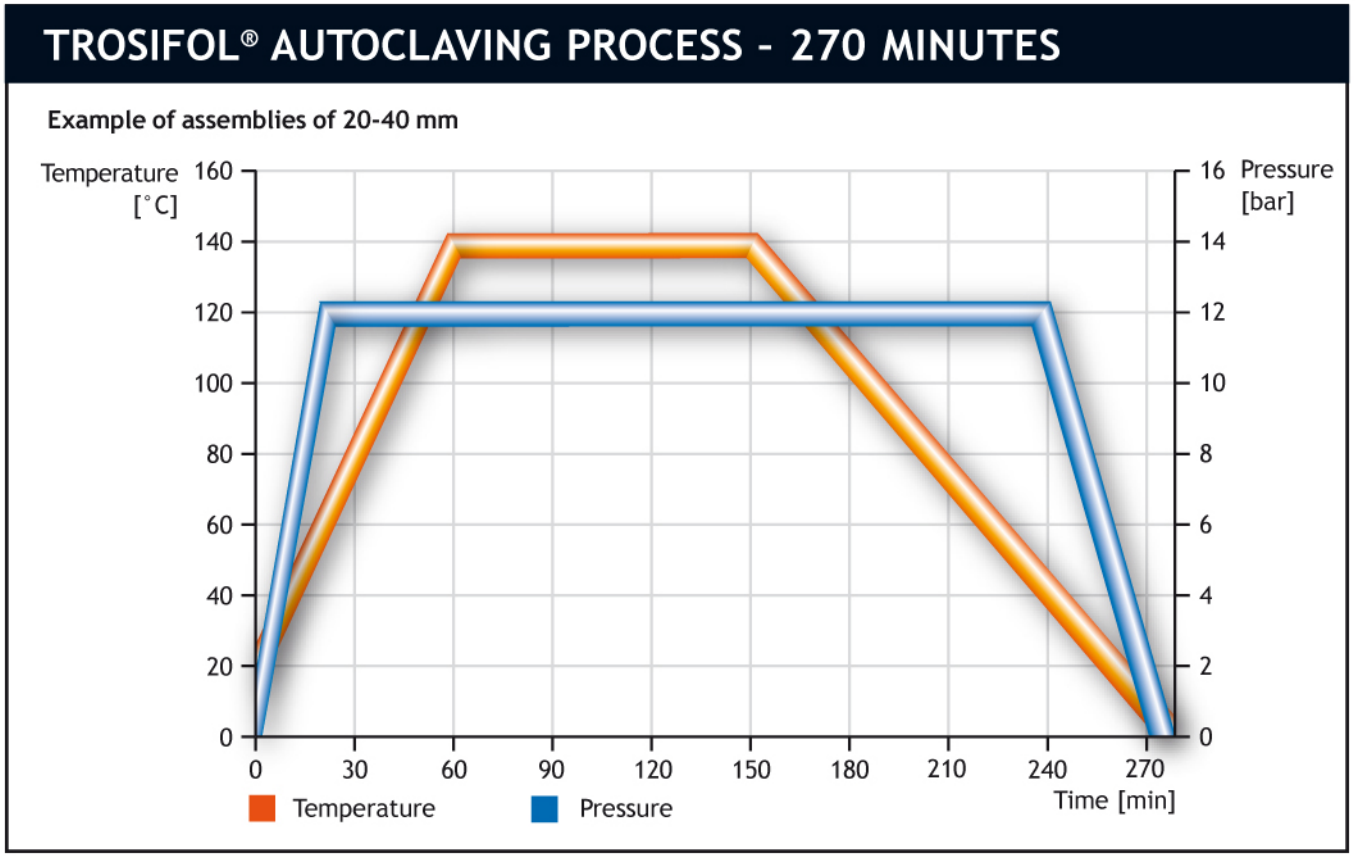

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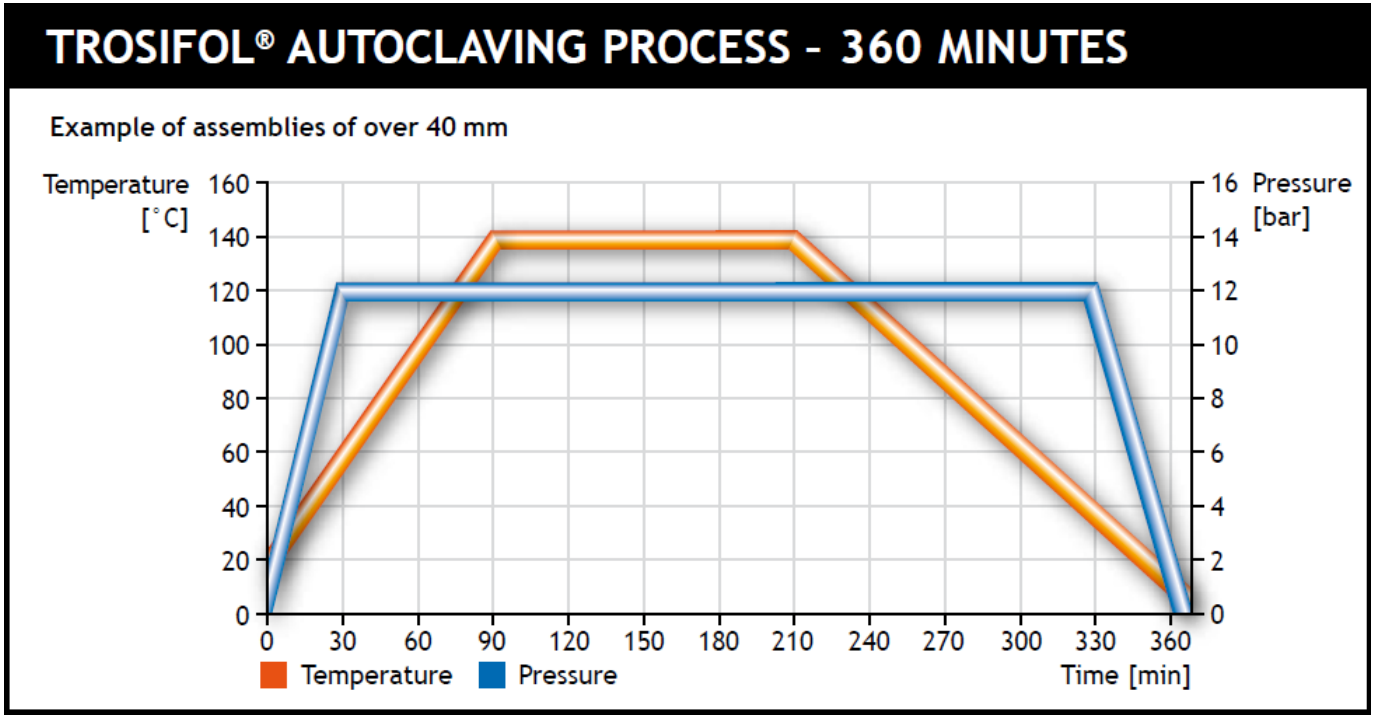
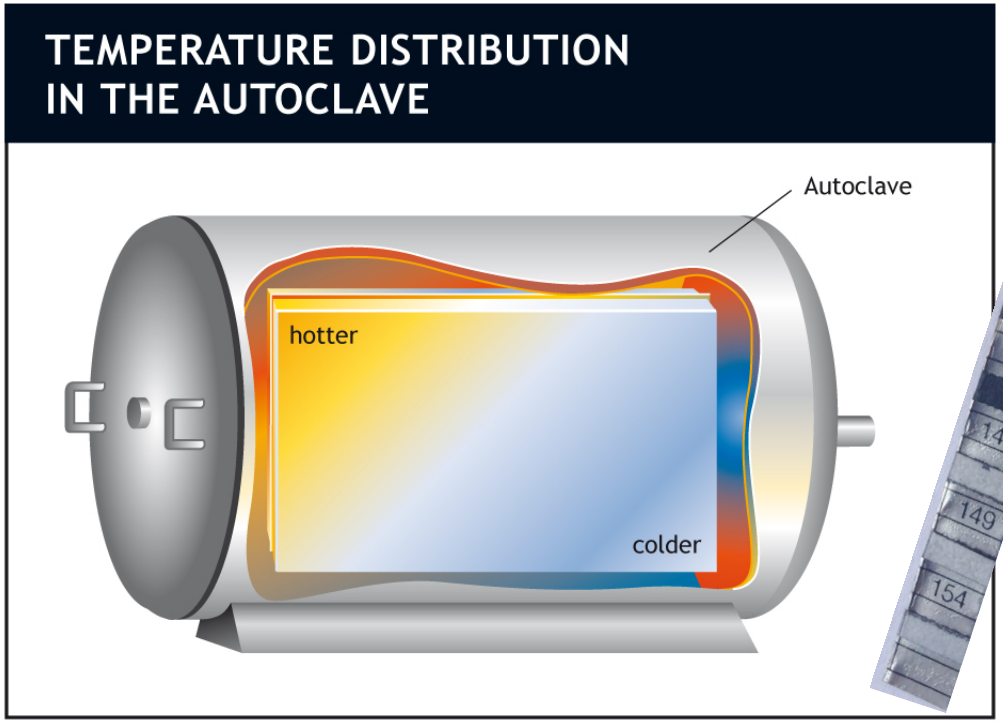


Autoclaving

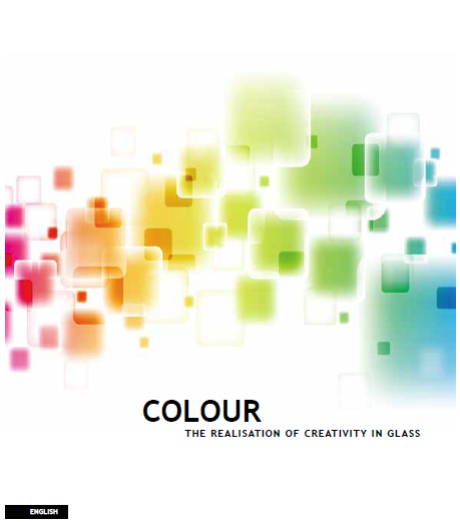
- Temperature distribution in the autoclave
  - The temperature distribution should be very uniform.
  - Use e.g.temperature measurement sticks to check the autoclave temperature from time to time.

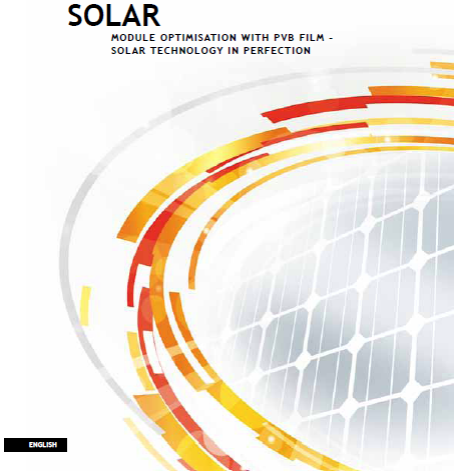


Autoclaving

- Risk for volatile evaporation and autoclave fire
  - Plasticizer evaporates during the autoclaving.
  - Plasticizer condenses in the insulation and can causes autoclave fire.
  - Regular autoclave cleaning cycles are recommended
    (up to maximum processing temperature with pressure release valve opened and pressure setting at 0,5 bar)

Further Information





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