Maximizing Durability and Longevity of Microirrigation Tubing

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Grange Network Webinar

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About Dow

- Dow is a global integrated science and technology company with 58 billion dollars in sales, employing 53,000 people at 201 sites around the world
- Performance Plastics is the largest Dow operating segment and the world's leading plastics business with over $22 billion dollars in revenue
- Dow was the first to offer specially designed polyethylene products to the microirrigation marketplace in the 1970's, greatly extending tubing performance at the time
- Today Dow provides the highest performance microirrigation resins to the marketplace under its FINGERPRINT™ brand

Outline

- Polyethylene
- Tubing Performance
- Tubing Failure Examples
- Tubing and Tape performance comparison

Poll Question

About how many acres are irrigated by microirrigation systems in the USA?

A. 31,600,000
B. 26,200,000
C. 4,610,000
D. 62,400,000

Poll Question

About how many acres are irrigated by microirrigation systems in the USA?

A. 31,600,000 ← Sprinkler

B. 26,200,000 ← Flood

C. 4,610,000 ← Microirrigation (2.9 Million Acres in California)

D. 62,400,000 ← Total Irrigated Acreage

Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p., http://dx.doi.org/10.3133/cir1405.

Tubing Material Components

Polyethylene

- Provides physical structure
- Tough yet flexible
- Stable at high temperature
- Resists cracking

