

# Tape coatings



**What are the differences in manufacturing technologies and which impact do they have on the material properties?**



# Agenda

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1. Introduction
2. Lamination vs. Coextrusion
3. 3-ply Tapes vs. 2-ply Tapes
4. 3-ply Tapes: Coextruded & Asymmetrical
5. Comparison of Material Properties
6. How to simply test Coextrusion - Lamination
7. Long Term Experiences with 3-ply Tapes
8. Conclusions



# 1. Introduction

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# Introduction

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## Tapes differ in various aspects:

- Production technology (Lamination vs. Coextrusion)
- Material (e.g. PVC-Bitumen vs. PE-Butyl rubber)
- Structure (2-ply vs. 3-ply)
- Composition (Symmetrical vs. Asymmetrical)

## ➤ **Tape ≠ Tape**

# Introduction

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Questions to be answered:

- *Do different tape structures and **production technologies** have an impact on the **quality** and intrinsic **material properties** of tapes?*
- *What are the impacts of tape structure and production technology on **long-term behaviour** of tape coatings?*

## 2. Lamination vs. Coextrusion

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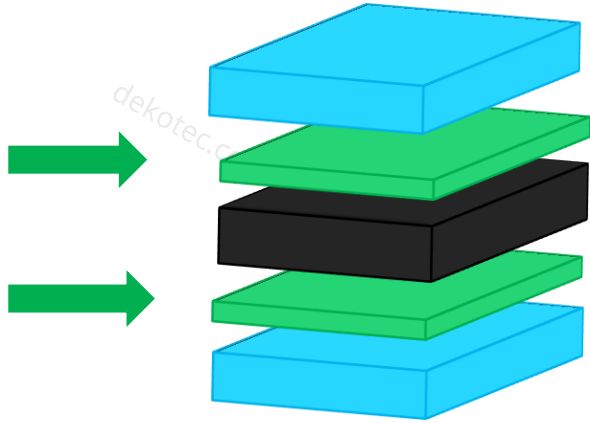
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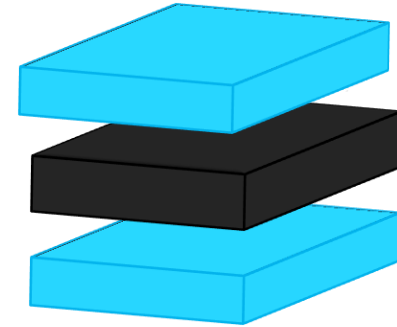
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# Objective: Bond different materials together



Using Adhesive (glue)



For Tape: Without Adhesive (glue):

- Lamination
- Coextrusion

# Lamination

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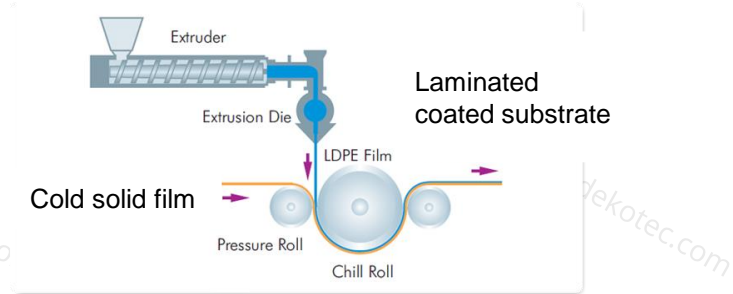
- 3 typical lamination technologies exist.
- For all technologies of lamination applies:

At least **one layer** has already **cooled down** and is then covered with another layer.

