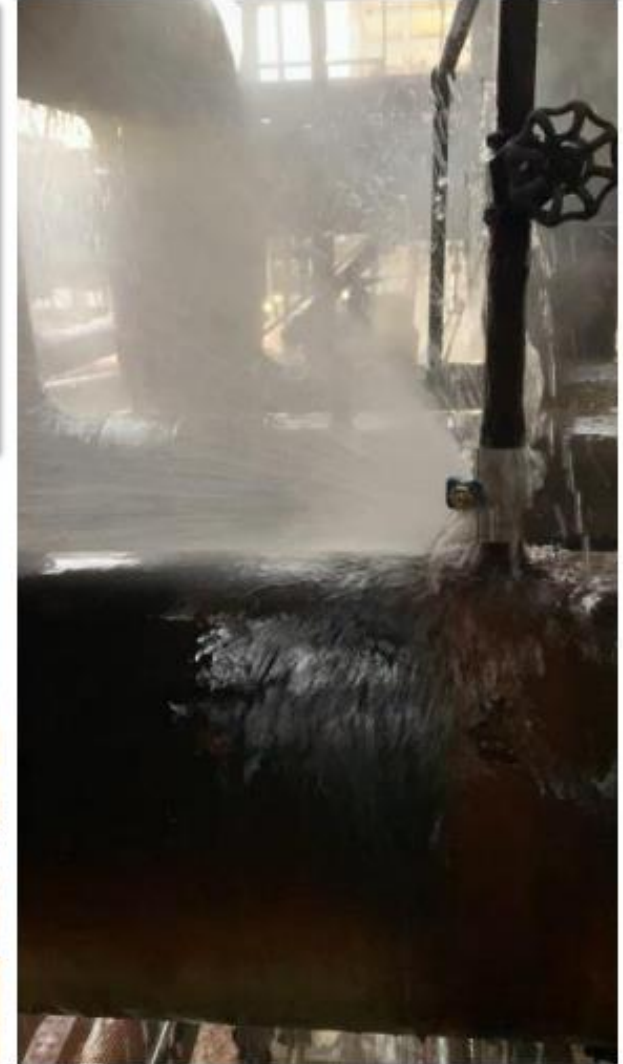




Identify Critical Requirements

- Leak sealing
- Corrosion Resistance
- Wear Resistance
- Mechanical Reinforcement
- Chemical Resistance





Secondly Determine Additional Requirements

- Job Conditions
- Delivery
- Supply Chain
- Price





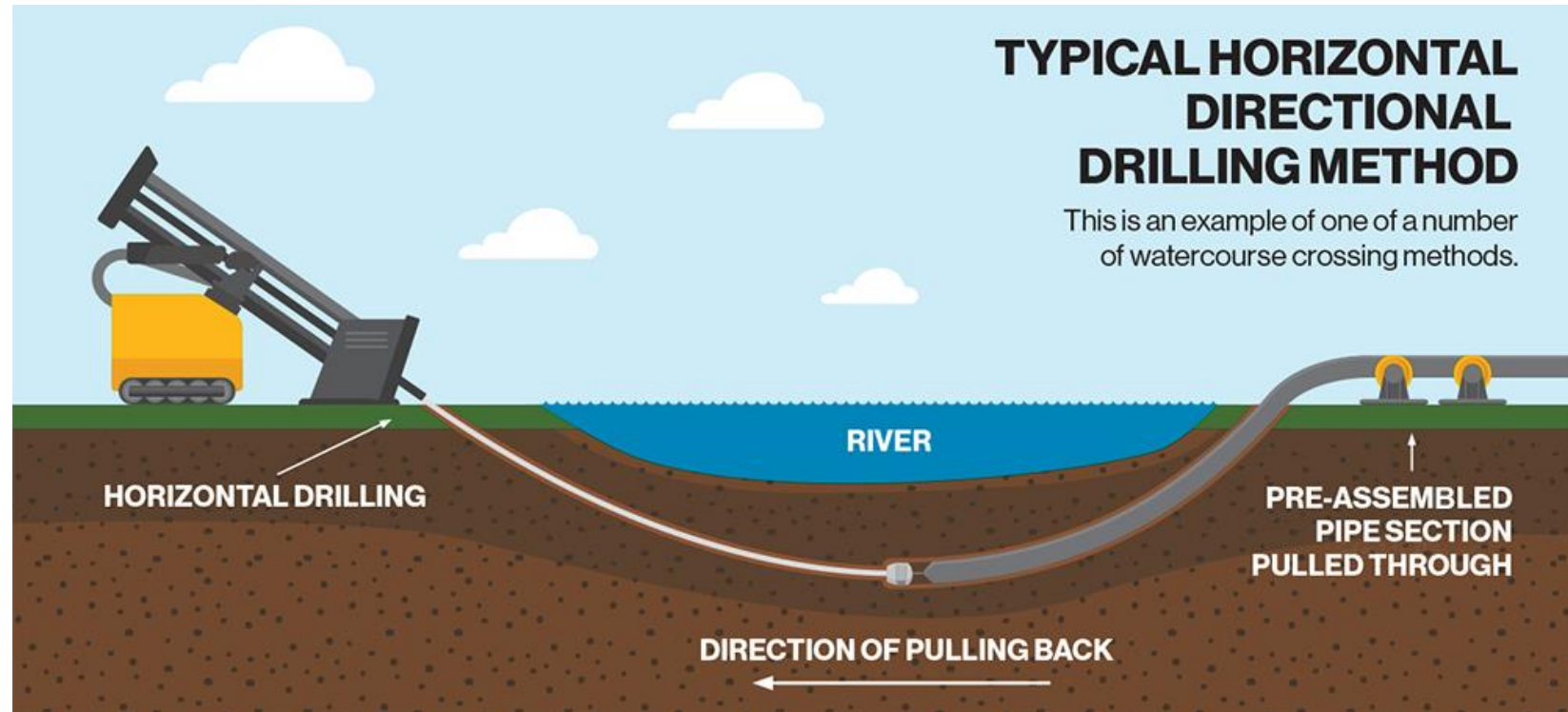
Horizontal Directional Drill Abrasion Resistant Over Coat (ARO)

