

# A New Approach to High Performance Polyolefin Coatings

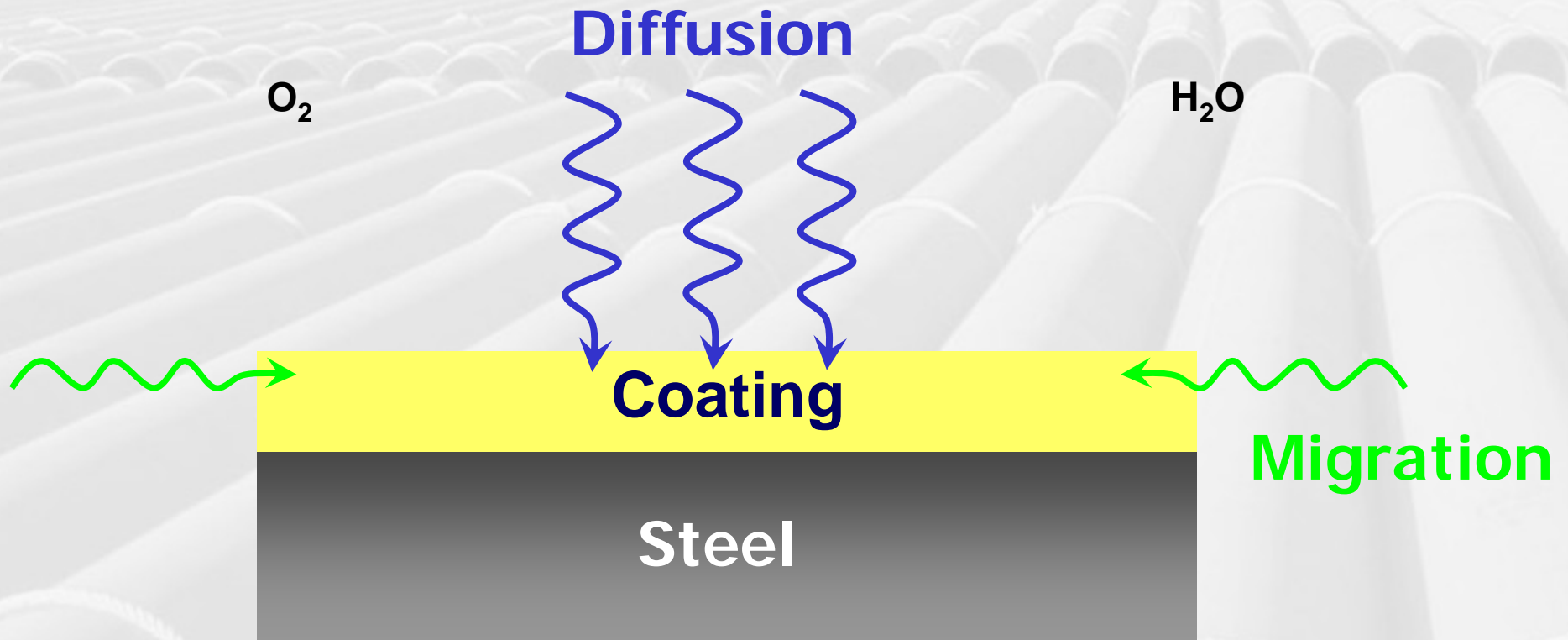


by

Catherine Lam, Dennis T. Wong, Robert E. Steele and Stephen J. Edmondson



# Steel Corrosion



- **Low Permeability**
- **Excellent Adhesion to Steel**

# Coating Systems for Pipelines

## Fusion Bonded Epoxy (FBE)

- Low permeability to oxygen
- Excellent Adhesion to Steel
- Excellent Resistance to Cathodic Disbondment
- Low Impact Resistance
- Permeable to moisture
- Tendency to disbond when exposed to HOT & WET conditions for long periods of time

# Coating Systems for Pipelines

## Polyolefins Topcoat

- Low Permeability to Moisture
- High resistant to Impact Damage
- Flexible
- Tough
- Relatively Low Cost (e.g. PE, PP)