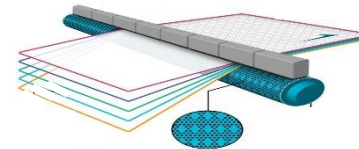


# 3 Typical Lamination Technologies

1. Extrusion of a second layer on the first cold solid film



2. Heating and pressing cold solid films together

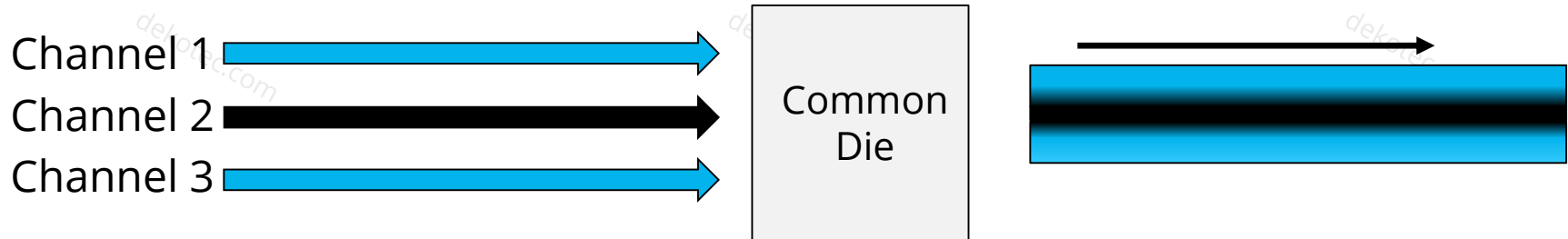


3. Liquid is distributed on a cold solid film.



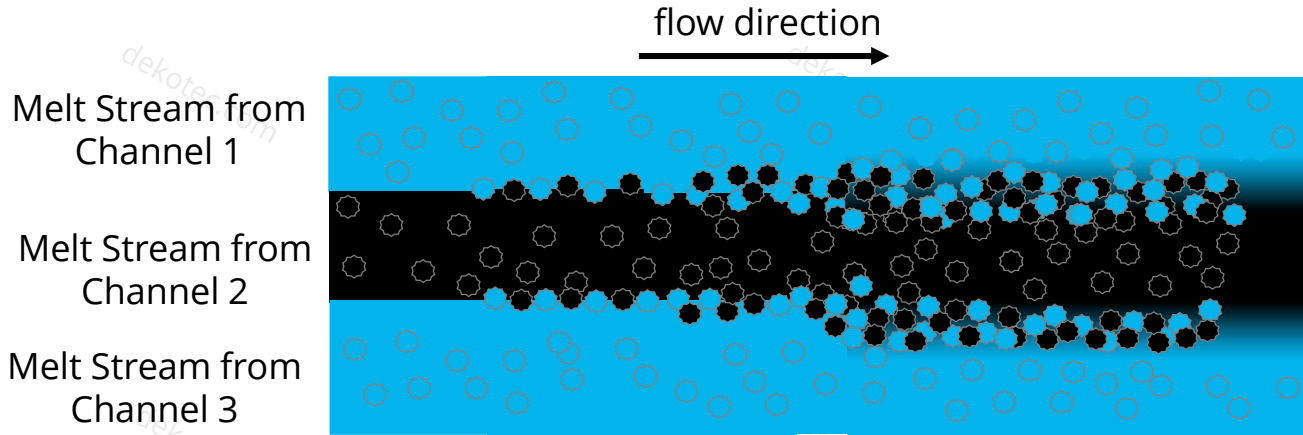
# The principle of real Coextrusion

- Coextrusion requires more than one polymer **melt stream**.
- Each melt stream is produced by its **own extruder**.
- Real coextrusion process: melt streams flow into different channels to and through **3 different entries into the Common Die**.
- The different molten polymers flow together to the outlet of the **common die**.

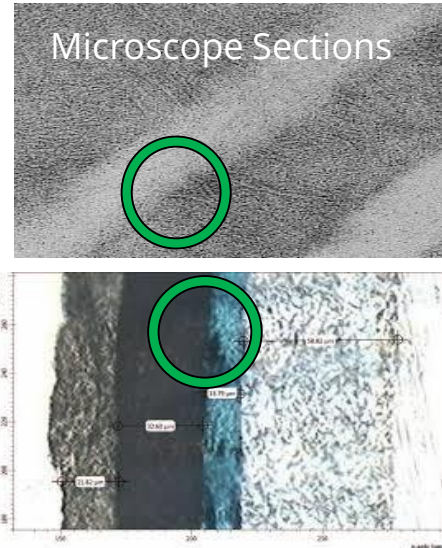


# The principle of real Coextrusion

- Inside Common Die: Macromolecules of the molten polymers flow into each other and are **intermingling** in the border zones.



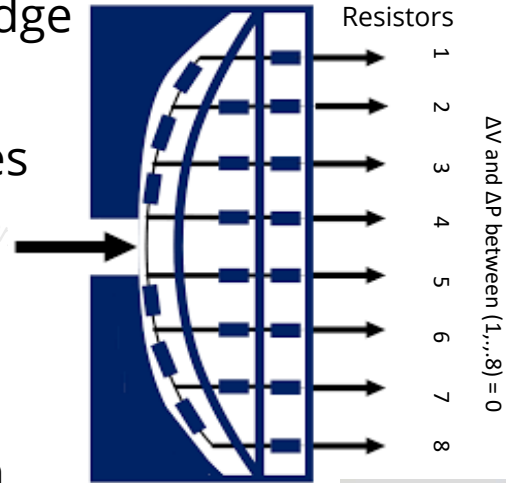
Along the flow path the melt streams flow into each other



- Equivalent to “**welding components**” with very strong bonding/merging between the layers.

