“The Manufacture of 600 Volt Underground Secondary Cables,”

Nick Ware
Technical Director

Southwire®

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Educational Session
Power Delivery System

600 Volt Underground Residential Distribution Cable
The Product

600V, 75°C or 90°C Cable,
Suitable for Direct Burial
Outline

• Processes – the basics!
• Design – as it affects processes
• Future Cables
Conductors and Insulators

“The metals are very good conductors of electricity, silver and copper being the best; and being nearly equally as good, copper is, of course, preferred for economy, and it is this property of copper which has so increased the demand for the metal during the last half-century.”

“Glass, india-rubber, cotton, and silk, are all such poor conductors that they have been termed non-conductors or insulators. Between the metals and these come some materials which are neither good conductors nor good insulators; and it must be borne in mind that these terms are merely comparative, for a substance might be a conductor for one purpose and an insulator for another.”

The Romance of Modern Electricity,
Let’s Not Start at the Beginning

• Fast forward from 1906 to today
  – Conductors are predominately aluminum 1350 (EC) with a small market for 8000 series aluminum alloy or copper
  – Insulation is typically low density thermoplastic polyethylene (PE) or crosslinked polyethylene (XLP) of low, medium or high density, or a combination thereof
  – For the most part, 600V UG products are considered a commodity item
    • drives process changes and improvements!
First We Need a Wire!

- Aluminum rod 3/8” diameter is “drawn” (pulled through progressively smaller dies) to size
- Size depends on what end product is desired

Now we need to strand the wire into a conductor…
The Conductor

- Concentric round, produced on a strander, either rigid head or tubular
- May be reversed layers
- “Lumpy” outer surface
  - increases covering usage
The Conductor

• 3% Compression
  – Provides a smooth outer surface
  – Reduces covering usage
  – Same equipment – die compressed
    • Not compacted…compressed!

[Image: Diagram of Concentric Round and Compressed Round conductors]
The Conductor

Rigid head strander

Tubular strander
The Conductor

- Compacted – very popular in building wires
  - 8-9% reduction in diameter
  - Same equipment, smaller dies
  - Further reduces covering usage
The Conductor

• 19W and 37W Bunchers
  – Can twist all layers simultaneously
  – Can shape wires while twisting
The Conductor

- Unidirectional concentric stranding
- Produced on a buncher
- What’s wrong with this picture?
The Conductor

• Must do something to change the hex shape
  – Combination Unilay
  – Compressed Unilay
The Conductor

• SIW Compressed
  – Uses similar input wires to make multiple conductor sizes
The Extrusion Process

• The basics
  – Drop pelletized plastic into a heated barrel and screw
  – Rotate screw to feed and blend materials
  – Push plastic through a “crosshead” to apply to wire

• The details…
The Extrusion Process

Polyethylene Insulation 75ºC

Thermoplastic line – apply plastic, cool it off
The Extrusion Process

• Plastic lines
  – Relatively inexpensive line
  – Easy to run and maintain
The Extrusion Process

Crosslinked Polyethylene Insulation 90°C

Thermosetting (CV) line – apply insulation, vulcanize (or cure) with heat and pressure, cool it off
The Extrusion Process

• CV lines
  – Expensive, complex line
  – Difficult to maintain
The Extrusion Process

• Crosslinking without heat?
  – Possible with newer water curable insulations
  – Allows use of thermoplastic lines, or CV lines to make XLP cables
  – Lowers cost of new installations
  – Curing step transfers to a heated high humidity room after cable is on the reel
The Extrusion Process

• Crosshead design – pressure set-up
  – Used on CV or thermoplastic lines
  – Centering & tolerances are critical
  – Fills interstices
The Extrusion Process

• Crosshead design – tubing set-up
  – Most often used on thermoplastic lines
  – “Tube” dimensions are independent of conductor
  – Lays over interstices
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Apply vacuum

Compound Flow

Tip moves forward to align with Die

Tube draws down on conductor
The Final Steps

- Plexing of singles into 2, 3, or 4 cable assemblies
- Final electrical testing
- Shipout
Future Cables

• Biggest problem with 600V UG cable is aluminum corrosion!
• Causes usually related to mechanical damage
• Solutions are here
Future Cables

- Sealant incorporated in discrete channels
- Bleeds when cut
- Viscoelastic sealant material seals cable and then stops bleeding
Future Cables

Leakage Current Testing

Salt Water Beaker Testing

Dirt Box Testing

Leakage, mA

Time

Leakage, mA

Time
Future Cables

• AC Breakdown
  – 30kV initial ACBD
  – 4kV ACBD after 30 minutes
  – Withstood 1 week at 1kV
  – 8kV ACBD after 1 week at 1kV volts
Future Cables

• Similar self-healing cables are commercially available from multiple manufacturers
• Several years of successful experience
• Offers alternatives to high failure rates and repair budgets
Conclusion

• Cable making machines are big!
• You can’t see it all in a slide show
• If you haven’t been, go visit a manufacturer!