# Coating Systems for Pipelines

## 3LPO Coating

  
**Mechanical  
Properties**

**Polyolefin**

**Copolymer Adhesive**

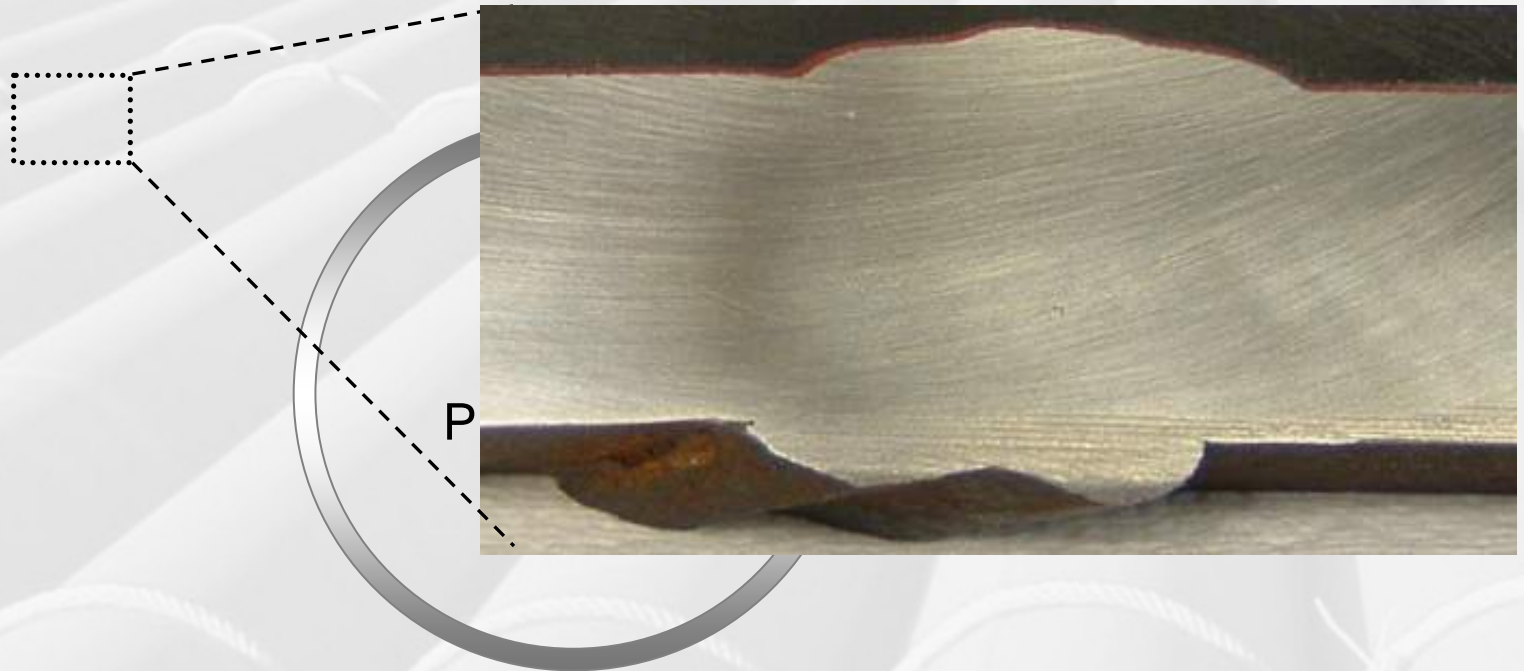
**FBE**

  
**Adhesion  
to Steel**

**Steel**

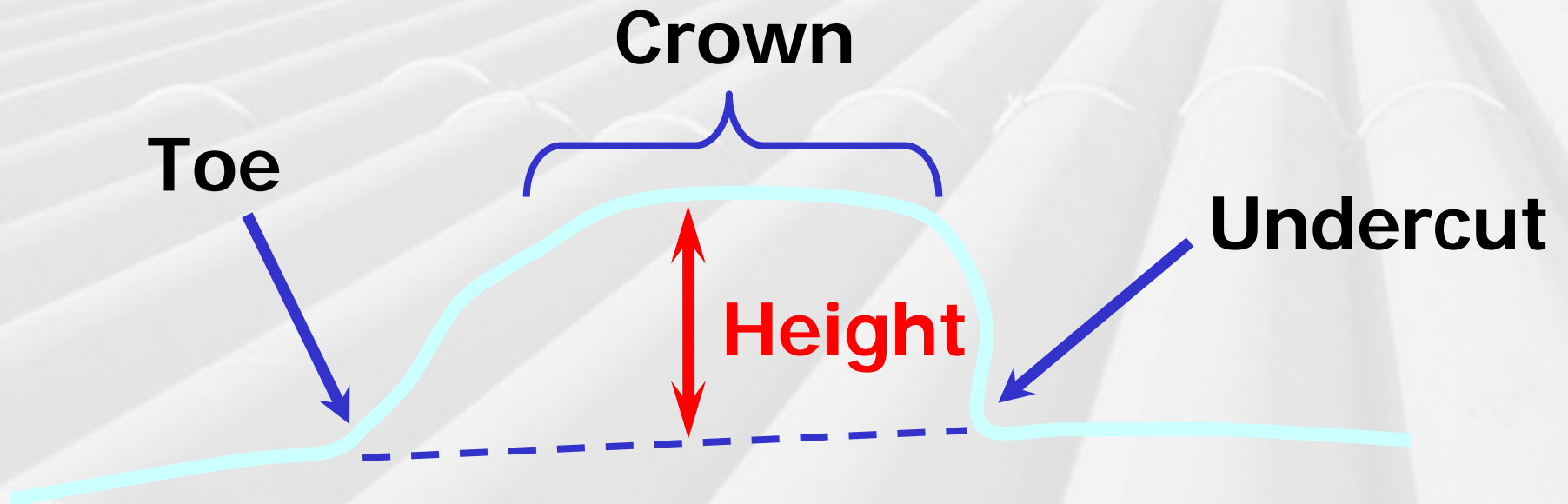
# Weld Geometry

**Pipes with OD > 24" (610 mm)**



**Cross Section of a Typical Weld on a Pipe**

# Weld Geometry

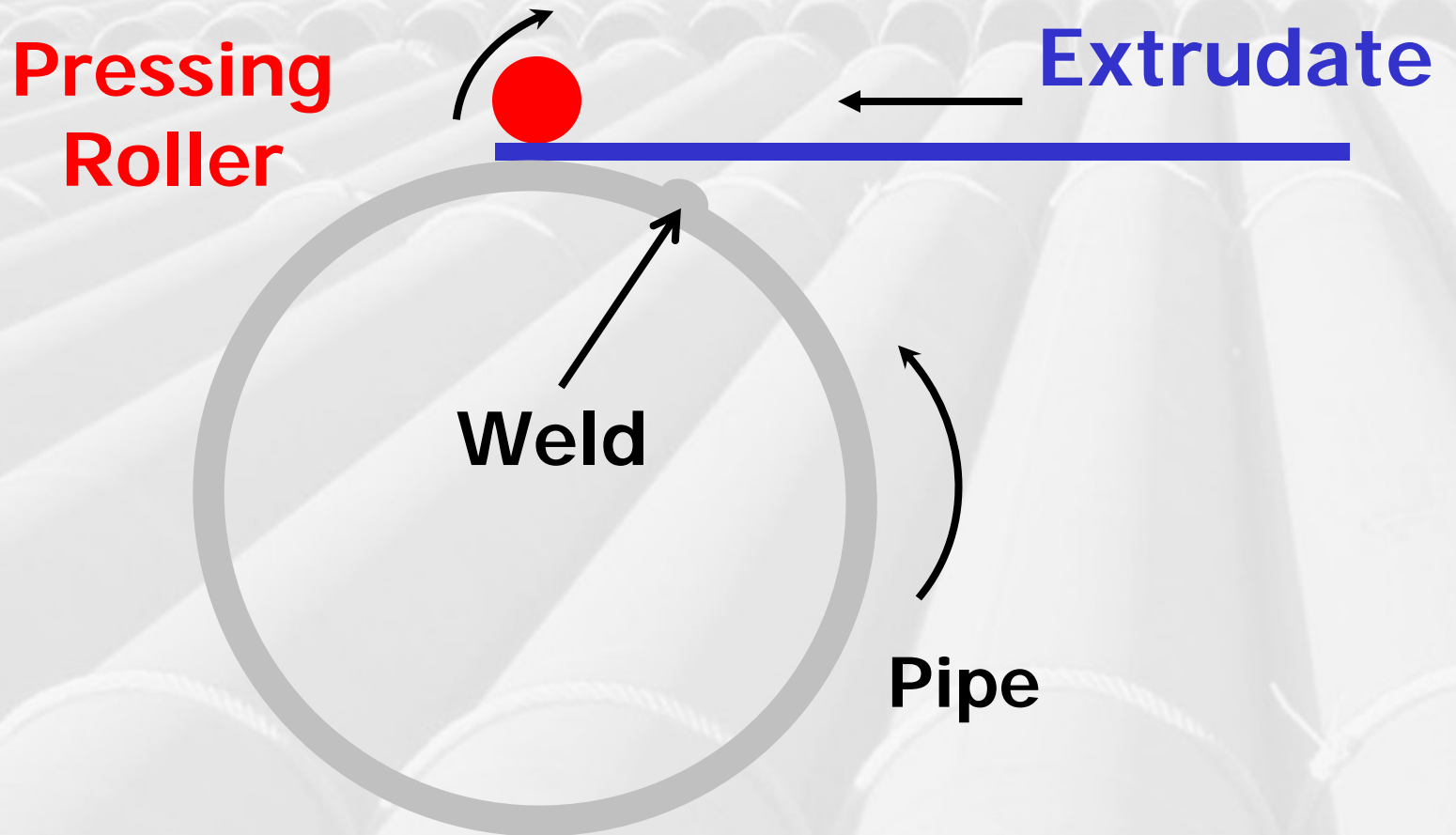


**Terminology used to describe Weld Geometry**

# Weld Geometry

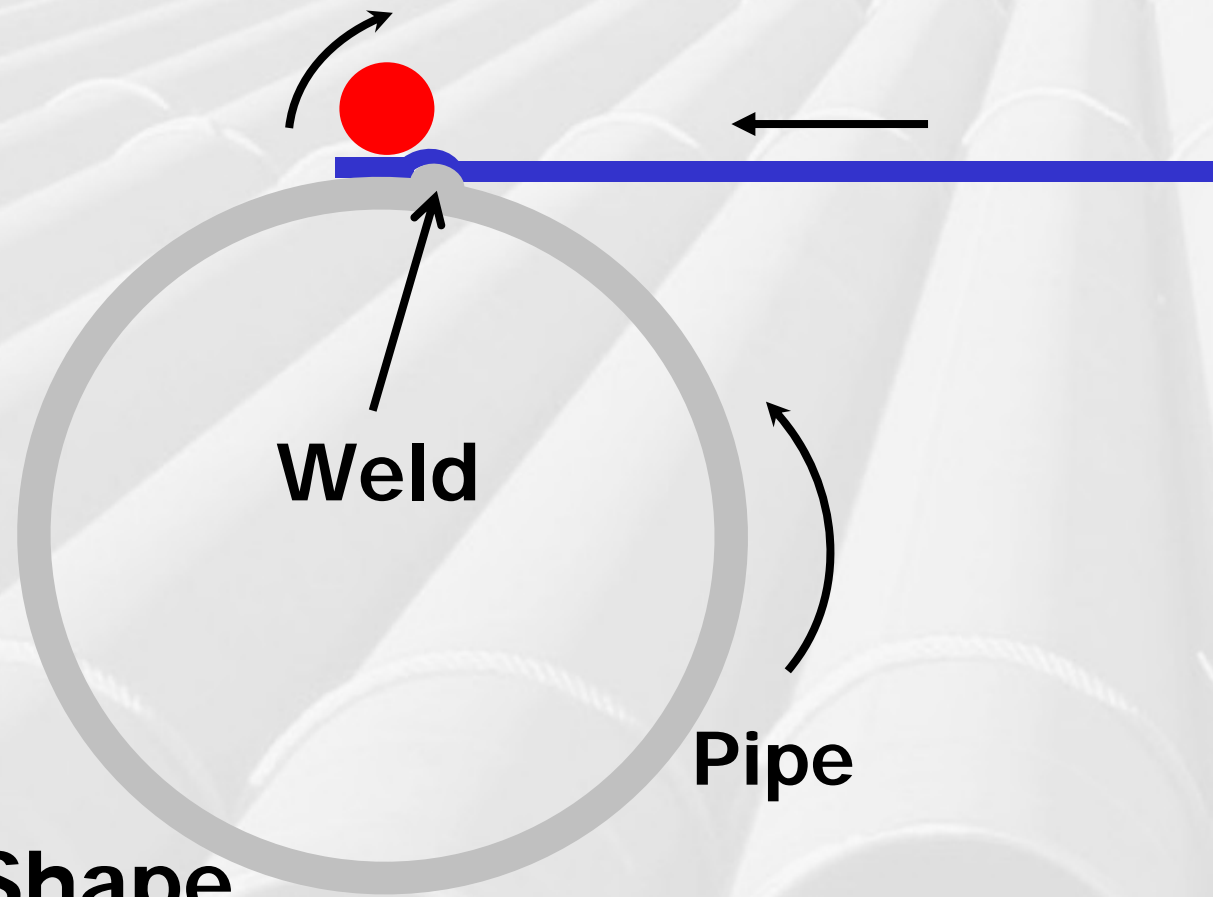
- ✓  Ideal weld shape
- ✗  Square edges
- ✗  Square edges with slight undercut
- ✗  Square edge with severe undercut
- ✗  Severe undercuts both sides and recess on top