# The principle of real Coextrusion

- Coextrusion requires expert knowledge and a lot of experience.
- Process Technology + Melt properties + "Recipes": must fit together.
- Each melt must flow with the **same velocity** (speed) over the complete width of the die to ensure a **stable and correct thickness distribution**.
- A real coextrusion die has its own channel and a **Coat-Hanger Manifold** for each component. That ensures an **equal pressure loss** on each flow path.



# Properties of real coextruded tapes

- Superior **Layer to Layer Adhesion.**

The layers never separate and delaminate from each other!

- Superior **Lap Shear Resistance.**

The layers do not move on each other!

- High **Elongation at Break** Resistance.

Poor values for *elongation at break* is an indication of inferior material quality or uncontrolled coextrusion process!

➤ **Real Coextruded Tapes = High Quality Tapes**

# 3. 3-ply Tapes vs. 2-ply Tapes

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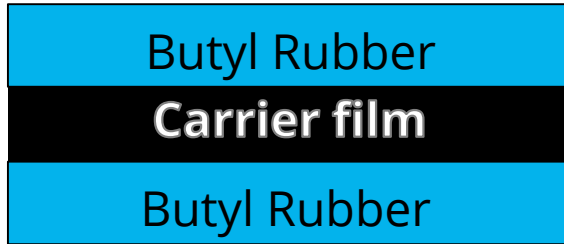
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# Material & Structure 3-ply vs. 2-ply Tapes

## 3-ply Tape:



- Structure: carrier film covered on **both** sides with adhesive.
- Material: **Butyl rubber only.**
- Lamination or Coextrusion.

## 2-ply Tape:



- Structure: carrier film covered only on **one** side with adhesive.
- Adhesive: Butyl Rubber **or** Bitumen.
  - Butyl Rubber: Lamination or Coextrusion.
  - Bitumen: only Lamination, **Coextrusion not possible!**

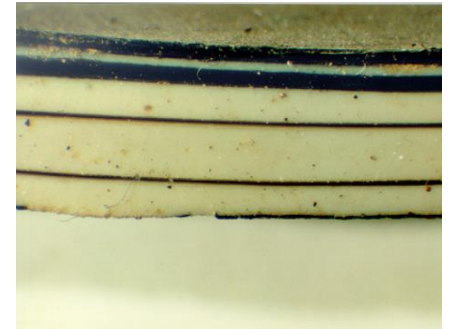
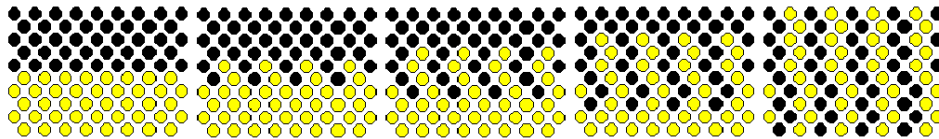
# Characteristics of Butyl Rubber

Ability to **„flow“** to a certain degree

- Small cavities of the steel surface are filled.

Butyl Rubber layers **self-amalgamate**  
**without any heat** (flame)

- Molecules migrate into each other to form an **homogenous structure.**



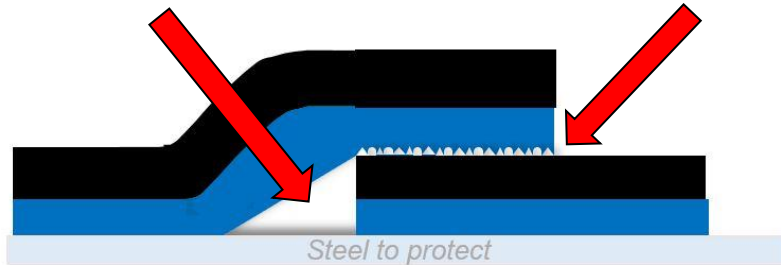


# 2-ply tapes: reliable corrosion prevention?

## 2-ply Tapes wrapped

**Lack of adhesion: danger of hollows**

**Lack of adhesion: Path for Moisture & Oxygen**



- In the remaining interface between the layers **micro channels** may occur!
- Possible **path** for moisture and oxygen!