Ultra Violet (UV) Protection Additives

- Protects polyethylene from harmful sun rays

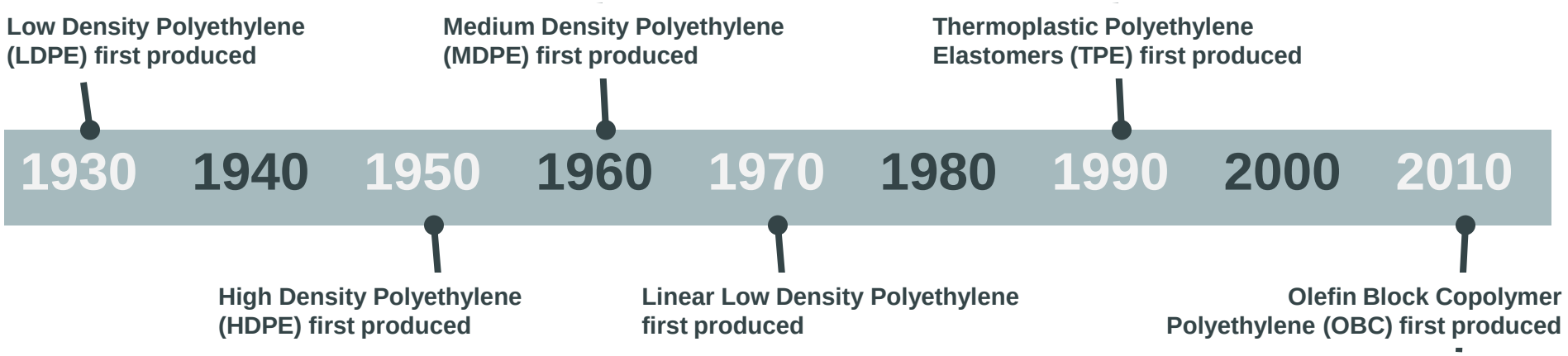
Stabilization Additives

- Protects polyethylene from degradation

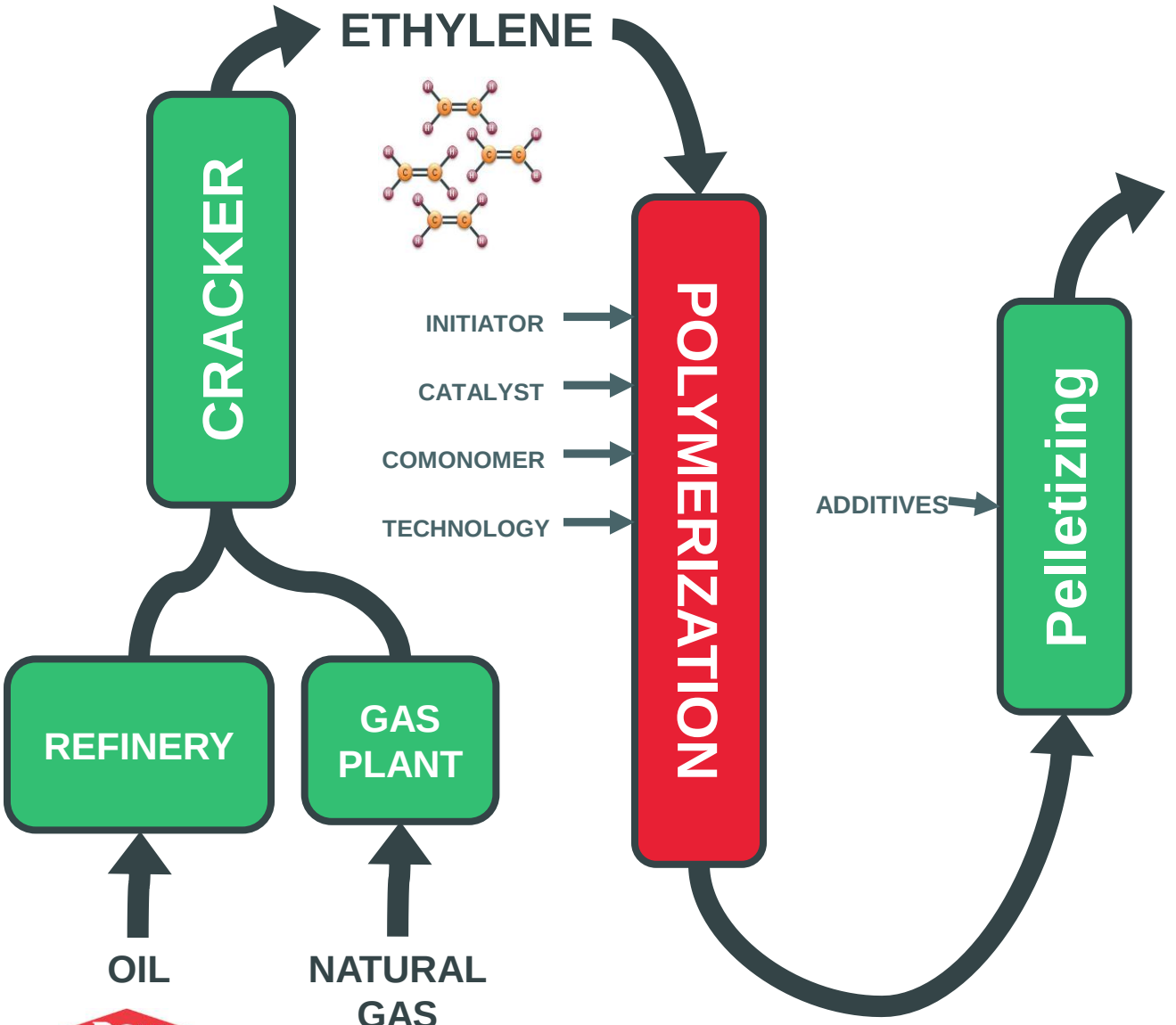
Polyethylene – It's not all the same

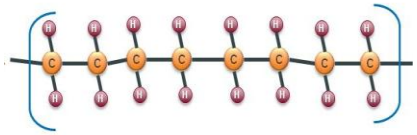
- Hundreds of different grades are produced and sold, each optimized for a wide variety of applications

No single grade meets all application requirements, therefore choosing the appropriate grade can be complex



Polyethylene – How it is made



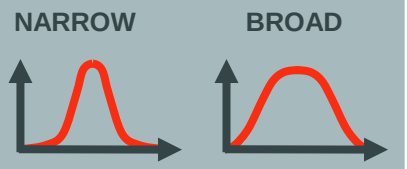
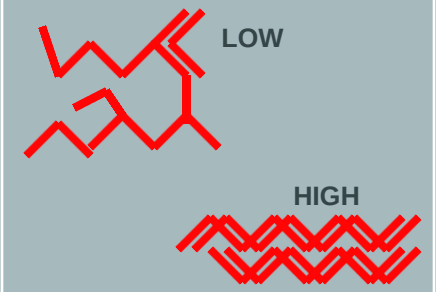


POLYETHYLENE

- Low Density - LDPE
- Linear Low Density - LLDPE
- Medium Density - MDPE
- High Density - HDPE

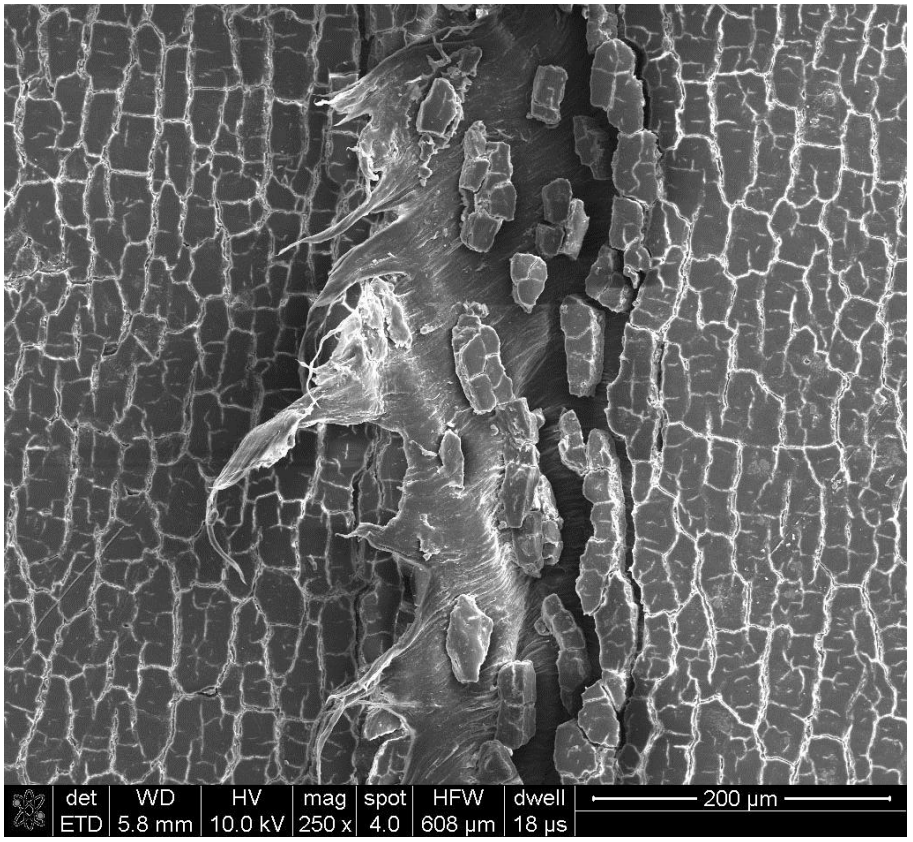
- Natural Gas used in North America
- Oil used in Europe
- Molecular architecture controlled using a variety of polymerization technologies

Polyethylene Fundamentals

Characteristic	Meaning	Picture	General Relationships
Molecular Weight (Indicated by Melt Index)	Average Size (length) of Molecules in Polymer Grade		↑MW ↑Crack Resistance ↑Strength
Molecular Weight Distribution (MWD)	Each polymer grade is made up of different size molecules, MWD describes the variation in size within the polymer grade		↑MWD ↑Melt Flow
Density	Weight per unit volume, how tightly packed are the molecules in the polymer grade		↑Density ↓Crack Resistance ↓Flexibility

