



HISTORY OF RUGGEDIZED URD CABLE DEVELOPMENT

Presented by

Kyle E. Cope

Pirelli Cables & Systems North America

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Early URD History

- Early 1800's: India rubber used as an insulation
- Late 1800's: Pitch/rubber combination as well as shellac used for insulation
- 1910 - 1920: Paper insulation
- 1960's: Polyethylene
- Late 1960's: Cross-linking via irradiation yields 90°C wet performance



Benefits of PE in URD Systems

- Low material cost
- Low cost of installation (at least initially!)
- Long cable life
- Simple repairs



Problems of the 1970's

- Failure frequency starting to be noticeable
- Customer's demanding better service
- Cable life not as long as expected
- Next evolution of cable design needed: Make cable tougher!



Why are Ruggedized Properties Needed?

- To minimize mechanical damage
 - This mechanical damage has been attributed to cuts, scrapes and dig-ins which occur during installation
 - When the aluminum conductor is exposed to moisture, corrosion begins
 - Premature electrical failure is the result



Typical Materials Used in Ruggedized Cable

- Polyethylene
 - Excellent Dielectric (2.3 at 1 MHz)
 - Excellent Physical Properties
 - Tensile Strength, 2300 psi typical
 - Elongation, 700% typical
 - Easy to Crosslink to get 90°C performance



Typical Materials Used in Ruggedized Cable

- Silane Masterbatches and Crosslinking
 - Used in silane injection
 - Consist of silane molecules, catalyst and peroxide
 - Insulation must be exposed to moisture to complete crosslinking
 - Can be used with commodity type resins
 - Must be careful of scorch
 - Low investment



Typical Materials Used in Ruggedized Cable

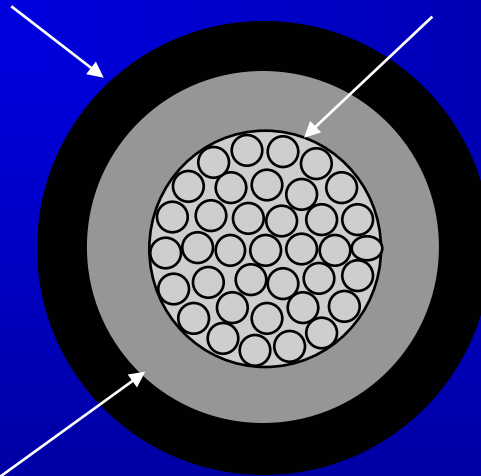
- Irradiation Crosslinkable Compounds
 - Typical Polyethylenes are modified to crosslink upon exposure to electron beams
 - Readily available, though not to the extent of polyethylene
 - Cost more than commodity resins
 - Low chance of scorch during processing
 - Requires irradiation facility (capital)



