Island Connections: Design of 3400-ft long HDD with XLPE in SC

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Team

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  - Jay Williams, Rachel Mosier
- Haley & Aldrich (H&A)
  - Abhinav Huli, Dennis Doherty (now Kleinfelder)
- Central Electric Power Cooperative Inc. (CEPCI)
  - Jimmy Tindal

Project Need

- A new 115-kV transmission line to increase reliability to Johns Island and Wadmalaw Island.
- New line had to cross Bohicket Creek, a waterway ~3400 ft (1036 m) wide, including extensive marshlands.
- Line started and ended in residential areas.
- Too beautiful for overhead.

Environmental Needs, Social Sensitivity

- Coastal seagrasses are protected in SC, so work included mapping seagrass areas along potential alignments and following the state's best management practices for working in coastal seagrass areas.
- Stormwater runoff was controlled carefully and monitored during construction operations.
- Construction noise was minimized on both sides of the crossing, and care was taken to avoid tracking mud from the construction areas onto the roadways.

Environmental Needs, Social Sensitivity

- Grand Oak trees — southern live oak trees with trunk diameters greater than 24 inches (610 mm).
- An Angel Oak tree near construction was estimated to be 400 years to 500 years old.
- Grand Oak trees were protected on both sides of the crossing, requiring minor changes to the project alignment and protective barriers outside the tree drip lines.

HDD Design

- Analysis of soil borings along the alignment showed a depth of about 54 ft (16.5 m) below the water bottom would be in a geological formation known as Cooper Marl
- No casing required
- Ideal civil and thermal properties for the planned 24-inch diameter bore
- Cable rating calculations verified the desired 800-A rating could be achieved with cables at that depth
- Determined preferred bore entry and exit locations to avoid the marsh areas
- Calculations performed for expected drilling conditions and installation of the cable ducts.

32-in Reamer Required

- 323,000-lb (146,510-kg) thrust and pullback drill rig was placed on Johns Island
- Gyroscope steering system provided guidance of the pilot hole to improve the navigation ability of the HDD contractor
- 1700-ft (518-m) pipe laydown area was staged in the existing overhead line right-of-way on Wadmalaw Island
- Unusual resistance during pull-back of the duct bundle, so bundle was removed and the bore size increased to 32 inches (813 mm).

Duct Bundle

- Four 8-inch (203-mm) diameter HDPE cable ducts (including one spare) and two 3-inch (76-mm) communication ducts.
- Duct bundles made up using butt-fusion welds along 115-kV overhead ROW on Wadmalaw Island.
- Extensive clearing and crane matting required.
- After pressure testing, the ducts were bundled together.
- Two 1700-ft strings were assembled, and the pullback stopped for several hours to allow joining the strings.

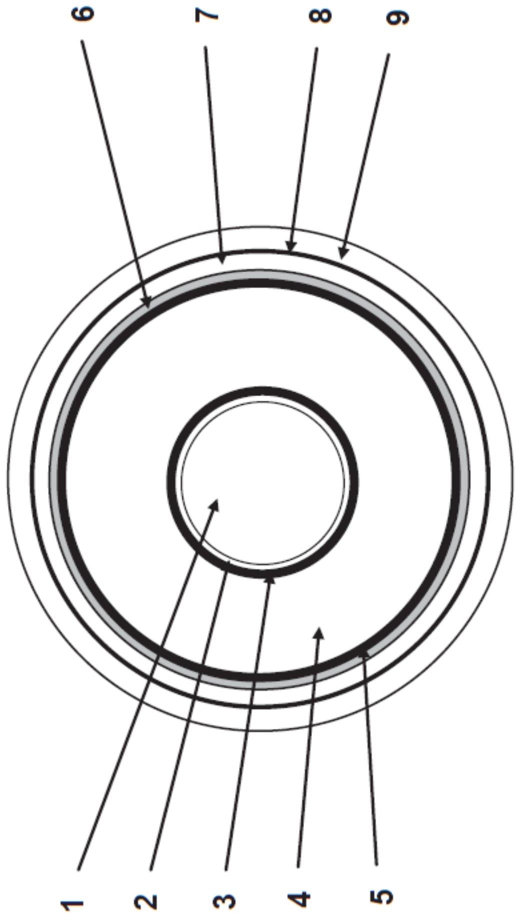
Cable System Design – Pros and Cons of HPGF

- Historically, HPGF pipe-type cables used for long crossings
  - They can be installed splice-free for lengths greater than 1.5 miles (2.4 km), but do require a trifurcating joint to separate the three phases in the 8-inch (20.32 cm) steel pipe into individual phases in stainless steel riser pipes to reach the terminations
  - A bore diameter of only 12 inches (305 mm) or so is required for the 8-inch steel cable pipe that contains the three phases
  - Pipe is rugged and pipe-type cable has an excellent and long history with HDD crossings as well as land installations
- Potential pipe corrosion could allow leaks of the 200-psig nitrogen pressure necessary to maintain electrical integrity of the paper insulation
  - Cable failure would require replacing all three phases
  - HPGF cables require a cabinet for monitoring nitrogen pressure, communications for sending alarms, and AC power supply for a cathodic protection – not feasible for the remote location of the circuit.