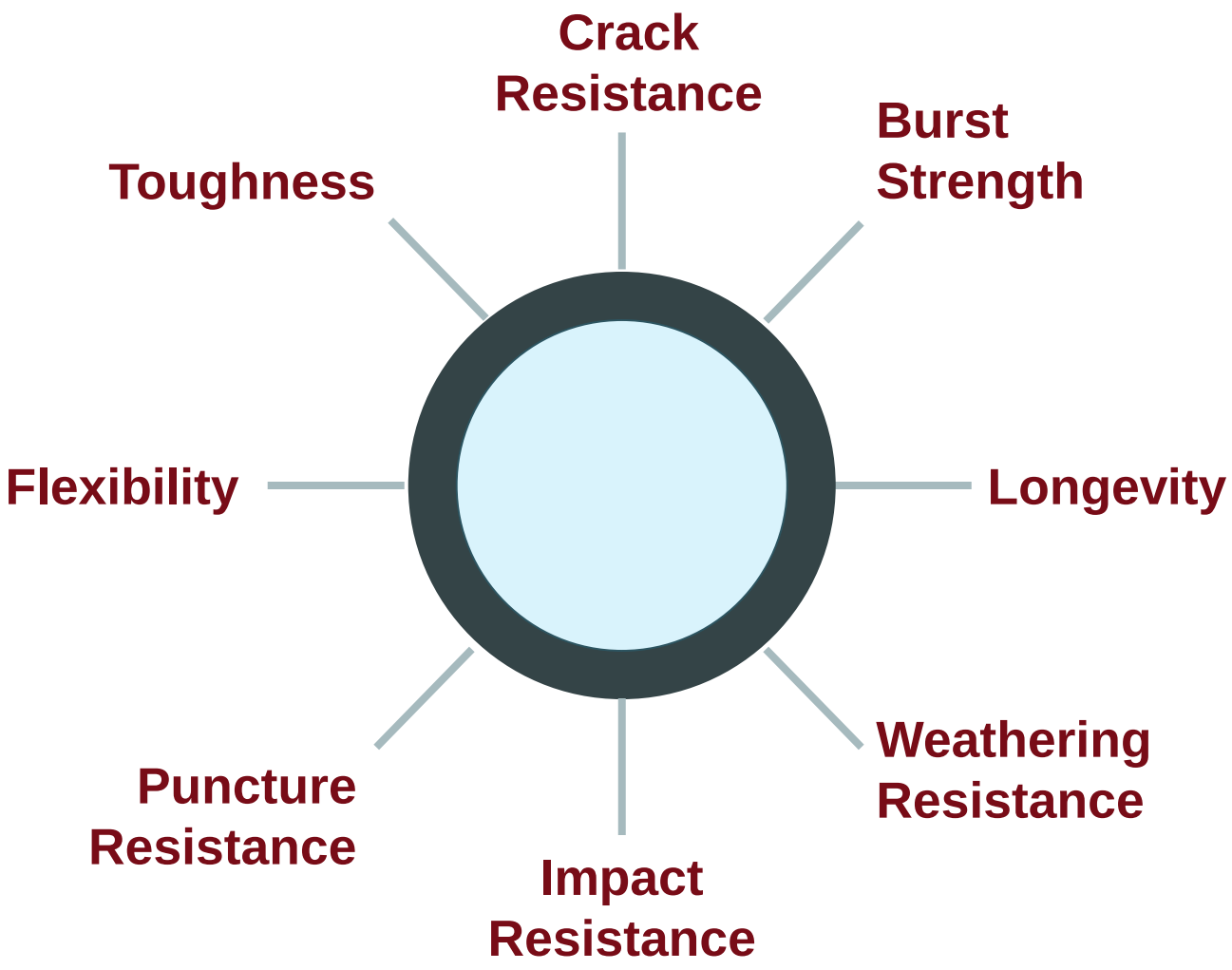
Polyethylene Degradation

- Degradation leads to a loss of physical properties
- Degradation pathways include
  - Oxidation: Oxygen from water, air, ozone
  - Ultra-Violet (UV) Radiation: Sun Exposure
  - Thermal Heat
  - Contamination
- Stabilization additives protect
  - Must consider polymer characteristics, fabrication method, and application requirements to appropriately formulate
- Carbon Black provides UV protection
  - Must be adequately mixed and dispersed into the polyethylene to protect



Scanning Electron Microscope Image of Degraded Surface and subsequent failure of Microirrigation Tube Taken at The Dow Chemical Company Laboratories in Freeport, Texas

Tubing Requirements



- Materials used to make tubing contribute to the performance and longevity of the tubing
- The grade of polyethylene used influences the level of performance in almost all of these areas
- Carbon black provides the weathering resistance properties

Poll Question

Have you experienced cracked tubing before in your operation?

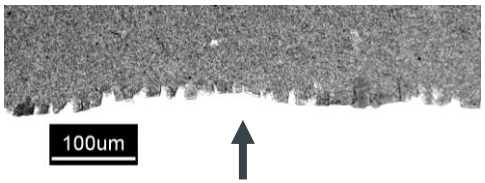
A. Yes
B. No, but know of a neighbor that has
C. No, have never experienced cracked tubing

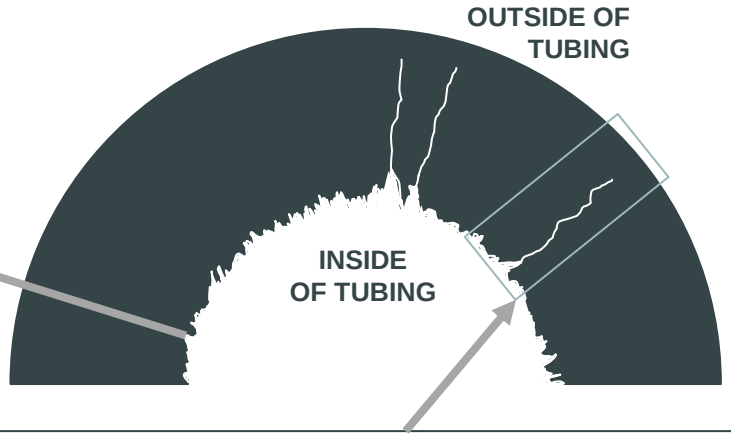
Tubing Performance Disappointments

- Crack resistance of tubing is impacted by the material components used to make it
- A desire to reduce cost leads to substandard materials being used which adversely impact crack resistance