Primary:

- 400,000 Linear Feet 2021 & 2022 Requiring ARO
- Abrasion & Impact Resistance
- Supply Chain

Secondary:

- Price
- Ease/Speed of Use
- Delivery





ARO Critical Design Requirements

Abrasion & impact resistance

- [Shore D hardness \(ASTM D2240\)](#)
- [Ply thickness \(direct impact on Wear & Gouge Resistance\)](#)
- Impact strength (energy absorbed before cracking)
- [Wear resistance \(ASTM D4060\)](#)
- [Gouge resistance \(CSA Z245.2\)](#)
- [Lap shear strength \(ASTM 5868\)](#)
- Cathodic protection



UNDERGROUND CONSTRUCTION TECHNOLOGY

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UNDERGROUND CONSTRUCTION TECHNOLOGY

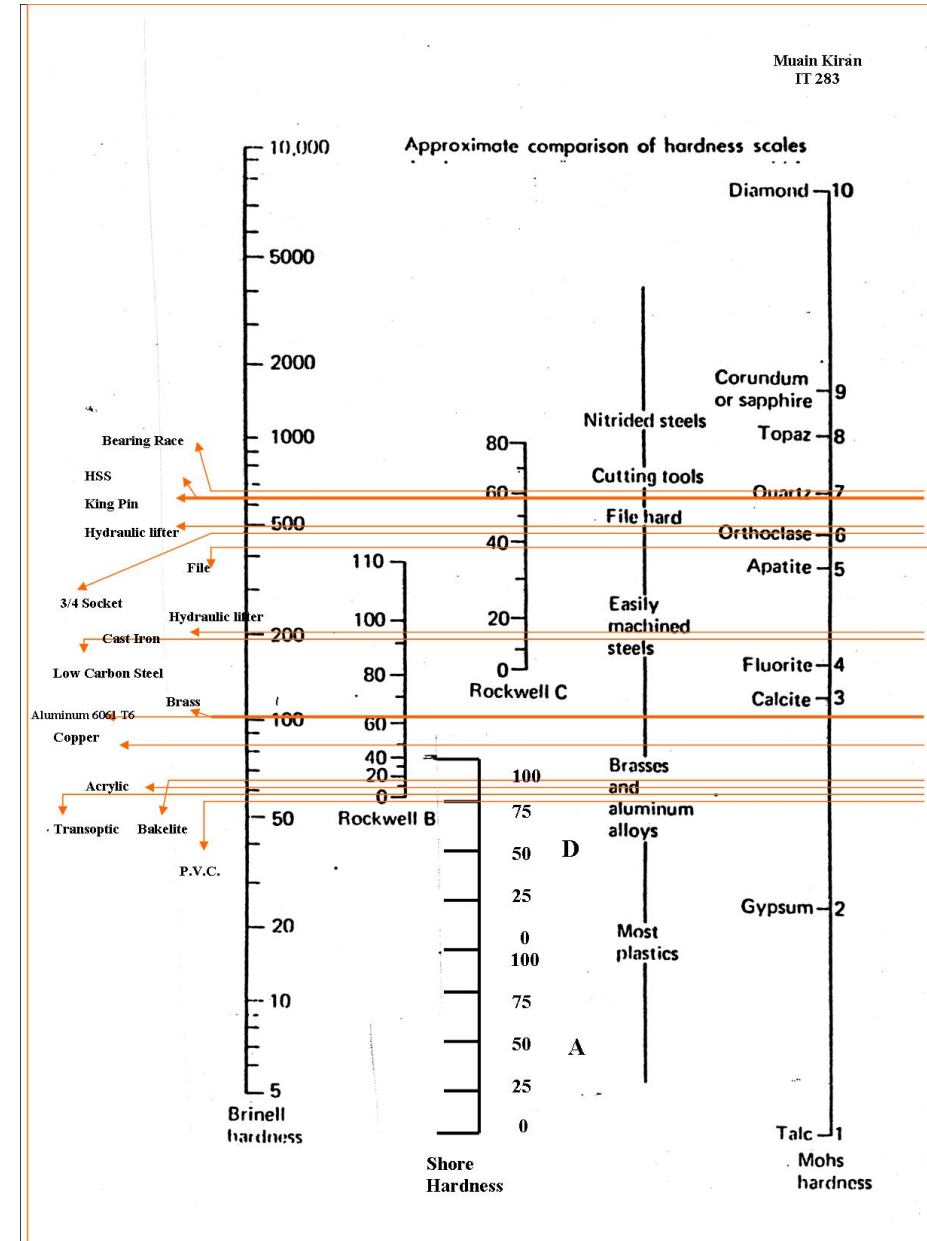
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Hardness Tests and Scales