# Conventional 3LPO Side Extruded Process



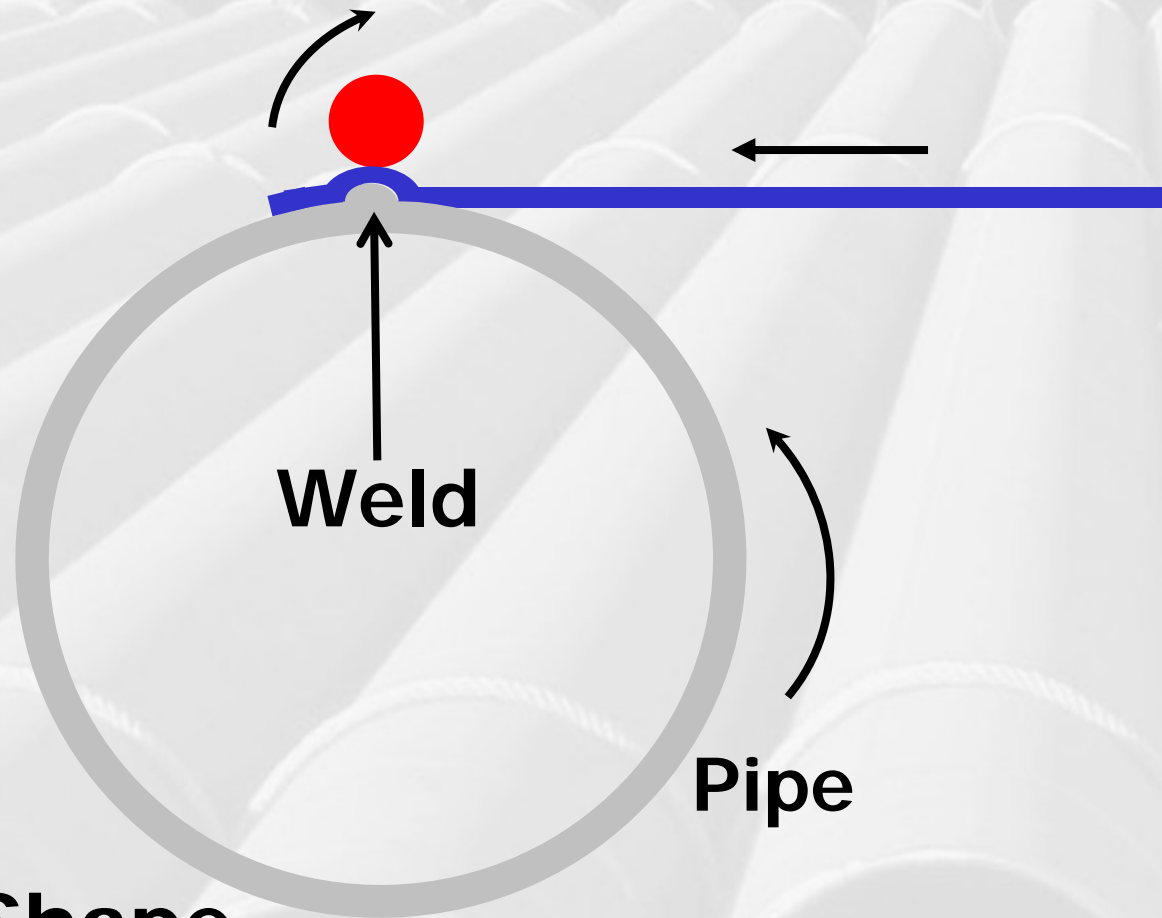
**Ideal Weld Shape**

# Conventional 3LPO Side Extruded Process



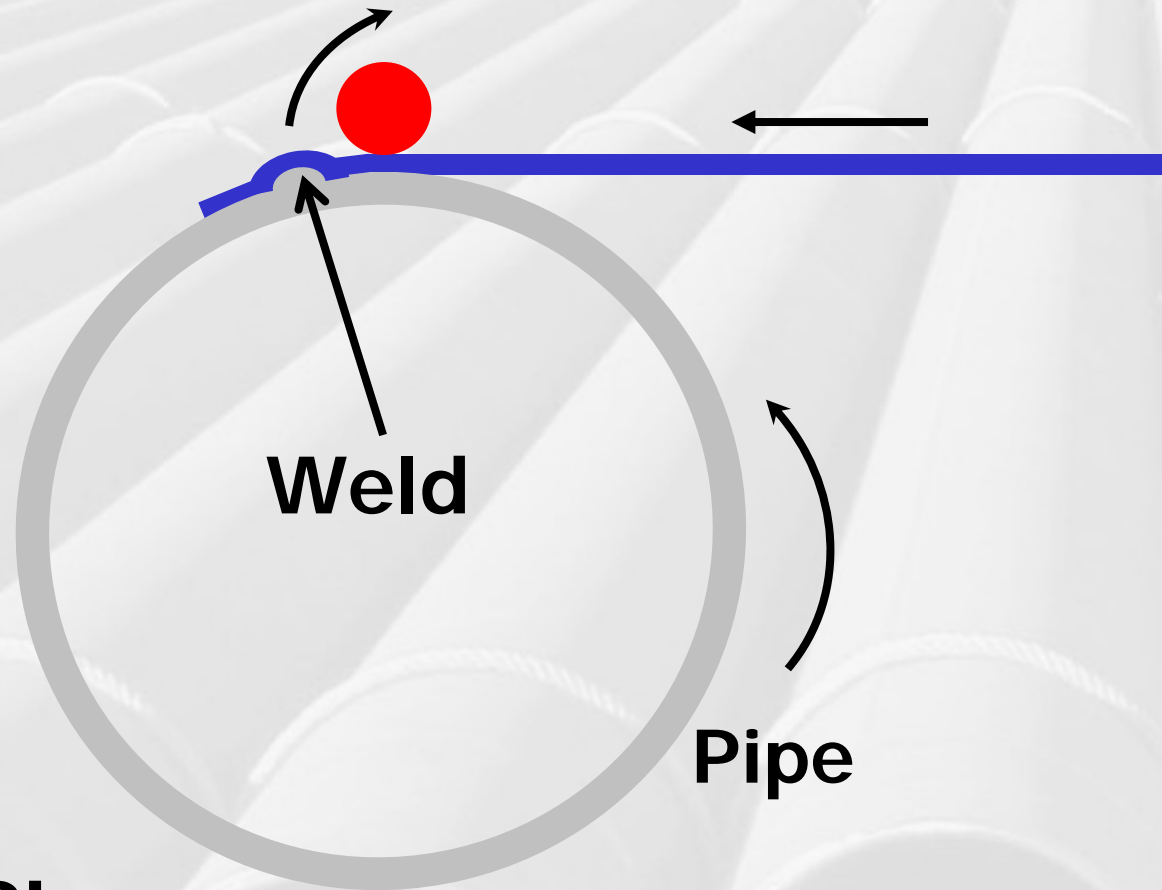
**Ideal Weld Shape**

# Conventional 3LPO Side Extruded Process



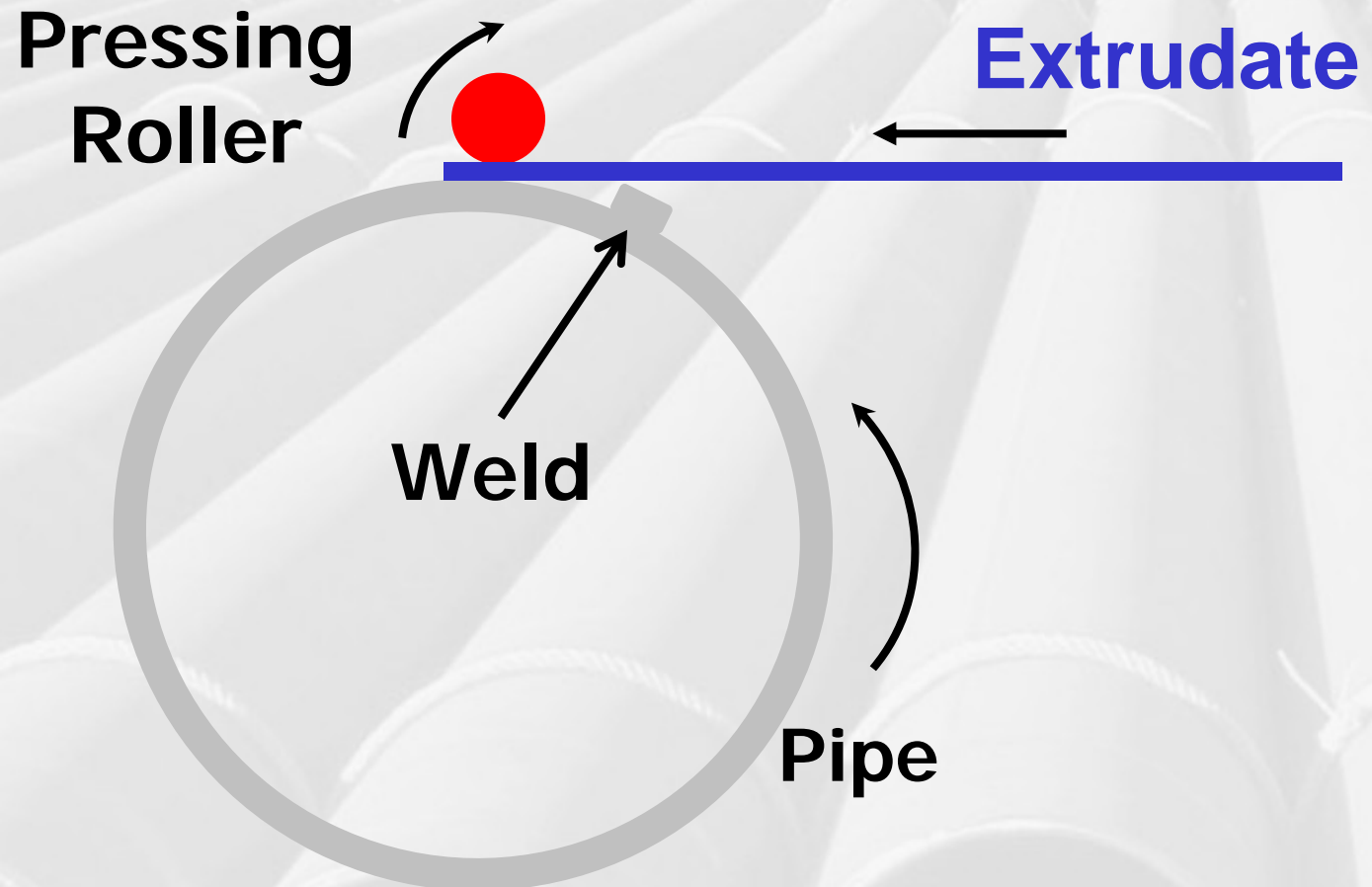