Tubing Failure: Inside-Out

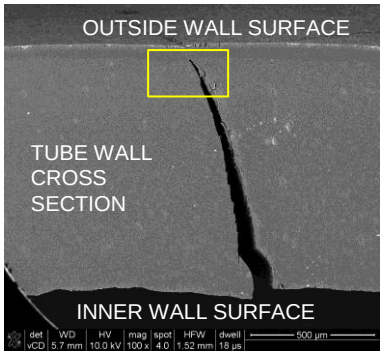
Photo of Tubing Sample, Less than 5 years In Use

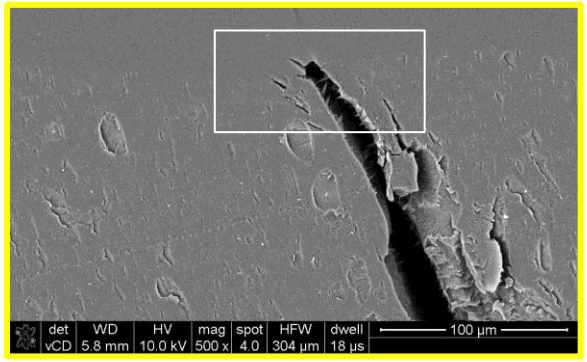


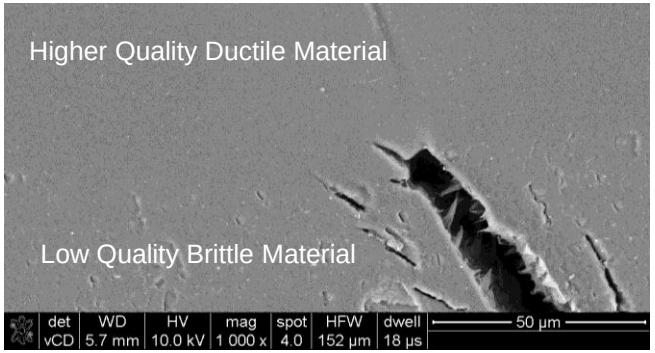


- Thin layer of higher quality material on the surface will prolong, but not eliminate, cracking when thick layers of poor quality materials are used in the core
- Oxidized polyethylene on inside of tube was brittle leaving thin layer of high quality material to hold all the pressure

Cracks Initiated from Inner Wall Surface



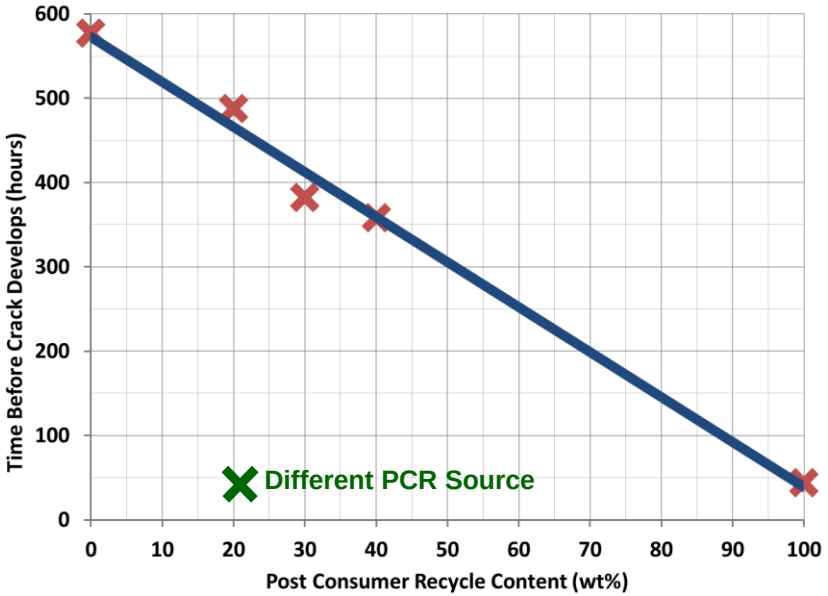




Scanning Electron Microscope (SEM) Images taken at The Dow Chemical Company Laboratories in Freeport, Texas to determine the cause of a Drip Tubing Failure

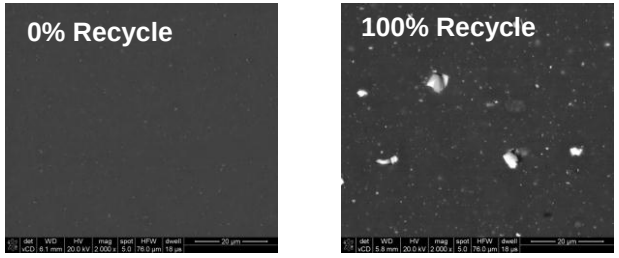
Impact of Incorporating Recycle Into Tubing

- Tubing manufactured using recycled material is more susceptible to cracking
- 1/2in tubing fabricated with FINGERPRINT™ DFDA-7510 and different levels of recycle
- Time it takes for tubing wall to crack decreases steadily as recycle content increases (Inverse relationship)
- Type of polyethylene recycle used influences crack resistance



½ inch tubing fabricated in one set, 10 Specimens were cut in machine direction from the sidewall of the tubing, bent and immersed in a 10% aqueous solution of TERGITOL NP-9 at 50°C. Time to crack was recorded. Average time is reported.