- Shore D (Measuring the Bounce of a Known Object)
- Rockwell C (Measuring the Indention Under Force of a Known Object)
- Where is Shore D?
- Where is Hard Rock?

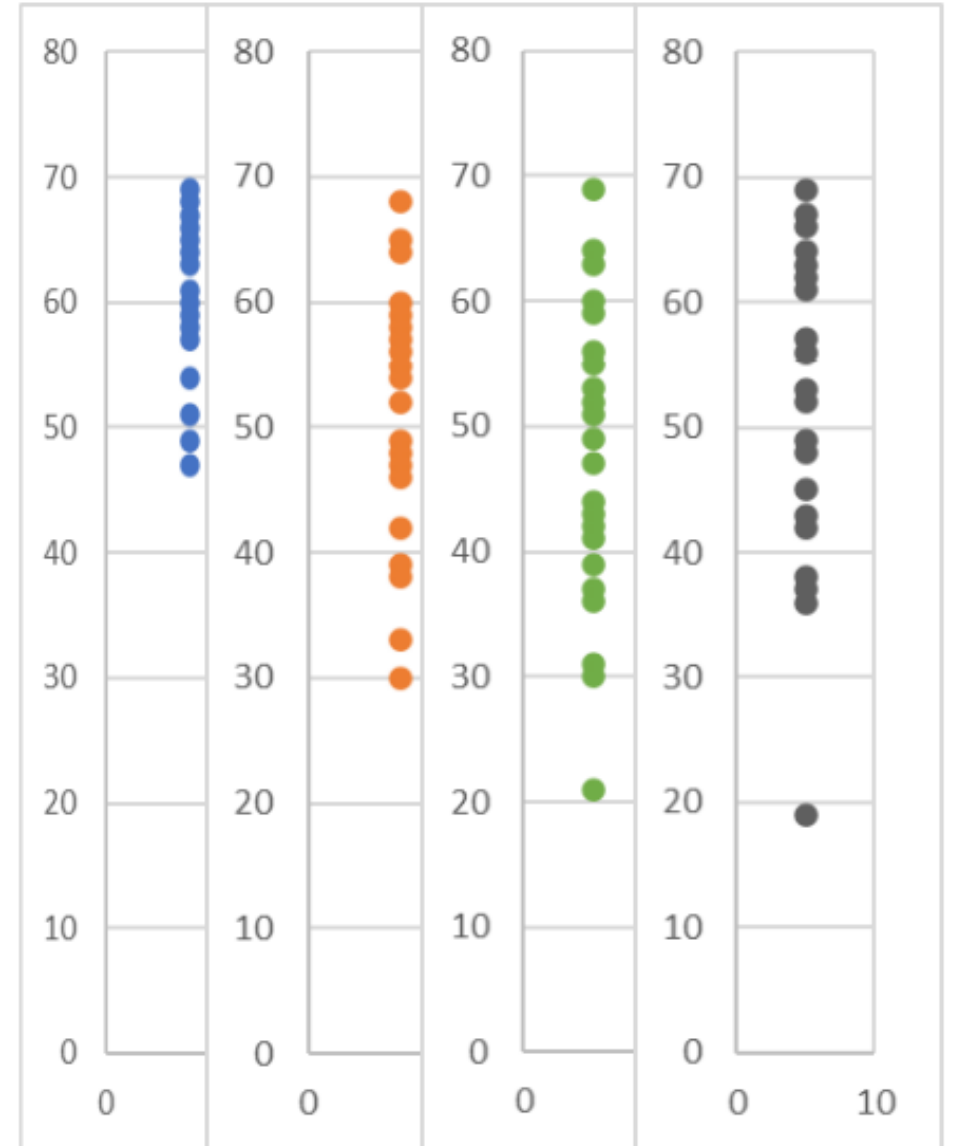


Shore D as Indicator of Cure



Four commercially available fiber-reinforced urethanes

- 17-hour cure time
- Fixed-point hardness measurement





ARO Critical Design Requirements

Secondary Consideration

- Application time/ease of application
- Cure time
- Delivery (shelf life, mess)
- Supply chain
- Regulation compliance