Cable System Design – Pros and Cons of XLPE

- Extruded-dielectric cables have a shorter operating history
- Require a much larger bore to accept the ducts that contain the individual cable phases - bore is more expensive, time consuming, and complex.
- No reliability and environmental concerns about corrosion and leaks.
- Individual phases can be replaced if there is a failure, and it is straightforward to add a spare duct or even a spare cable.
- No joints required - 3400 ft (1.04 km) or even longer can be installed termination-to-termination without the need for splices
- No auxiliary equipment, ac sources, or communications channels required
- There are many more cable suppliers and installers for extruded-dielectric cables than pipe-type cables

Cable System Design – 1500 kcmil Cu, XLPE, Lead Sheath



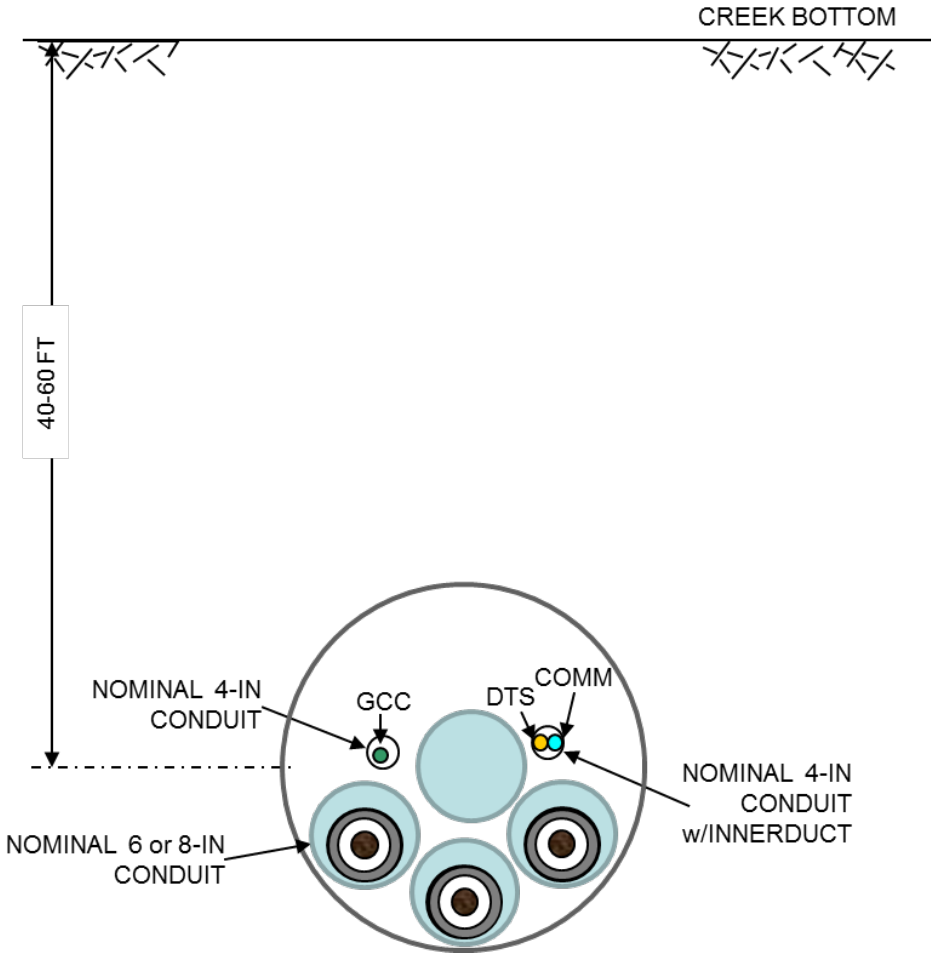
No	Description	Unit	Particulars
0	**Rated voltage**	kV	115
1	**Conductor**		Copper wires
	- nominal cross- sectional area	kcmil	1500
	- shape		Compact
	- diameter(approx.)	inch(㎜)	1.319(33.5)
2	**Conductor binder**	-	Semi-conducting tape(s)
3	**Conductor shield**		Semi-conducting thermosetting compound
	- thickness (min.)	mils(㎜)	24(0.61)
4	**Insulation**		Cross-linked polyethylene(XLPE)
	- thickness (nom.)	mils(㎜)	590(15)
5	**Insulation shield**		Semi-conducting thermosetting compound
	- thickness (min./max)	mils(㎜)	40(1.02) / 100(2.54)
6	**Longitudinal water barrier**	-	Semi-conducting water swellable tape(s)
7	**Metal sheath**		Cu-Te Lead alloy
	- thickness (nom.)	mils(㎜)	145 (3.7)
8	**Anti-corrosion layer**		Bitumen
9	**Jacket**		Black HDPE with graphite coating
	- thickness(min.)	mils(㎜)	100mils (2.54)

Cable System Design – 1500 kcmil Cu, XLPE, Lead Sheath

- Conventional cable design
- Lead sheath because the ducts would be filled with water, and the cables must operate for many decades under a hydrostatic head of more than 60 ft (18 m).
  - Laminate shields have a good operating history for land installations
  - Lead sheath has proven reliability in a water environment, commonly used for submarine cable applications
  - Calculations showed added weight of lead sheath was acceptable for the 3400-ft pull length.
- The cable was delivered to the port of Charleston on three individual reels, trucked to the local co-op's storage yard and brought to the installation site on special reel trailers for installation.
- Cable installation went smoothly, due in part to the liberal application of lubricant.