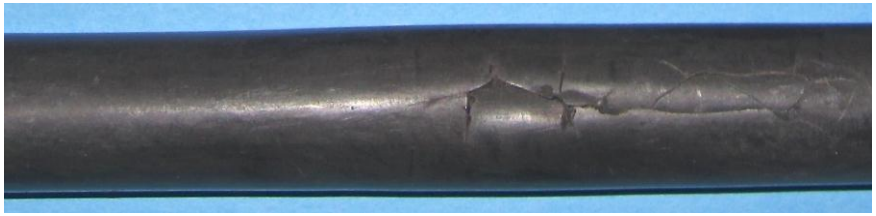
Backscatter Electron Images
(Lighter Colors Indicate Inorganic Contaminants)

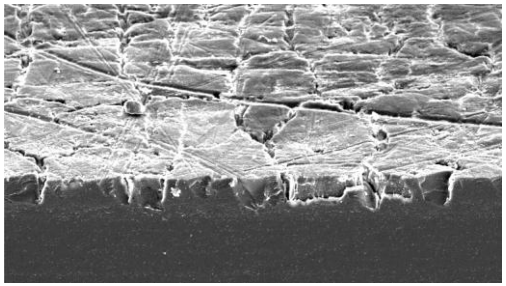


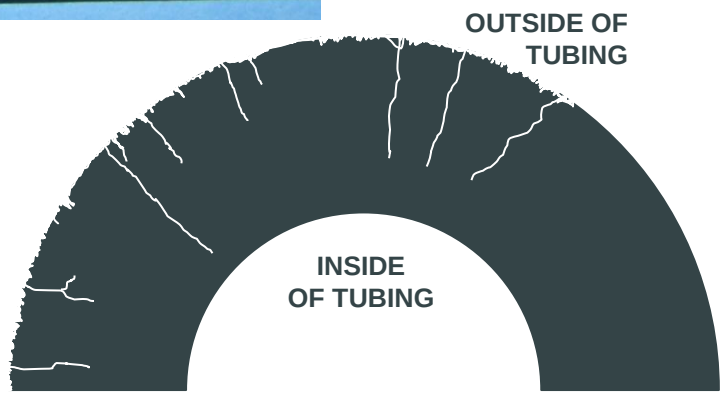
Backscatter Electron Images taken at The Dow Chemical Company Laboratories in Freeport, Texas

Tubing Failure: Outside-In

Photo of Tubing Sample, Less than 5 years In Use

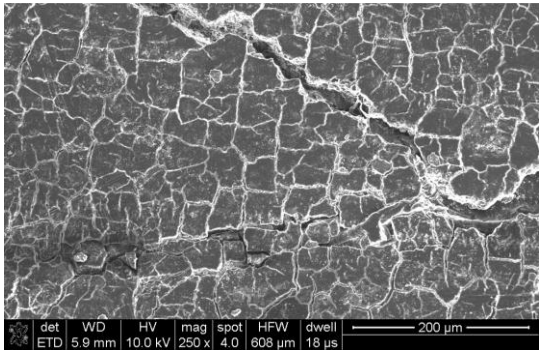


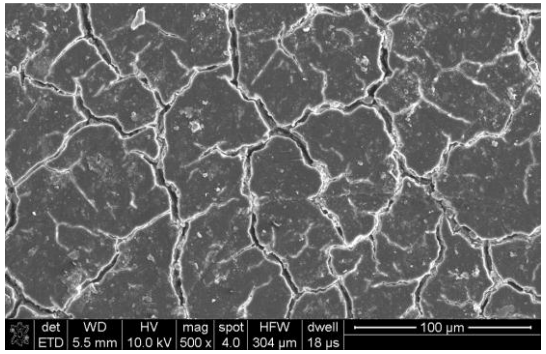


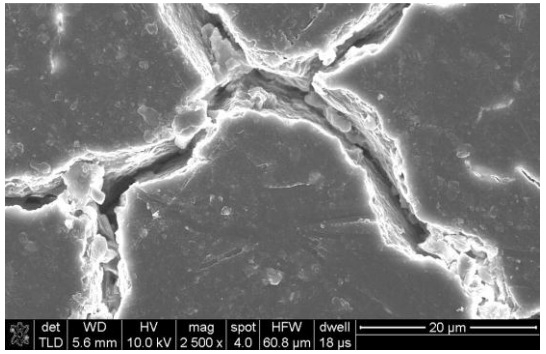


- Inappropriate stabilization of polyethylene leads to accelerated degradation and cracking
- Undispersed carbon black leads to accelerated degradation and cracking
- The materials used and fabrication methods impact tubing performance

Images Show Outside Surface of Polyethylene Microirrigation Tube That has Significantly Degraded



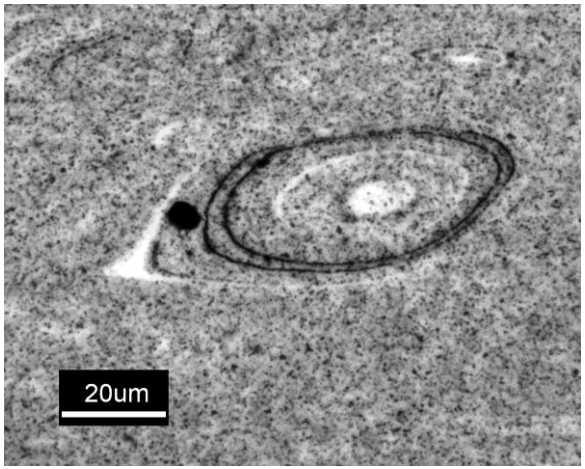


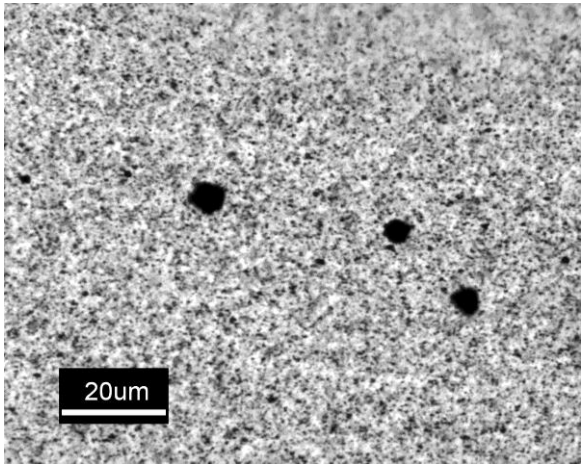


Scanning Electron Microscope (SEM) Images taken at The Dow Chemical Company Laboratories in Freeport, Texas to determine the cause of a Drip Tubing Failure

Carbon Black Dispersion

- Carbon black addition to the polyethylene is important for weathering performance
- Tubing and tape typically contain between 2-3 % carbon black
- The smaller the carbon black particle size and better the dispersion throughout the polyethylene matrix the greater the weathering performance
- Key is minimizing carbon black agglomerates and achieving a uniform carbon black/polymer morphology





Poll Question

Which standard defines minimum requirements for microirrigation tubing?