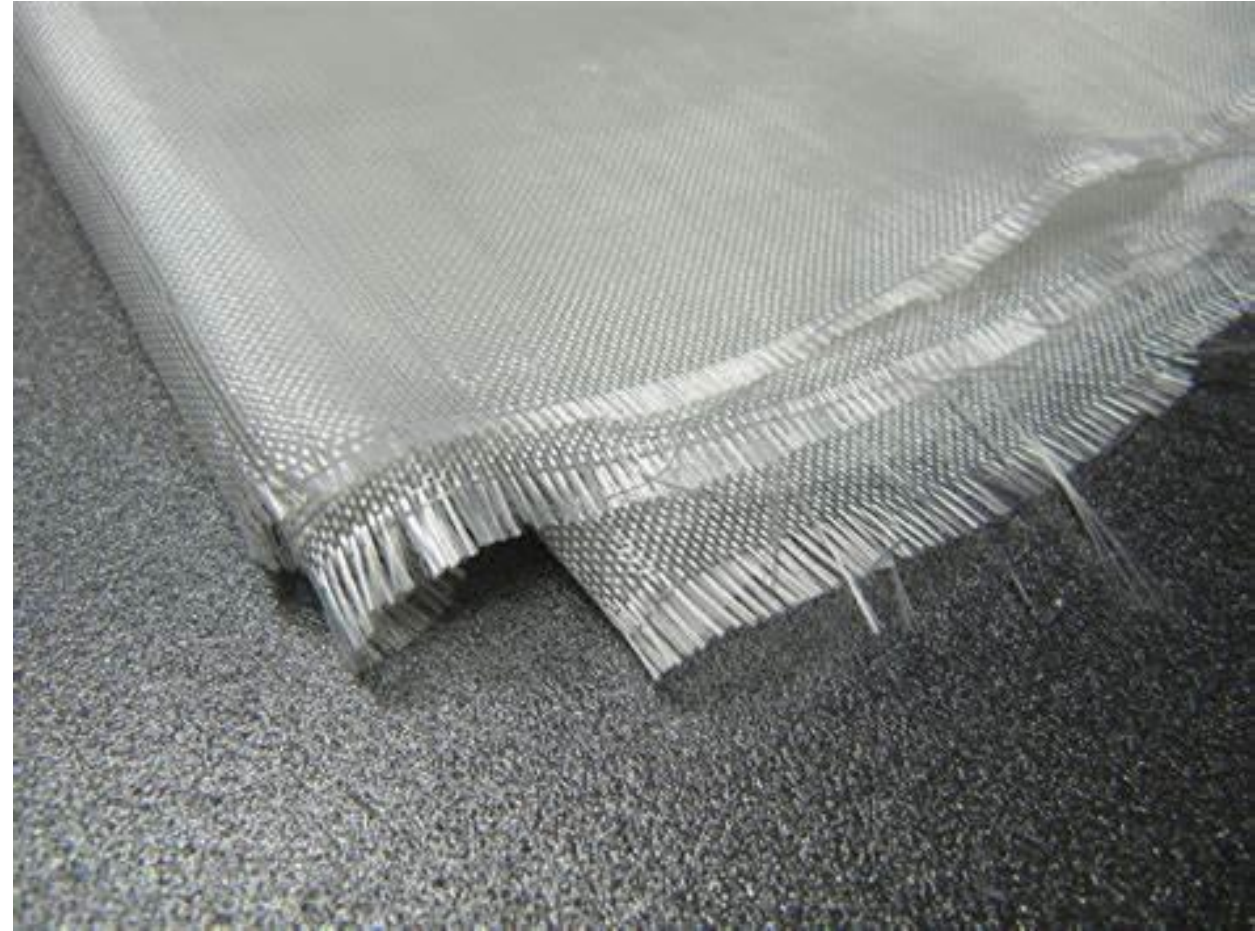
Glass Fiber

- Quilted, Weaves, Mesh
- Tows: Biaxial, Triaxial, Quadaxial, Sexaxial, No Axes

Testing For:

- Strength of Overall Composite
- Resin Loading from Pre-Impregnation
- Ease of Installation (Spiral Rapping)
- Supply Chain Stability
- Width of Finished Product