➤ **SPIRAL CORROSION**

# 2-ply tapes: Risk of Spiral Corrosion!

**SPIRAL CORROSION** is frequently found on pipelines where **2-ply tapes** are used as **corrosion prevention** tape.

**Spiral Corrosion**



# 3-ply tapes: strong corrosion prevention

## 3-ply Tapes wrapped

- Butyl-Rubber layers **self-amalgamate** when tapes are wrapped.
- Molecules migrate into each other:
  - Tapes form a homogenous **“Impermeable Hose Type Coating”**
  - No interface, hollows or micro channels!
  - **NO SPIRAL CORROSION**





# 4. 3-ply Tapes: Coextruded & Asymmetrical

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# 3-Ply Tapes - Coextruded & Asymmetrical



## 1<sup>st</sup> step: Coextrusion:

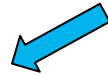


Butyl Rubber real coextruded with Carrier film.



Intermediate Butyl Rubber real coextruded with Carrier film.

## 2<sup>nd</sup> step: Adding Butyl Rubber:



Chemical bond: Butyl-Rubber + Butyl-Rubber



Additional Butyl Rubber is building the required thickness.

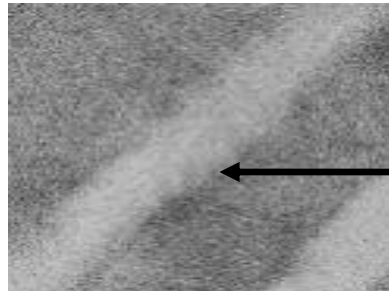
# 3-Ply Tapes - Coextrusion vs. Lamination

## Coextrusion:



Strong **chemical bond** between Butyl-Rubber and PE!

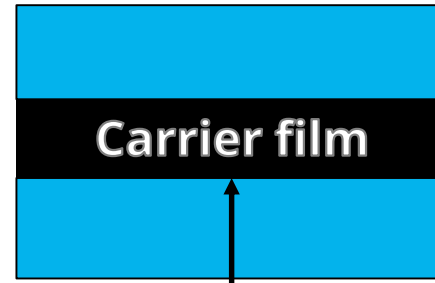
**Chemical bond:** Butyl-Rubber + Butyl-Rubber



Penetration of macromolecules between layers:

**Excellent Long-term properties!**

## Lamination:



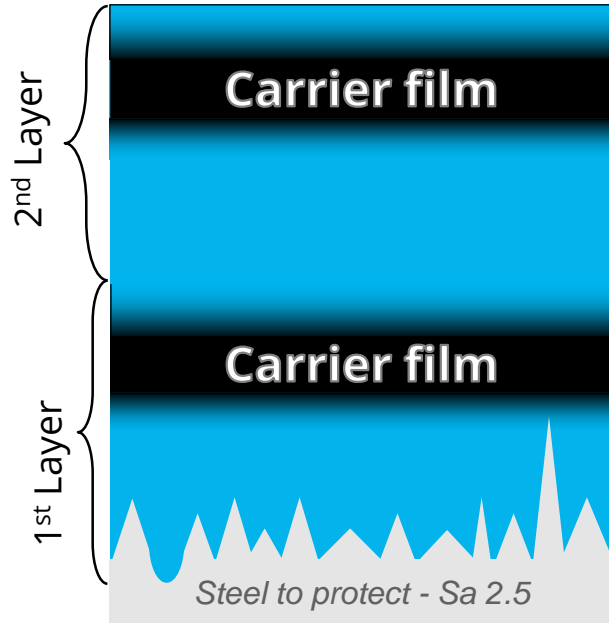
Only mechanical bond between Butyl-Rubber and PE



No Penetration of macromolecules between layers: **Long-term properties**, after aging, are significantly **reduced**.