A. ASAE S435.1
B. ASAE S553
C. ASAE S526.3
D. Not aware a standard exists

Poll Question

Which standard defines minimum requirements for microirrigation tubing?

A. ASAE S435.1 ← Drip Tube

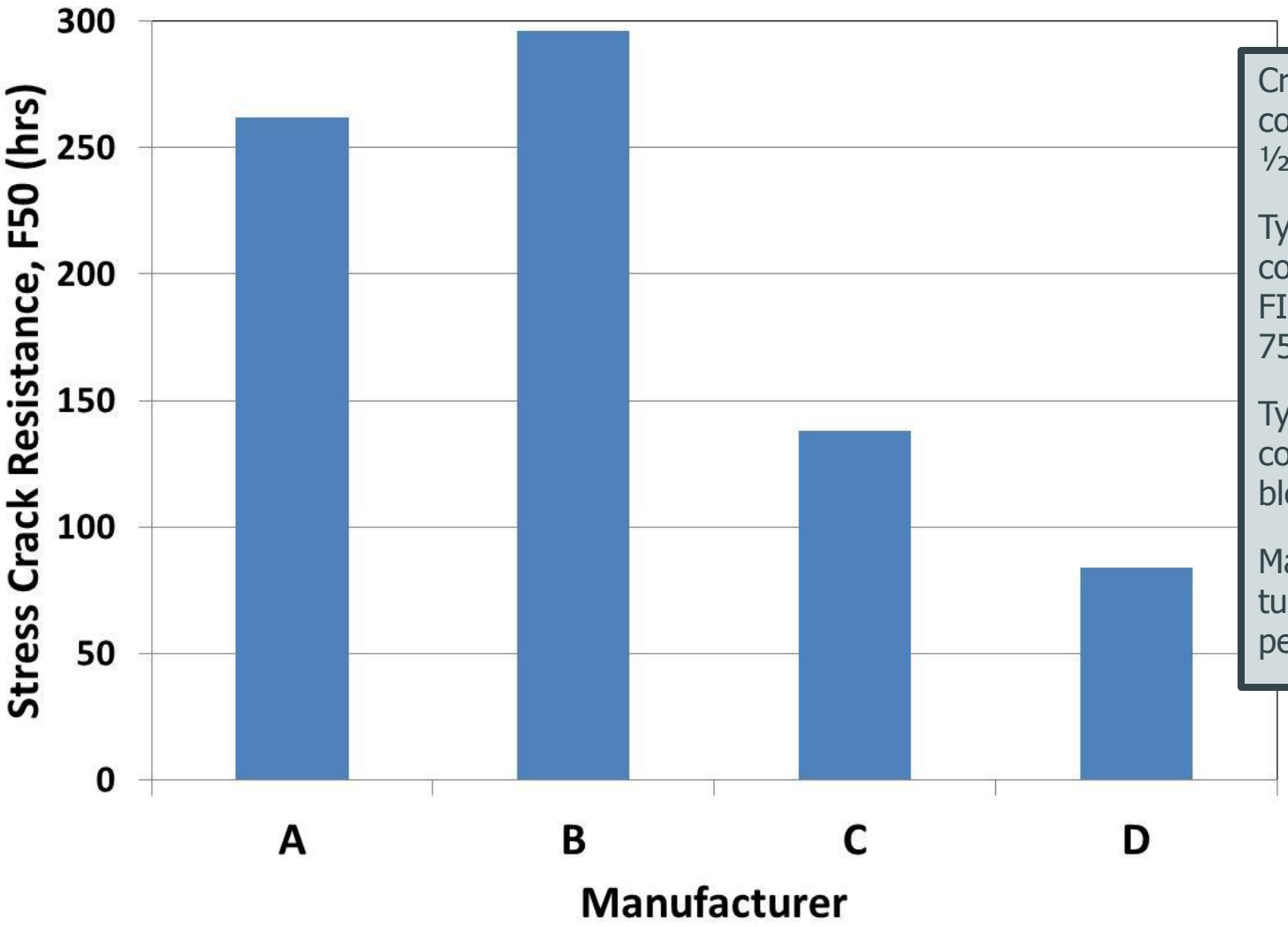
B. ASAE S553 ← Drip Tape

C. ASAE S526.3 ← Soil & Water Terminology

D. Not aware a standard exists

ASAE stands for American Society of Agricultural Engineers

Differentiating Tubing Performance



Crack resistance of commercially available ½ in tubing varies

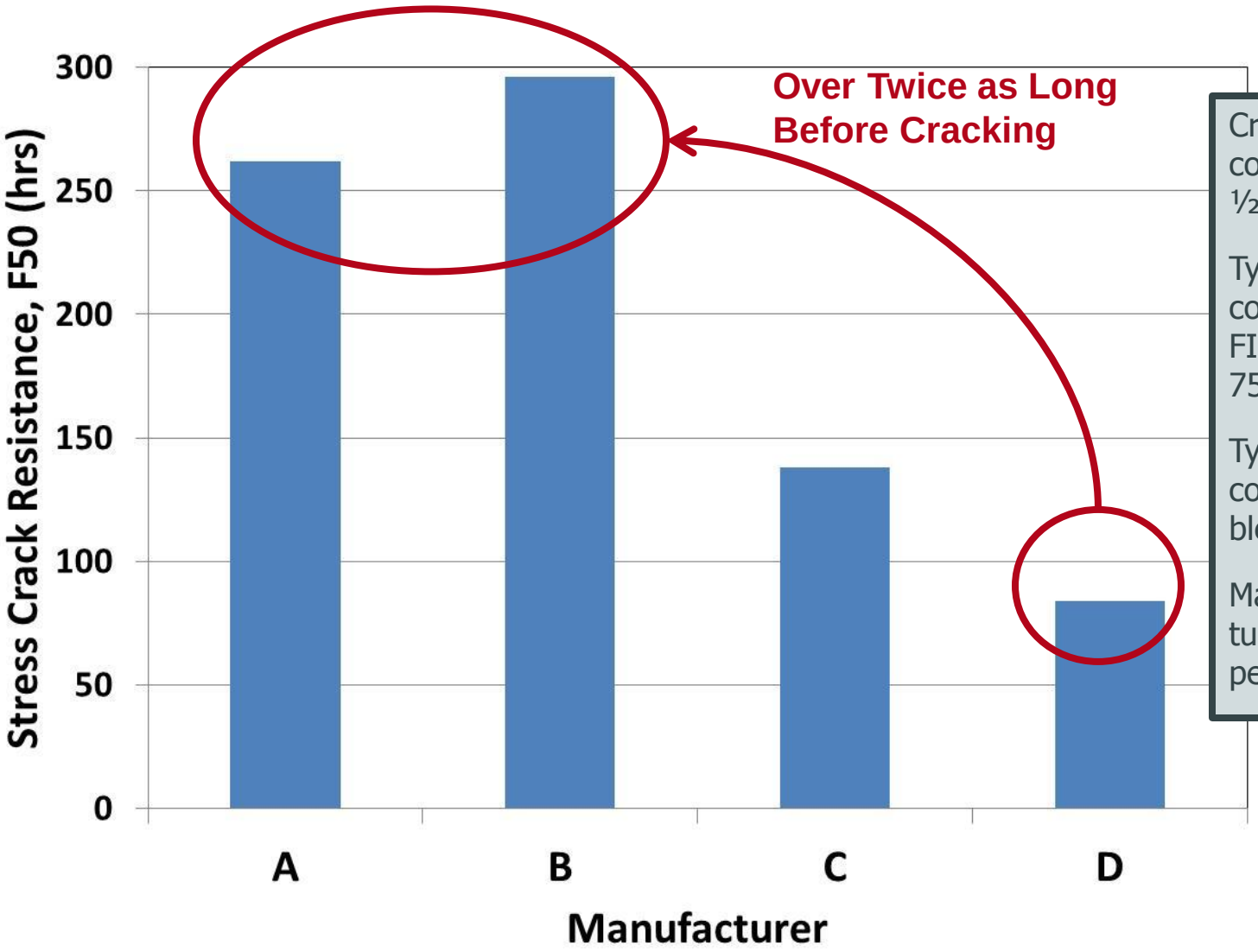
Types A and B contained FINGERPRINT™ DFDA-7510