Dual Layer/Single Layer Design

Polyolefin Outer Layer

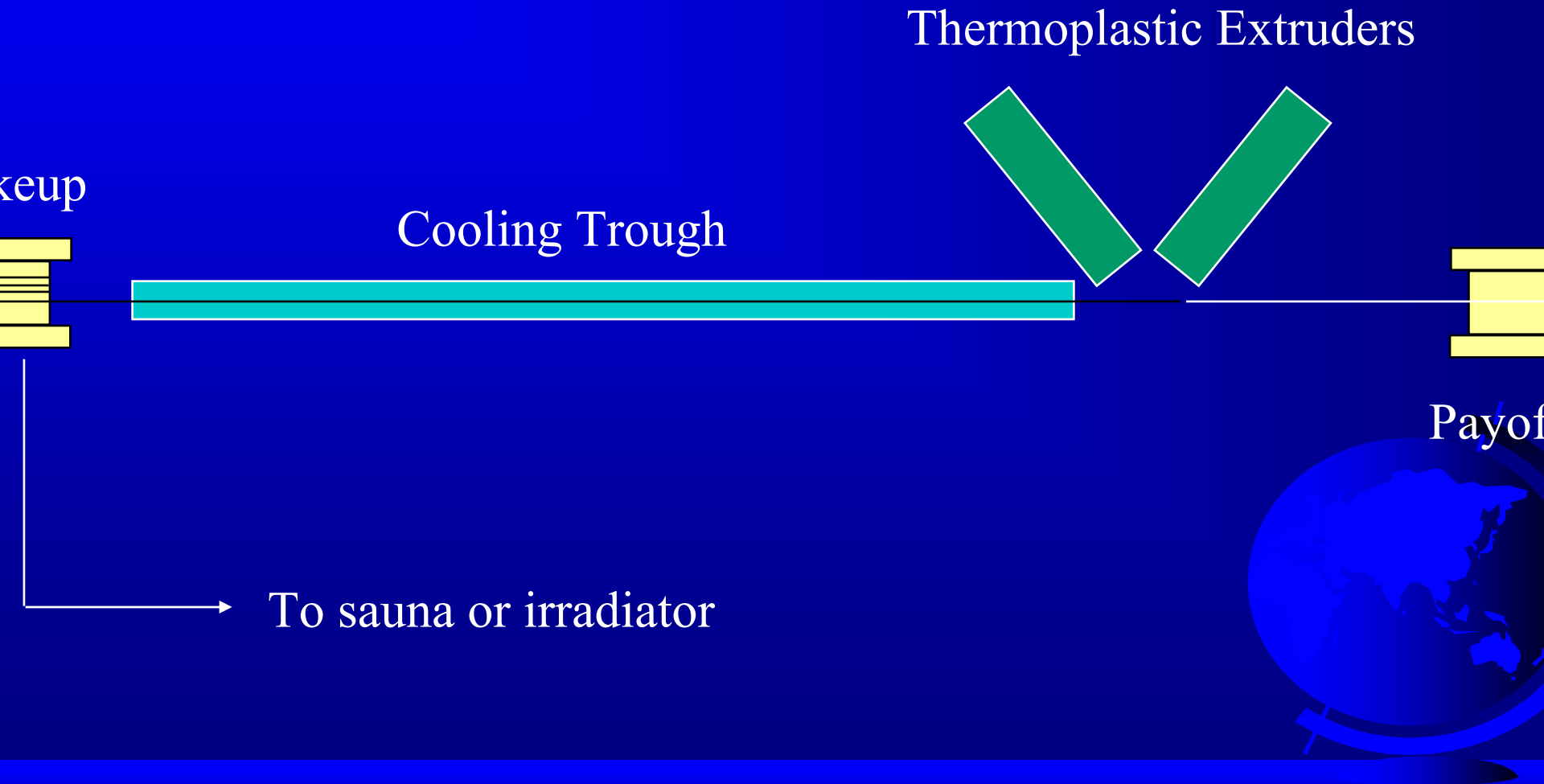
Aluminum Conductor



Polyolefin Inner Layer



Simplified Extrusion Line Layout



Testing of Ruggedized Properties

	Typical Ruggedized Cable	Standard XLPE
Sharp Impact, in-lb	30	20
Blunt Impact, in-lb	90	60
Abrasion, # cycles	650	200
Scoring, # cycles	1600	200
Puncture, lbs	80	60
Crush, lbs	900	650



Future Designs

- Current installed design has been in use since mid-1970s.
- Cable is tougher, but faults can be reduced even further.
- Next evolution of design: Cable that heals itself!