**Ideal Weld Shape**

# Conventional 3LPO Side Extruded Process



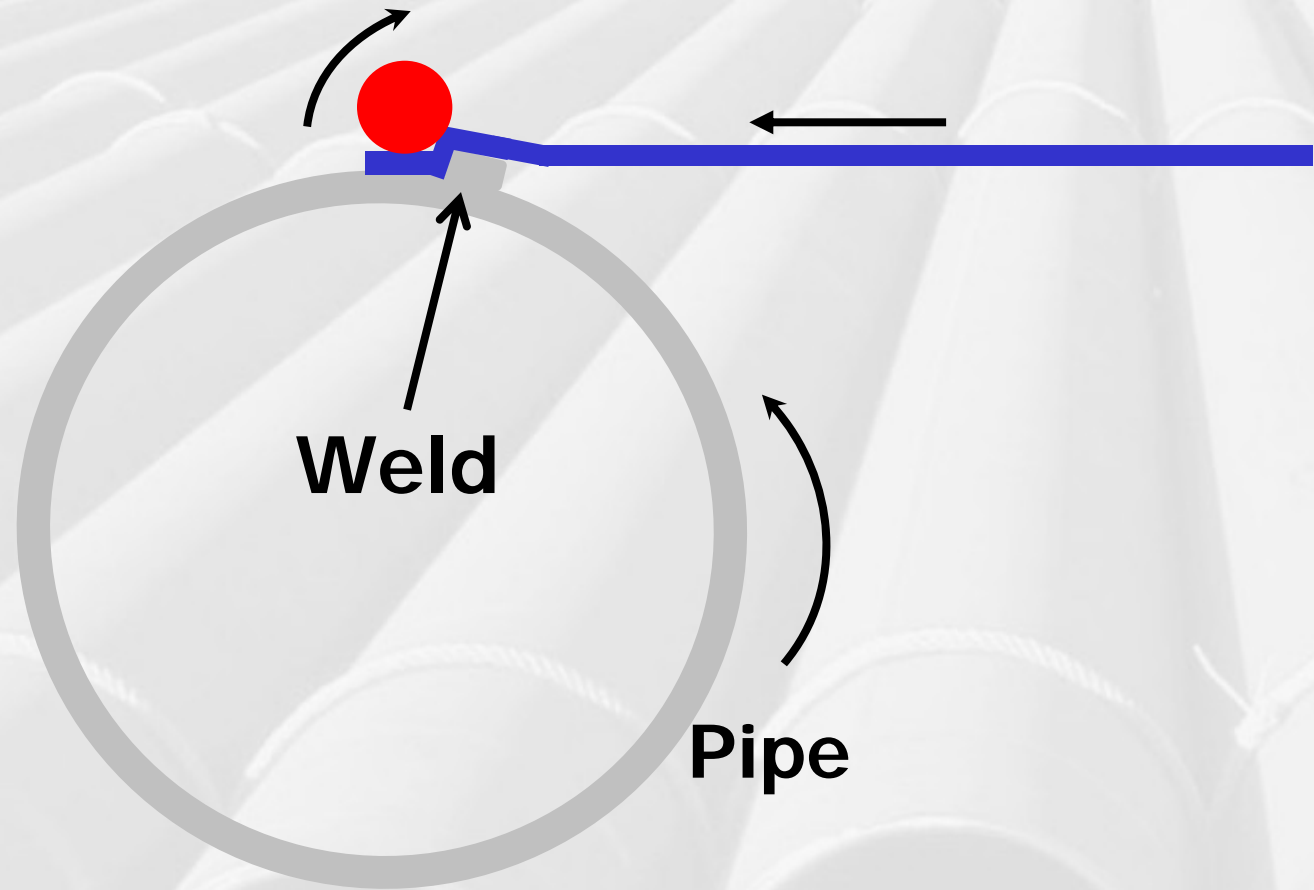
**Ideal Weld Shape**

# Conventional 3LPO Side Extruded Process



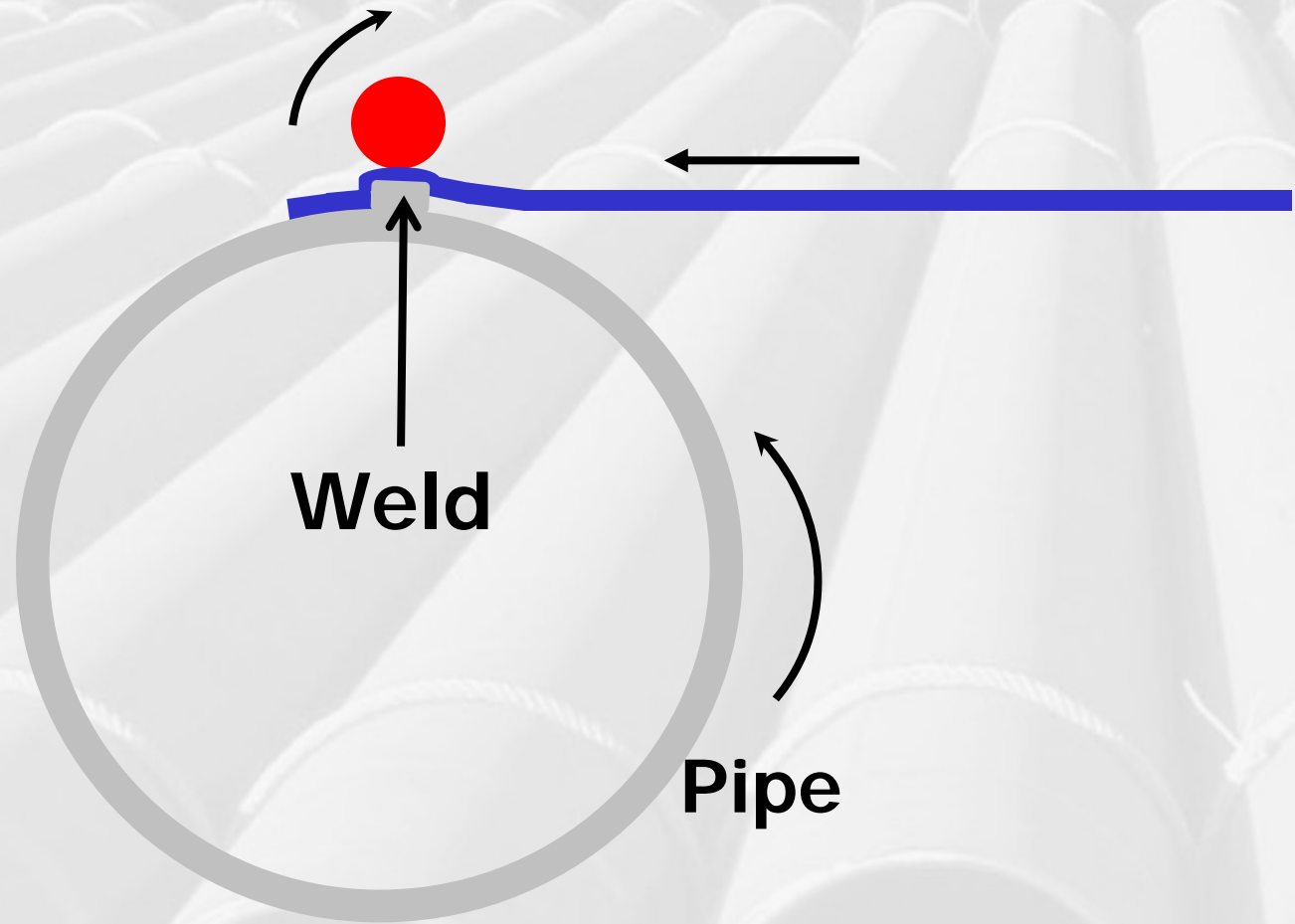
High Raised or Square Weld

# Conventional 3LPO Side Extruded Process



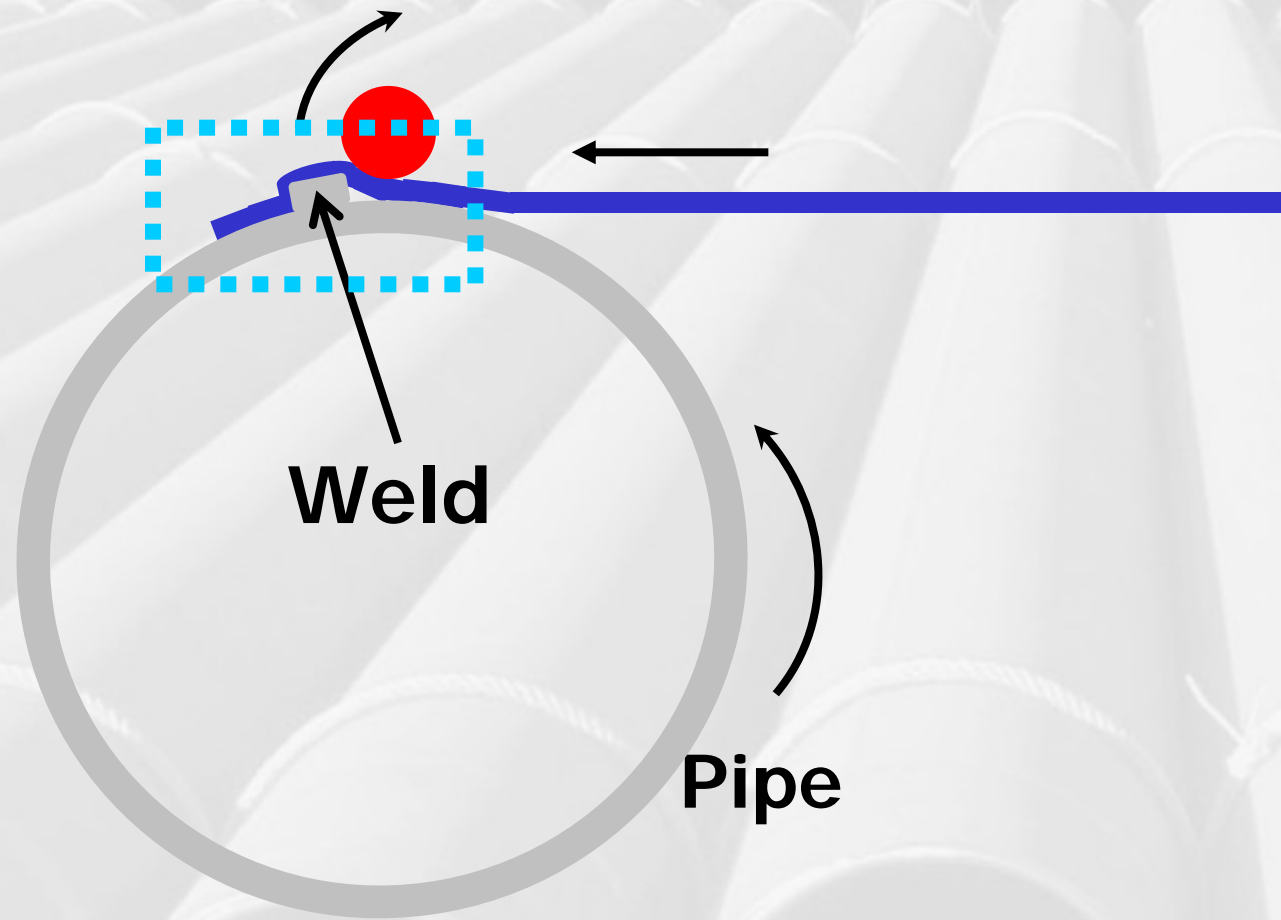
**High Raised or Square Weld**

# Conventional 3LPO Side Extruded Process



**High Raised or Square Weld**

# Conventional 3LPO Side Extruded Process



**High Raised or Square Weld**

# Conventional 3LPO Side Extruded Process

With high raised or square weld ...