Cable System Design

- Separate fiber-optic cable installed to permit multiple single-mode communications fibers as well as a few multimode fibers for distributed temperature sensing.
- Utility considered installing and terminating a fourth cable for quick connection if one of the primary cables failed, but since alternate paths existed to feed Wadmalaw and Johns Islands, for the time it would take to obtain new cable, the utility opted to install a fourth duct that could be used for replacement cable if a failure occurred.



Transition Structures

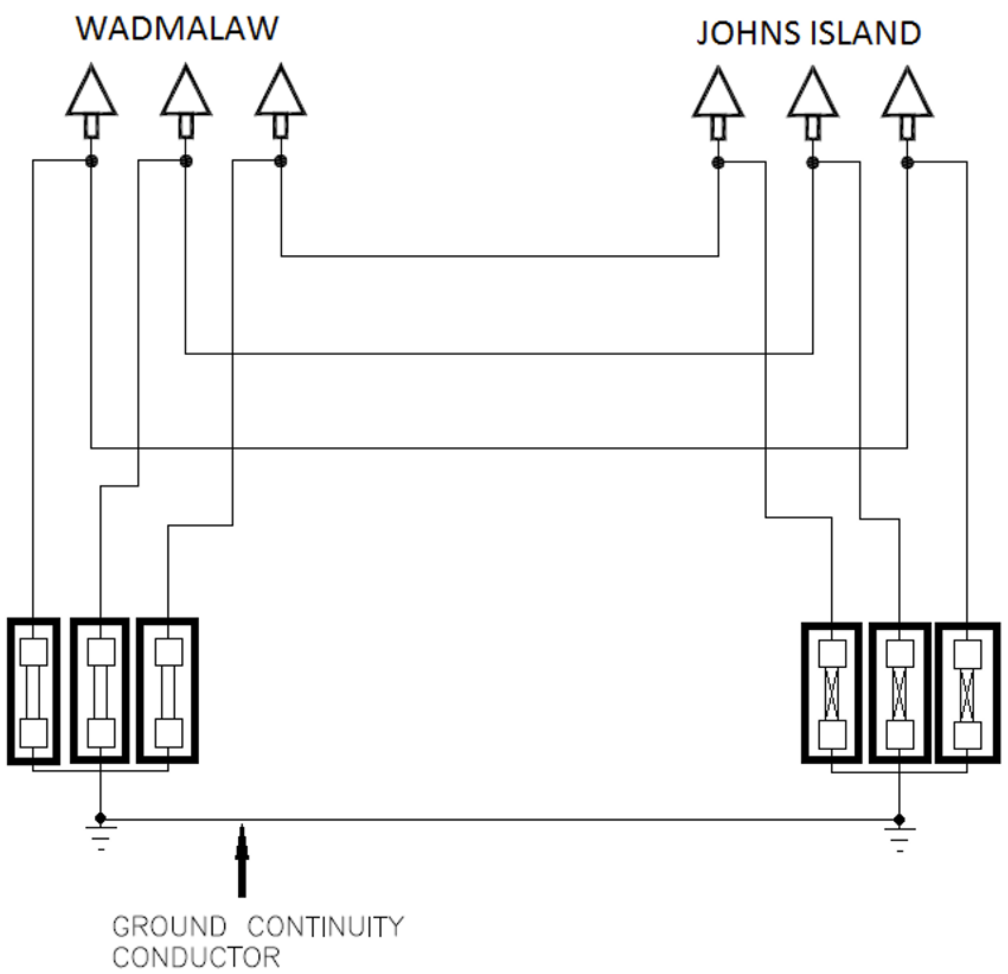
- From the end of the HDD ducts to the base of the termination pole was directly buried, and an S-bend was placed in the excavation to allow termination replacement if needed, without having to install a splice.
- The entire area was covered with a weak-mix concrete for mechanical protection.

Transition Structures

- Transition monopoles at each end of the line
- Steel shroud
- Terminations were made at final pole-arm height using manlifts
- 138-kV class terminations were chosen because of the proximity to saltwater

Single-point Bonding

- SVLs sized for available fault current of 30 kA for 30 cycles
- For 1066 m, the induced sheath voltage would be 16.9 kV
- SVL with MCOV of 12.7 kV selected (curves show it can handle 18 kV for 30 cycles)



Commissioning

- Jacket integrity tests to verify there was no cable damage during installation
- AC withstand 1.7 U_0 for 1 hr
- PD Measurements
- All tests were passed successfully, and the transmission line was placed into service in June 2018 on Johns Island and Wadmalaw Island.