Cable Failure Mechanism

Mechanical Abuse

Insulation Breakdown

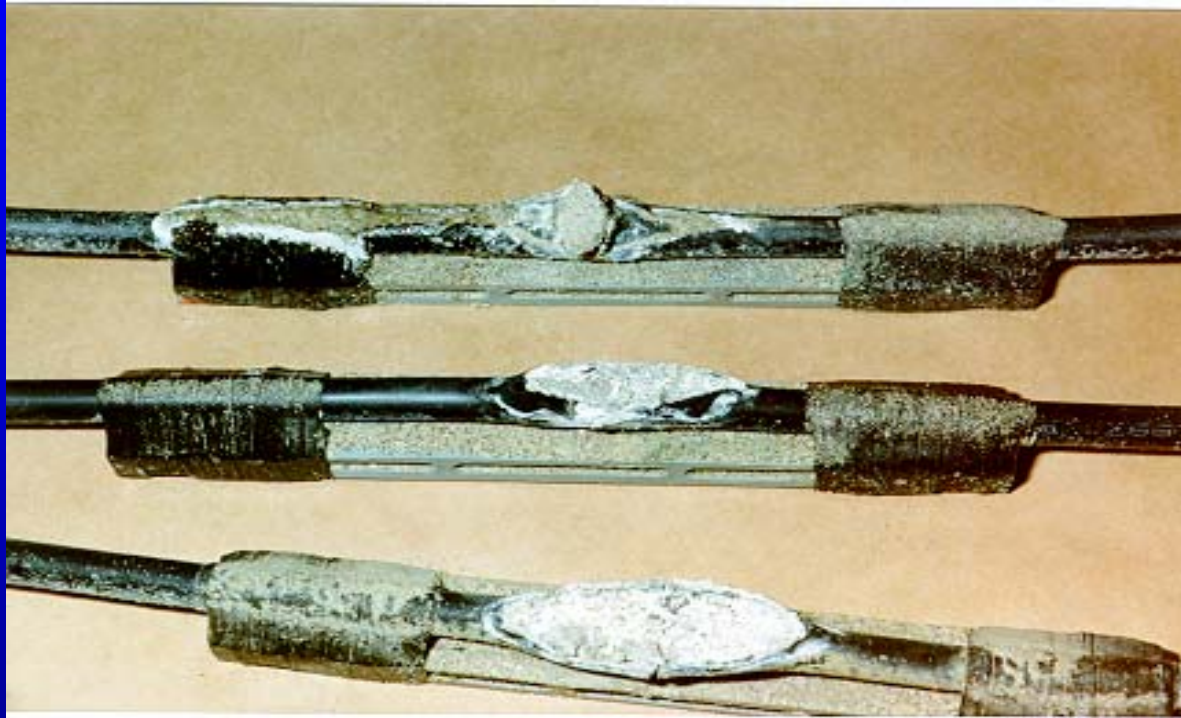
Conductor Corrosion

Increased Leakage Current

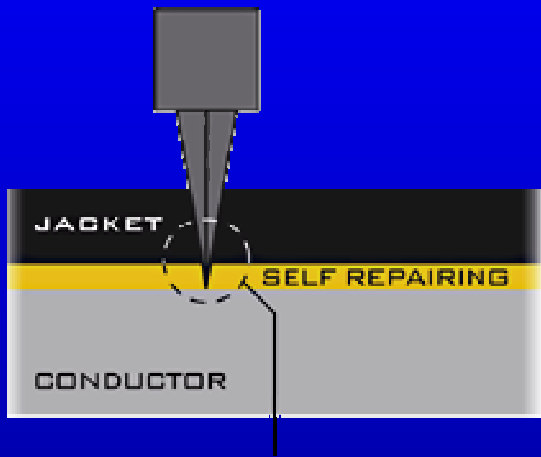
Cable Failure



Failed Samples



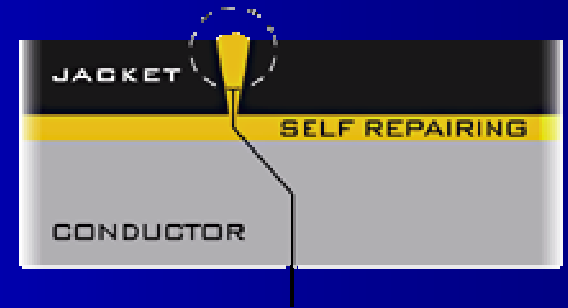
Self-Repairing Cable Concept



Damage through insulation
to Conductor



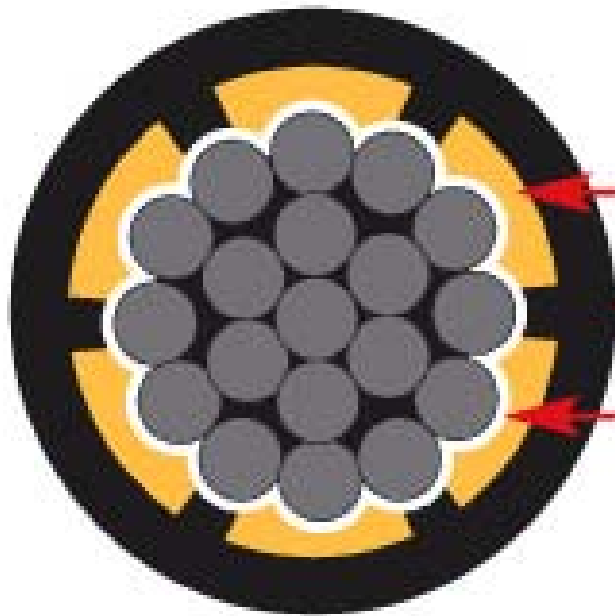
Self Repairing Starts



Cable Fully Repaired



Self-Repair Construction



Self-Repairing Compound

High Density XL Polyethylene

Mylar Separator Tape



Self-Repair Design After Damage



Self-Repairing Material Characteristics

- A dielectric material
- Highly cohesive
- Excellent cold flow behavior
- Flow stops when cut filled in
- Insulation characteristics are restored



Leakage Current