**Void**

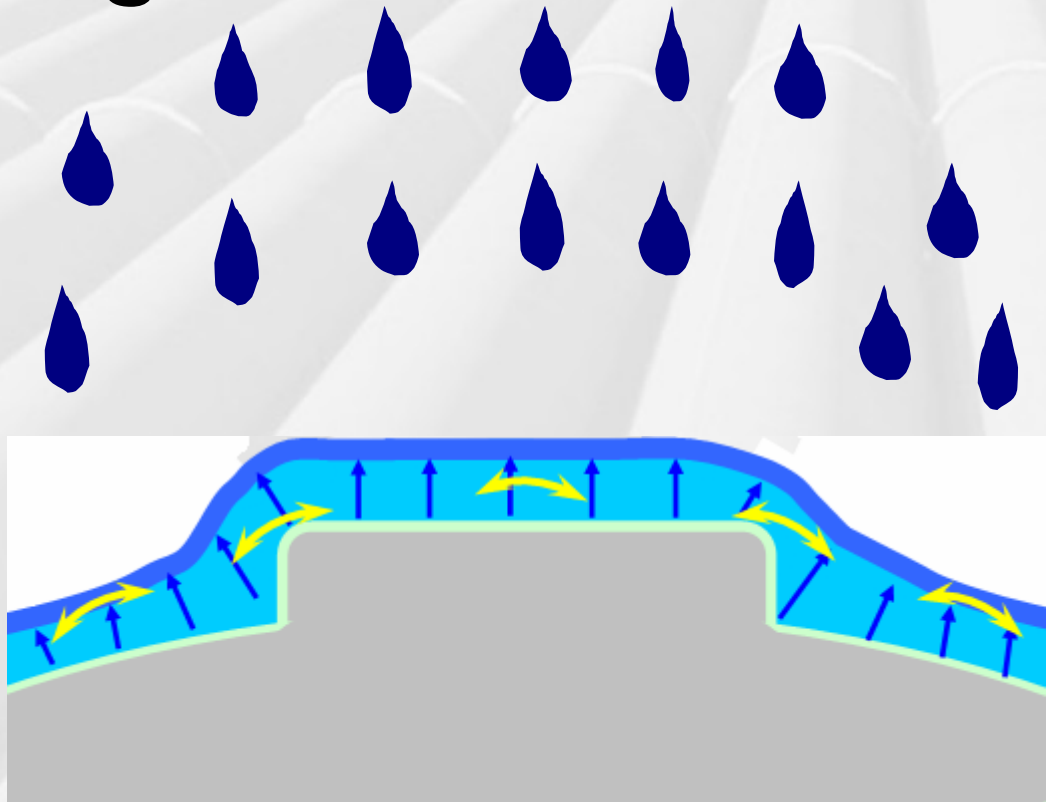
**Pressing roller is NOT Effective!**

# Conventional 3LPO Side Extruded Process

## Water quenching

• Volume Shrinkage

• Hoop Stress



# Conventional 3LPO Side Extruded Process

## Common Problems:



**Voids**

- Weld Tenting
- Thinning across the top of the weld

# "Graded Structure" PE Coating

## Powder Applied PE adhesive and Topcoat



- No distinct interface
- Smooth transition from rigid FBE to much tougher and compliant PE

# "Graded Structure" PE Coating

## Advantages:

- Eliminate interlayer adhesion failure
- Provide excellent uniform coverage of the raised weld
- Allow production of lower thickness coatings than is possible with conventional 3LPO coating process

# "Graded Structure" PE Coating

## Disadvantages:

- More expensive for additional step of polyolefin grinding
- More difficult to apply a thick coating by powder application due to loss of heat transfer

# New Approach to Multi - Layer Polyolefin Coatings

**Graded  
Structure  
PE Coatings**



**Side-Wrap  
Extruded PE  
Coatings**

- Prevent delamination and loss of adhesion
- Provide uniform coverage over raised welds

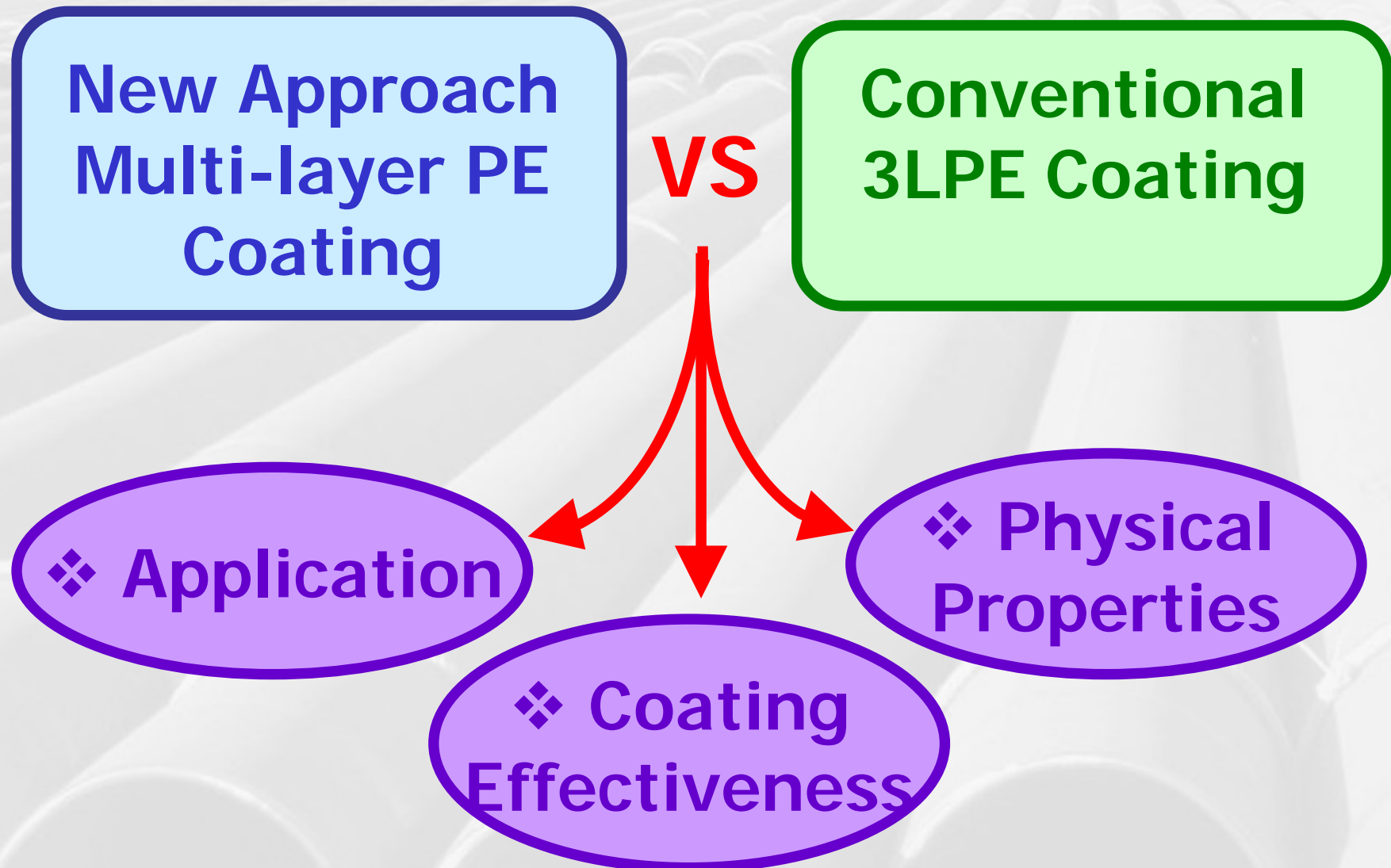
- Attain thick coatings
- Lower cost
- Higher throughput

# New Approach to Multi - Layer Polyolefin Coatings

## Advantages:

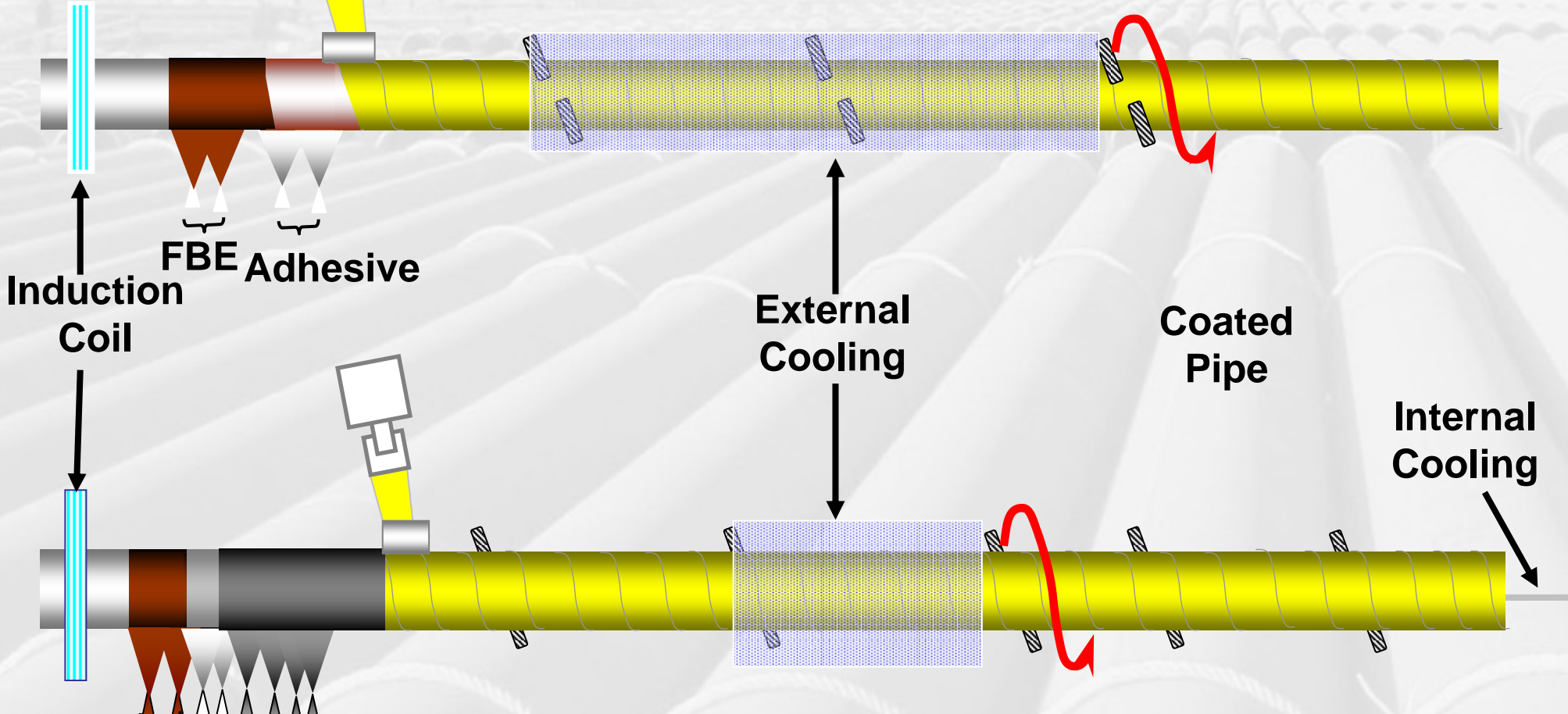
- Allow production of Multi-layer Polyolefin of any thickness with Uniform Thickness at all points
- No Tenting along the edges of welds