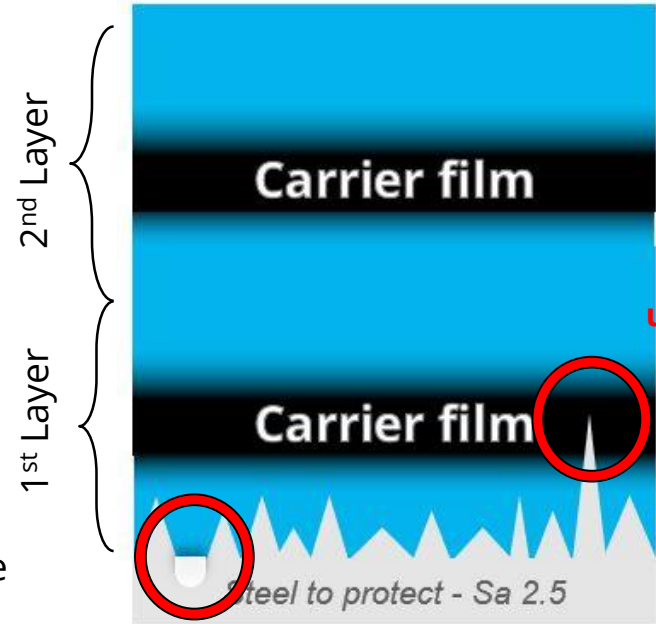
# 3-Ply Tapes - Asymmetrical vs. Symmetrical

## Asymmetrical:



Approx. 2 x thickness of Butyl-Rubber in direct contact with the steel to protect

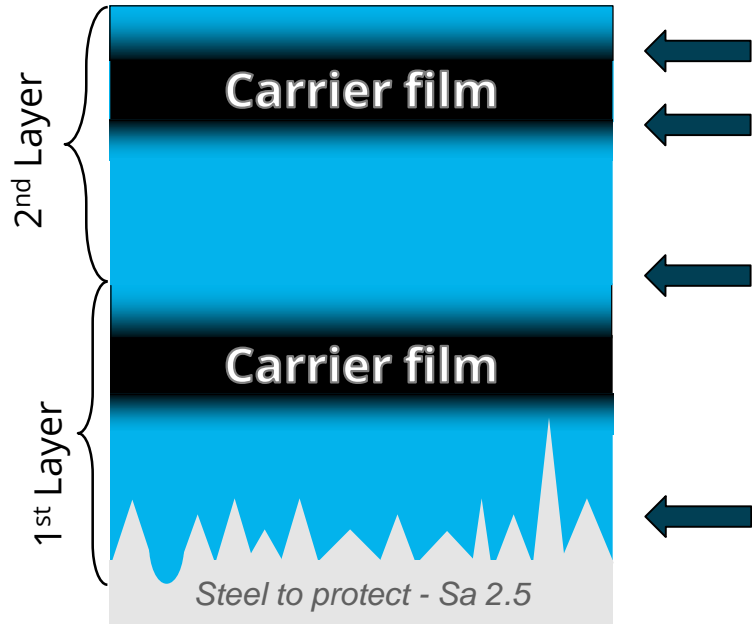
## Symmetrical:



Risk of unprotected peaks

Risk of unprotected hollows

# 3-Ply Tapes - Coextruded & Asymmetrical



## Strong Chemical bonds:

➤ Carrier film & Butyl Rubber

➤ Butyl Rubber & Butyl Rubber

## Best Steel Coverage

# Favorite Combination



# 5. Comparison of Material Properties

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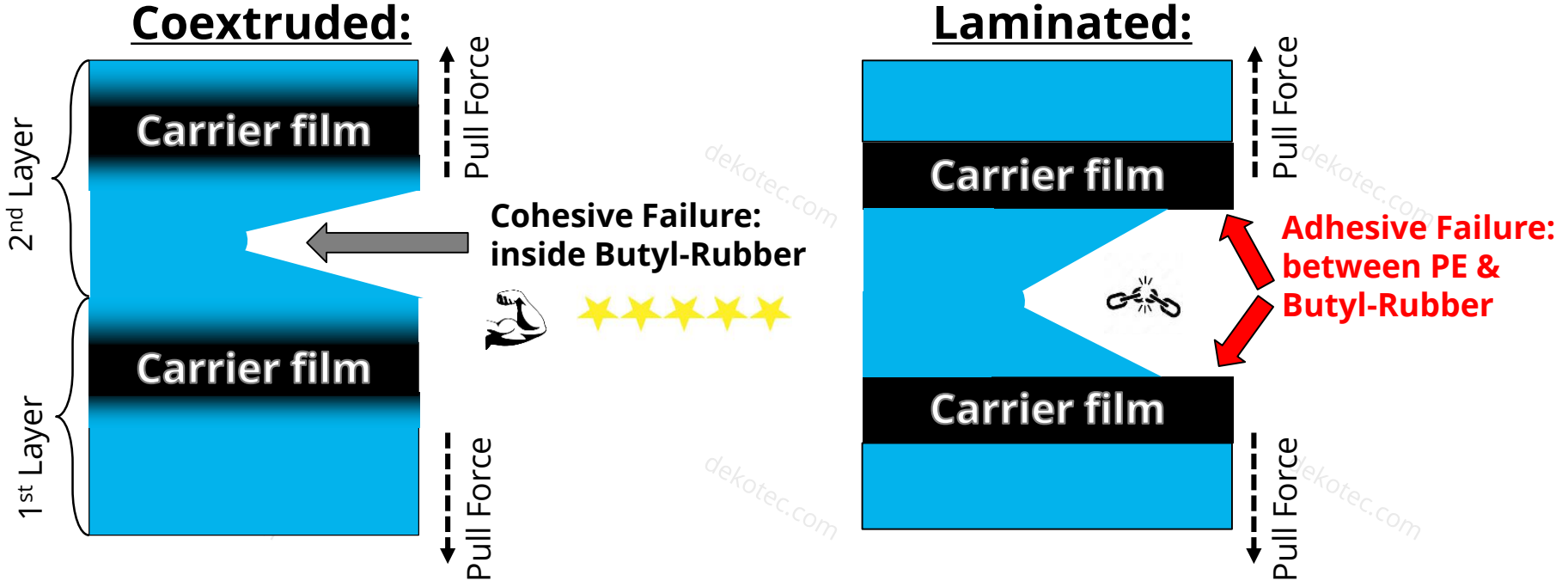
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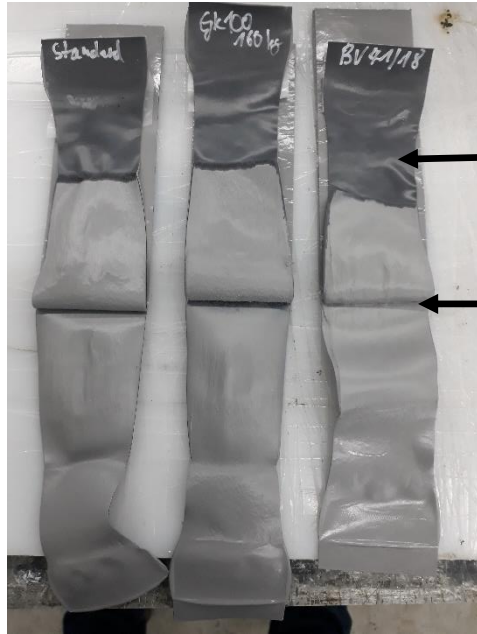
# 3-Ply Tapes - Layer to Layer adhesion