Types C and D contained unique blends of materials

Materials used to make tubing affect final performance

½ inch tubing purchased, 10 Specimens were cut in machine direction from the sidewall of the tubing, bent and immersed in a 10% aqueous solution of TERGITOL NP-9 at 50°C. Time to crack was recorded. F50 represents time it takes for 50% of specimens to crack.

Differentiating Tubing Performance



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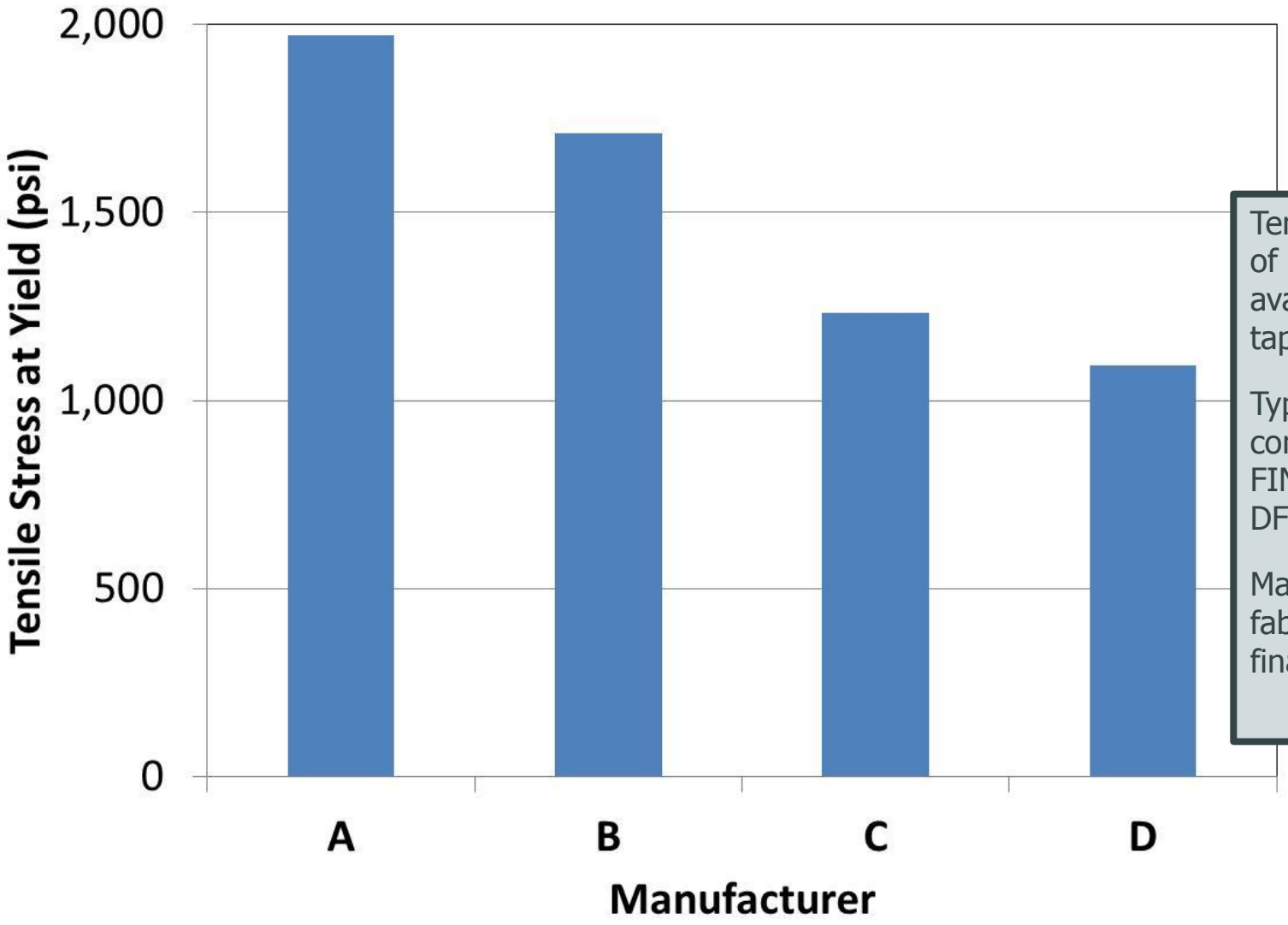
Differentiating Tape Performance