# New Approach to Multi - Layer Polyolefin Coatings

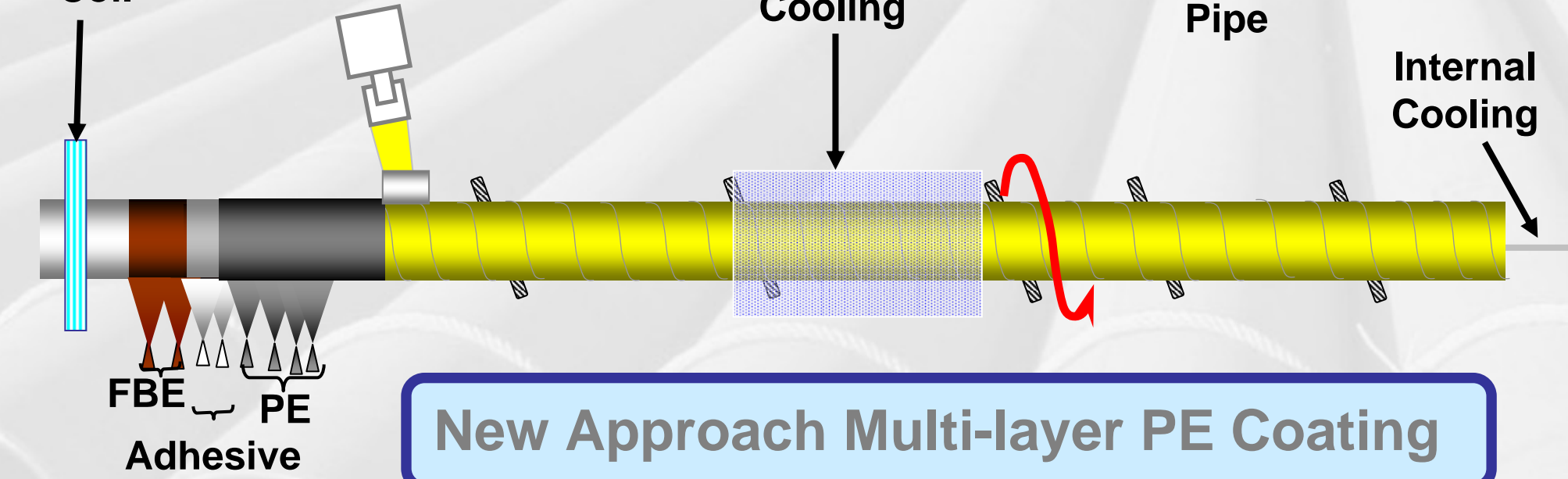


Sheet Extruder

# Conventional 3LPE Coating



# New Approach Multi-layer PE Coating

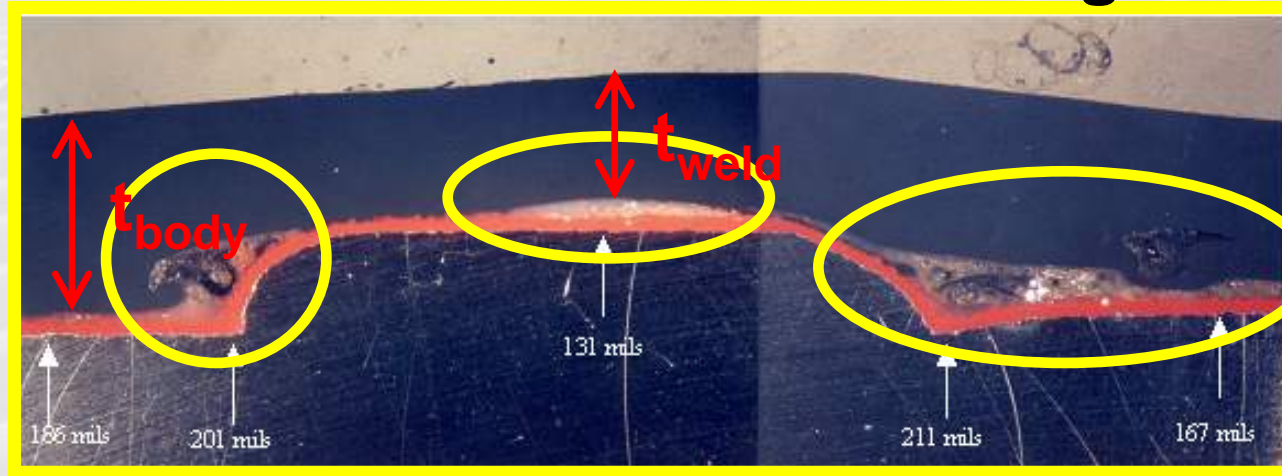




# Coating Effectiveness

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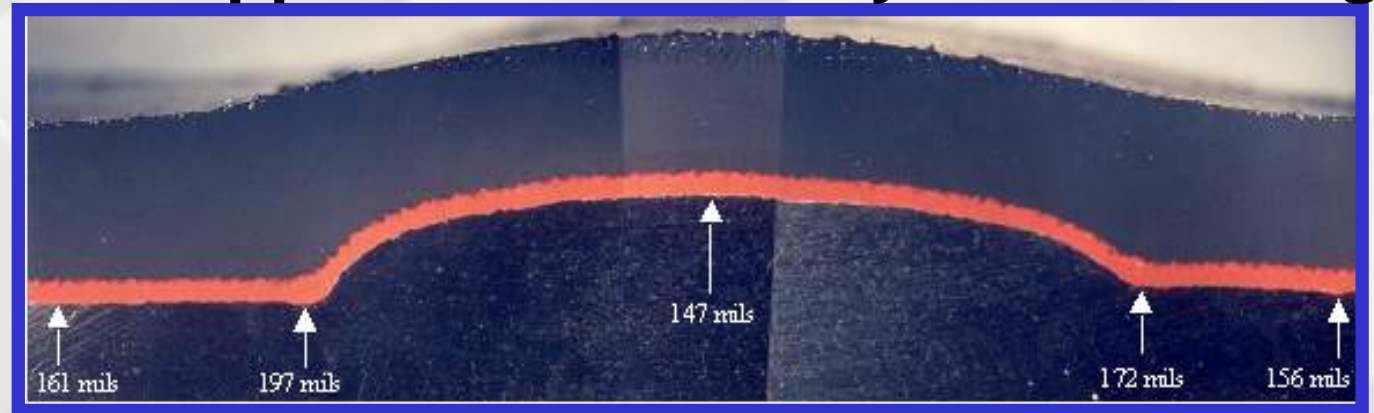
## Conventional 3LPE Coating