**➔ Certain risk of delamination with laminated tapes only.**

# 3-Ply Tapes - Layer to Layer adhesion

## 3-Ply coextruded Butyl Rubber/PE:



↑ Pull Force

← Elongation of PE

← Cohesive Failure: inside Butyl-Rubber



↓ Pull Force

## 2-Ply laminated Bitumen/PVC:



↑ Pull Force

← Adhesive Failure: between PVC & Bitumen

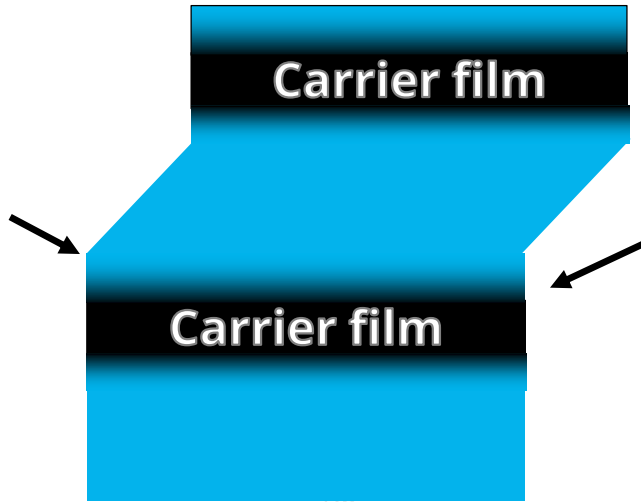


↓ Pull Force

# 3-Ply Tapes - Lap Shear Resistance

## Coextruded:

-----> Pull Force

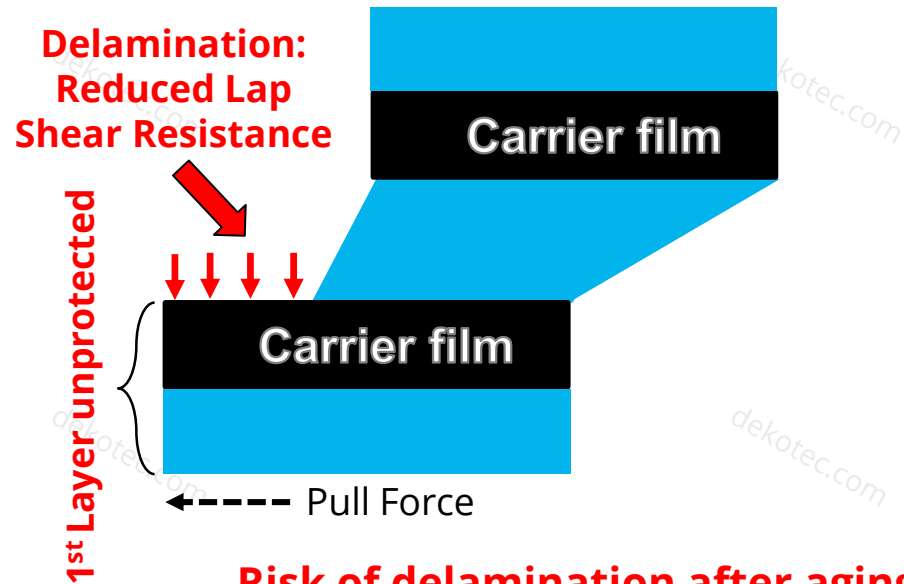


----- Pull Force

**No delamination:  
High Lap Shear Resistance**

## Laminated:

-----> Pull Force



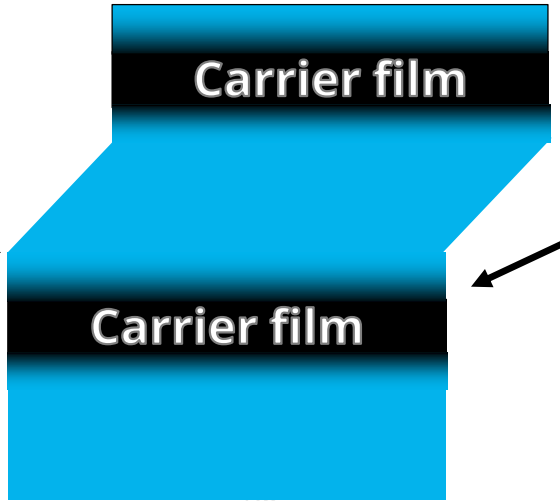
----- Pull Force

**Risk of delamination after aging  
with laminated tapes only**

# 3-Ply vs. 2-Ply Tapes - Lap Shear Resistance

## Coextruded - 3-Ply:

-----> Pull Force



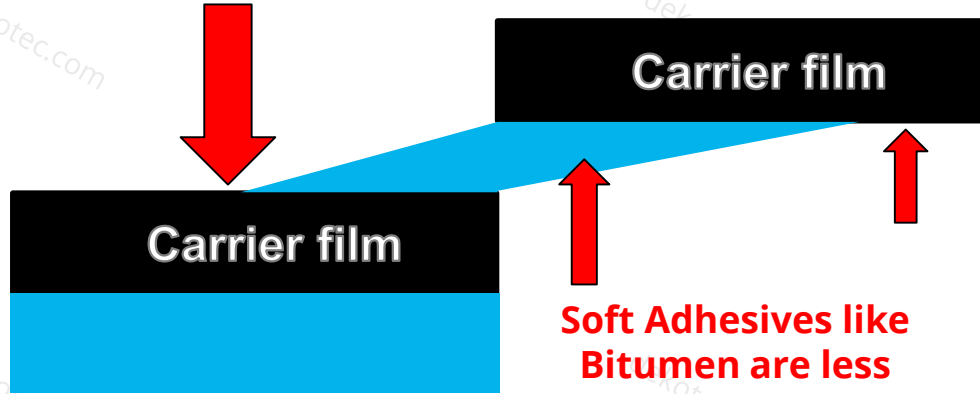
----- Pull Force

**No delamination:  
High Lap Shear Resistance!**

## Laminated - 2-Ply:

**Delamination:  
Poor Lap Shear Resistance!**

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----- Pull Force

**Soft Adhesives like  
Bitumen are less  
resistant to Lap  
Shear Forces!**

**High Risk of delamination with  
laminated 2-Ply tapes!**

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# Bad performance of laminated 2-Ply-Tapes