25% wider product takes 25% less time to install





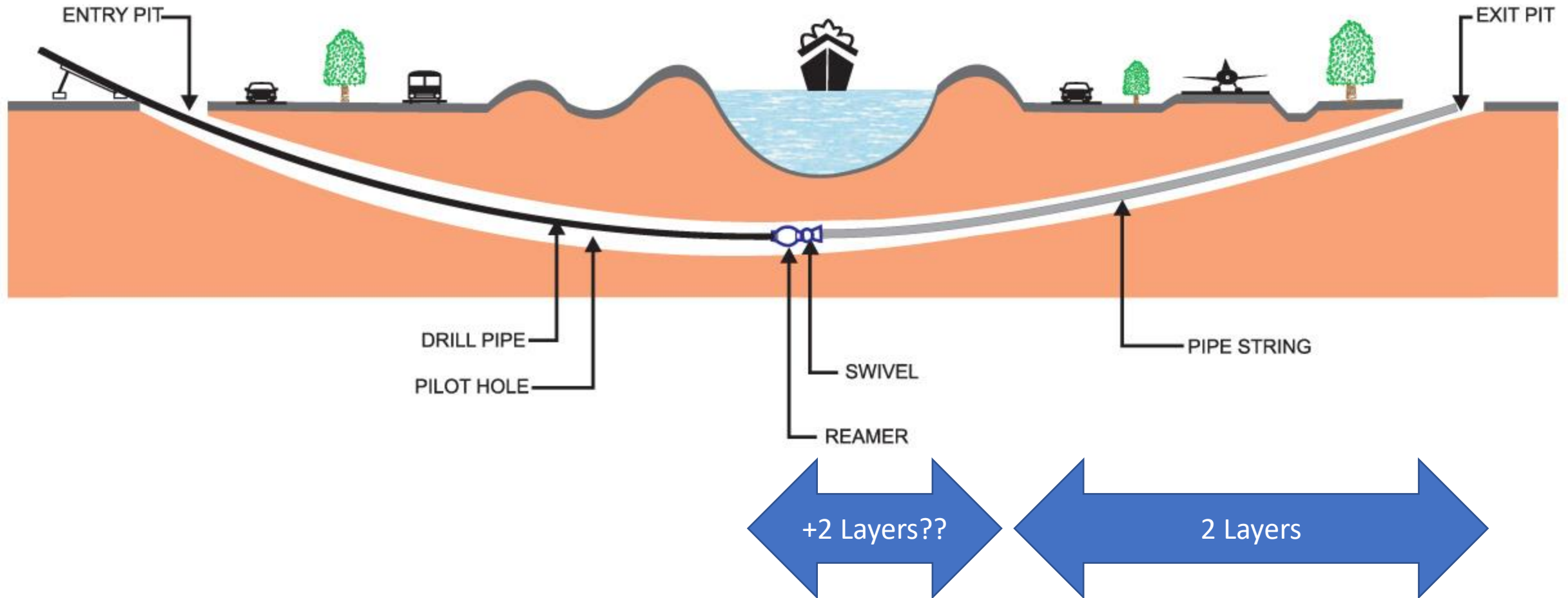
“Resin on the Pipe, not on your Boots!”

- Waste/Cost
- Ease of Use
- Homogeneous System??





After Pull Voltage Surveys Show Majority of Metal Loss is on the First Sections of Pipe





Questions?



Casey Brister

Casey.Brister@InduMar.com

Phone: 281-682-3683