$$\frac{t_{weld}}{t_{body}} \sim 60-70\%$$

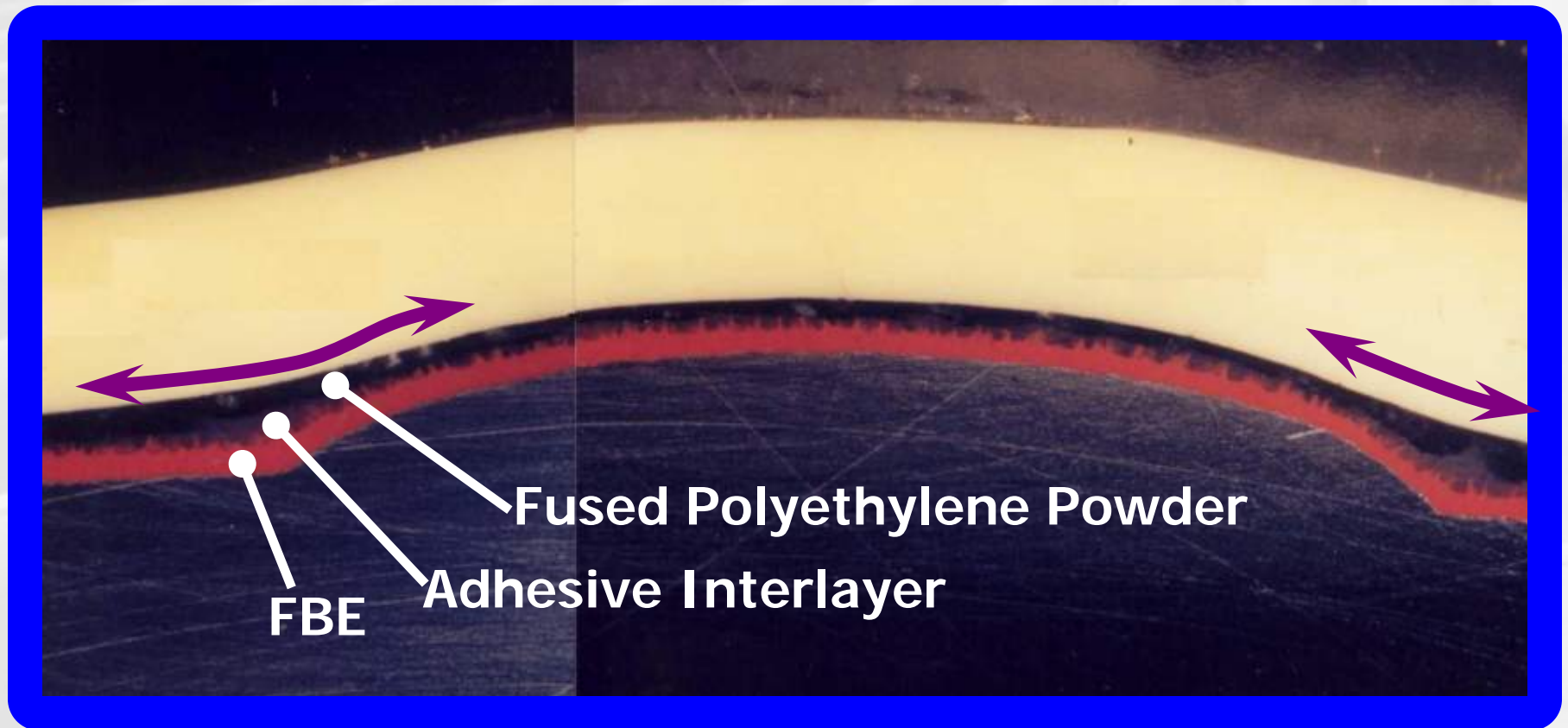
**Weld Tenting**

## New Approach to Multi-layer PE Coating



# Coating Effectiveness

## New Approach to Multi-layer PE Coating



# Coating Effectiveness



**Side-Wrapped GSPE on Spiral Weld Pipe (30")**

# Coating Effectiveness



Note how well-defined the weld seam is.

Close-Up Showing Excellent Conformance to the Long Seam Weld

# Coating Effectiveness



**Intersection of the Long Seam and the Girth Weld  
on Double-Jointed Pipe**



# Physical Properties

# Physical Properties

Flexibility Test at  $-30^{\circ}\text{C}$  with  $4.2^{\circ}/\text{pd}$



Conventional 3LPE  
Coating



New Approach Multi-layer  
PE Coating

# Physical Properties

Rock Impact Test at - 40°C with 22 lb Rock  
Fell from 2 meters to the tested Coating



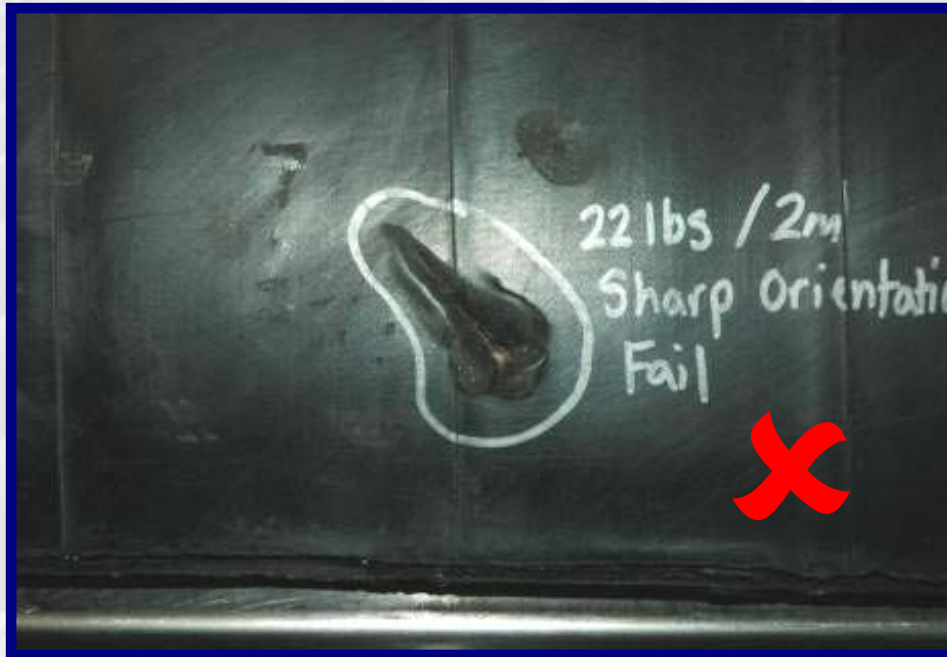
Round Rock



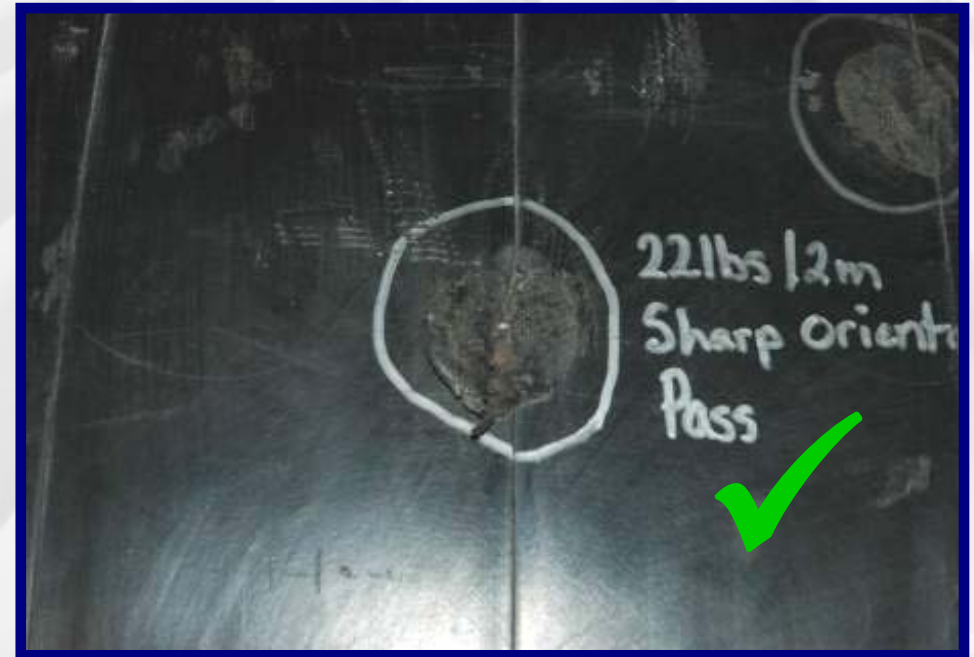
Sharp Rock

# Physical Properties

Rock Impact Test at - 40°C with 22 lb Rock



Conventional 3LPE  
Coating



New Approach Multi-layer PE  
Coating

# Conclusions

- A new coating system consists of HDPE Side-Wrapped over a “graded structure” PE is introduced.
- This new coating system overcomes the drawbacks of the conventional 3LPE coating.

# Conclusions

## The new coating system .....

- Provides exceptionally uniform coverage of external welds on both long and spiral welded pipes
- Eliminated “weld tenting”
- Leads to a coating with reduced residual stress

# Acknowledgements

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Thank

You!