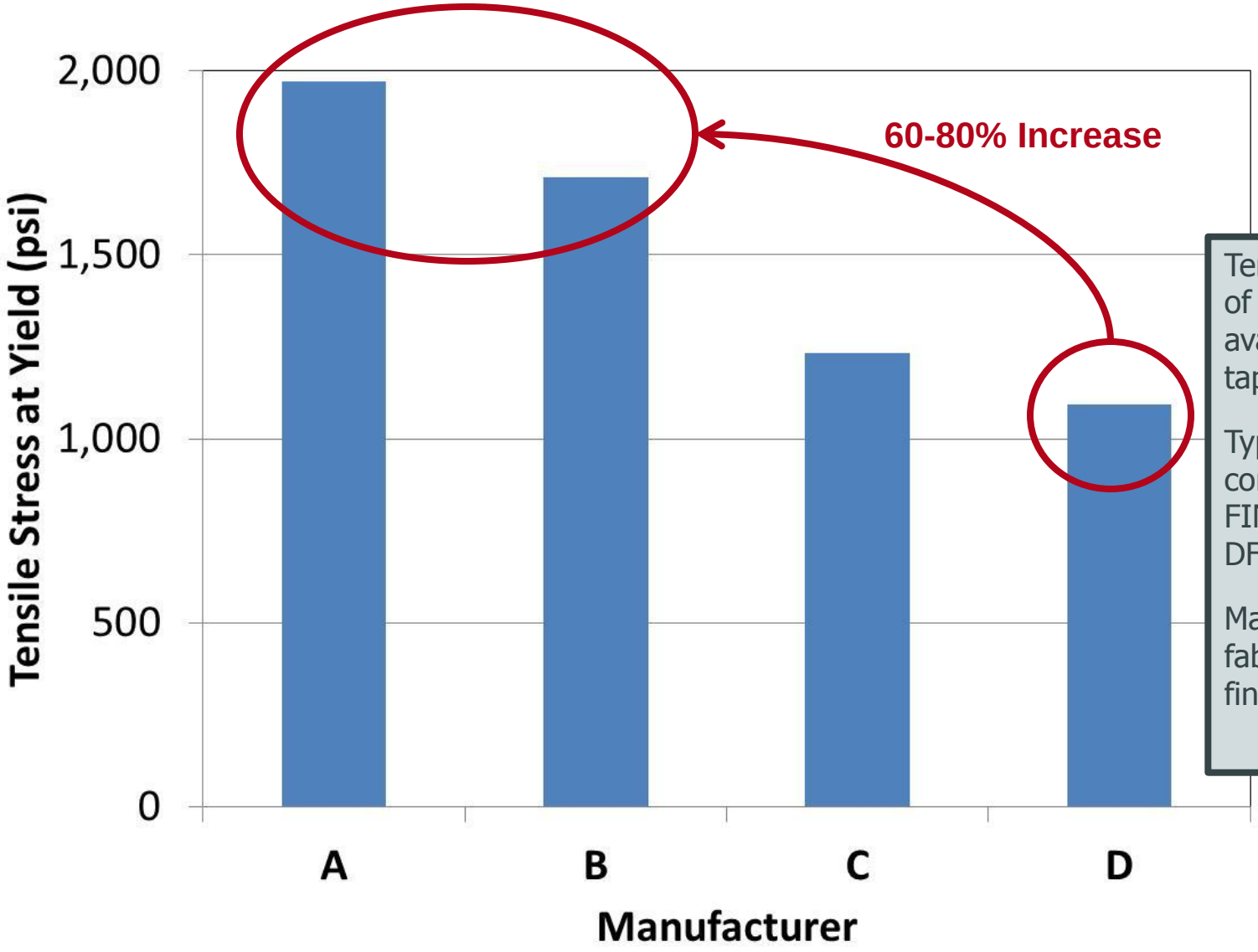
Tensile Stress at Yield of commercially available 5/8in 8mil tape varies

Types A and B contained FINGERPRINT™ DFDC-7525

Materials used to fabricate tape affect final performance

5/8in 8mil tapes were purchased. 10 sections from each tape were cut and pulled using 20in/min pull rate at 23°C

Differentiating Tape Performance



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5/8in 8mil tapes were purchased. 10 sections from each tape were cut and pulled using 20in/min pull rate at 23°C

Poll Question

What are your key takeaways from this webinar?

Please list them in the chat

Summary

- There are hundreds of grades of polyethylene, designed and optimized to deliver needed performance for specific applications
- Polyethylene with high stress crack resistance, good stabilization, and low contamination level are key to maximizing tubing life
- Undesired tubing failures are occurring today, and in most cases the cause can be traced to inappropriate material choices
- FINGERPRINT™ polyethylene is designed, formulated, and produced for microirrigation tape (DFDC-7525) and tubing (DFDA-7510) applications

Thank You