**Poor Lap Shear Resistance: Poor Soil Stress Resistance**

# Overview of Tape Properties

Tape Properties	Real Coextruded 3-ply Tapes	Laminated	
		3-ply Tapes	2-ply Tapes
Long term performances (ageing)	High	Low	Low
Layer-to-layer adhesion	Higher than EN-ISO	EN-ISO	Poor
Layer-to-layer failure mode	100% Cohesive	Adhesive-Cohesive	Adhesive
Lap Shear Resistance	Higher than EN-ISO	EN-ISO	Poor
Spiral Corrosion Risk	Very Low	Low	Very High
Equal Thickness	Perfectly uniform	Less uniform	Less uniform
Steel Coverage	Excellent	Limited	Limited
Flexibility at low temperature	Excellent	Poor	Poor



# 6. How to simply test Coextrusion - Lamination

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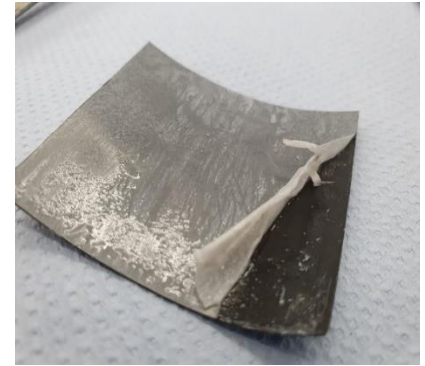
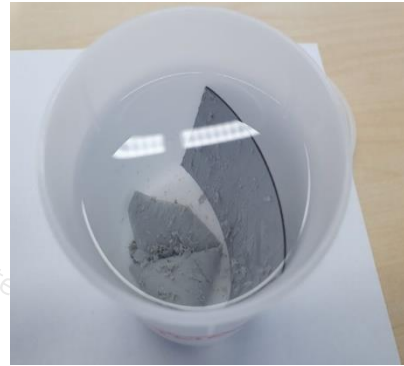


# Petrol Immersion Test Coextrusion - Lamination



Petrol Immersion : 2-Ply or 3-Ply tape for minimum 2 hours

- Residual adhesive is easily removed, Carrier film is smooth or glossy: **Lamination**
- Residual adhesive can only be removed with strong mechanical devices: **Coextrusion**



Adhesive easily removed: **Lamination**

Adhesive difficult to remove: **Coextrusion**



# 7. Long term experiences BUTYLEN-3-Ply Tapes

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# Reference: Energienetz Bayern (Germany)

## Energienetz Bayern GmbH (Munich/Germany)

Pipeline network of 9.500 km

### Moosburg – Straubing Pipeline

- Year of Construction: 1976
- Used corrosion protection: coextruded BUTYLEN 3-ply PE/Butyl-Tapes.
- Year of Excavation: 2015  
(after **39 years** in operation)

### Field joint coating assessment after 39 years:

- No failure – No corrosion
- *Peel strength:*  $\geq 1,83\text{N/mm}^*$  – Cohesive break

\*Requirements of EN 12068:  $\geq 1,00\text{N/mm}$



# Reference: Gascade STEGAL (Germany)

## Gascade Gastransport GmbH - Germany

Pipeline network of 2.900 km

### 36-inch STEGAL Pipeline

- Year of Construction: 1992
- Used corrosion protection: coextruded BUTYLEN 3-ply PE/Butyl-Tapes.
- Year of Excavation: 2012  
(after **20 years** in operation)

### *Field joint coating assessment:*

- No failure – No corrosion
- *Peel strength:* 6,40N/mm\*
- Cohesive break: Res. Thick: 344 microns

\*Requirements of EN 12068:  $\geq 1,00\text{N/mm}$





# 8. Conclusions

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# Real Coextruded 3-Ply Tapes

- Self-amalgamation = *"Impermeable **Hose type coating**".*
- **No spiral corrosion.**
- Best steel coverage.
- Superior **Layer to Layer** adhesion.
- Superior **Lap Shear Resistance** = *"Superior Soil Stress Resistance".*
- Excellent **long-term expectancy** proven by Coating Inspections.
- No other tape coating has a longer **proven track record in field.**



# Conclusion

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- **Tape Structure matters:**

- 3-ply Tapes create a hose-like coating.
- 2-ply Tapes risk to fail as corrosion prevention tape.

- **Tape Material matters:**

- PE/Butyl-Rubber is superior to i.e. PVC/Bitumen.
- PE/Butyl-Rubber successfully proven in field for decades!

- **Production Technology matters:**

- Real Coextrusion is the superior production technology.
- Laminated layers risk to fail on long term.



Thank you for your attention!

If you have any further questions  
please contact us!



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