

Safety-Class Medium Voltage

Design Considerations that Reduce Cost and Lifetime Risk

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Nuclear Promise

- *An initiative will help ensure that nuclear energy remains a vital, innovative and cost effective part of America's increasingly clean electricity portfolio by achieving the following outcomes:*
- Redesign nuclear power plant processes to improve efficiency and effectiveness to enable a **30 percent reduction** in electric generating costs, on average industrywide.
- Optimize resourcing throughout the nuclear enterprise to spur greater efficiencies at nuclear energy facilities and among suppliers.
- **Analyze technological and operational changes** that could enhance safety and provide greater efficiency.
- **Leverage technology** to ensure widespread industry adoption of innovative tools and techniques that could reduce costs.

References

- *EPRI Plant Engineering: Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants, Revision 1*
- *NEI 06-05 Medium Voltage Underground Cable White Paper, April 2006*
- *Details a Study Performed Across a Variety of Medium Voltage Cables Installed in US Nuclear Power Plants*
 - *81/104 US nuclear units reported*
 - *74 US Nuclear Units provided information on originally installed cables, failures, and replacement cables*

NEI 06-05 Medium Voltage Underground Cable White Paper

- “Most respondents indicated use of 5-kV rated cables in underground applications operating at 4.16-kV.”*

Originally Installed 5-kV Insulation Types

Insulation	Units	Percent of Reporting Units
Butyl Rubber	4	5
EPDM	1	1
Black EPR	48	65
Brown EPR	20	27
Red EPR	31	42
XLPE	23	31

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Unit Population Failure Comparison by Insulation Type

Insulation Material	Number of Units with Material	Failures	Failures per Unit with Material
Butyl Rubber	3	2	0.67
EPR - Black	34	23	0.67
EPR - Pink	29	3	0.10
EPR - Brown	12	1	0.08
XLPE	12	17	1.42

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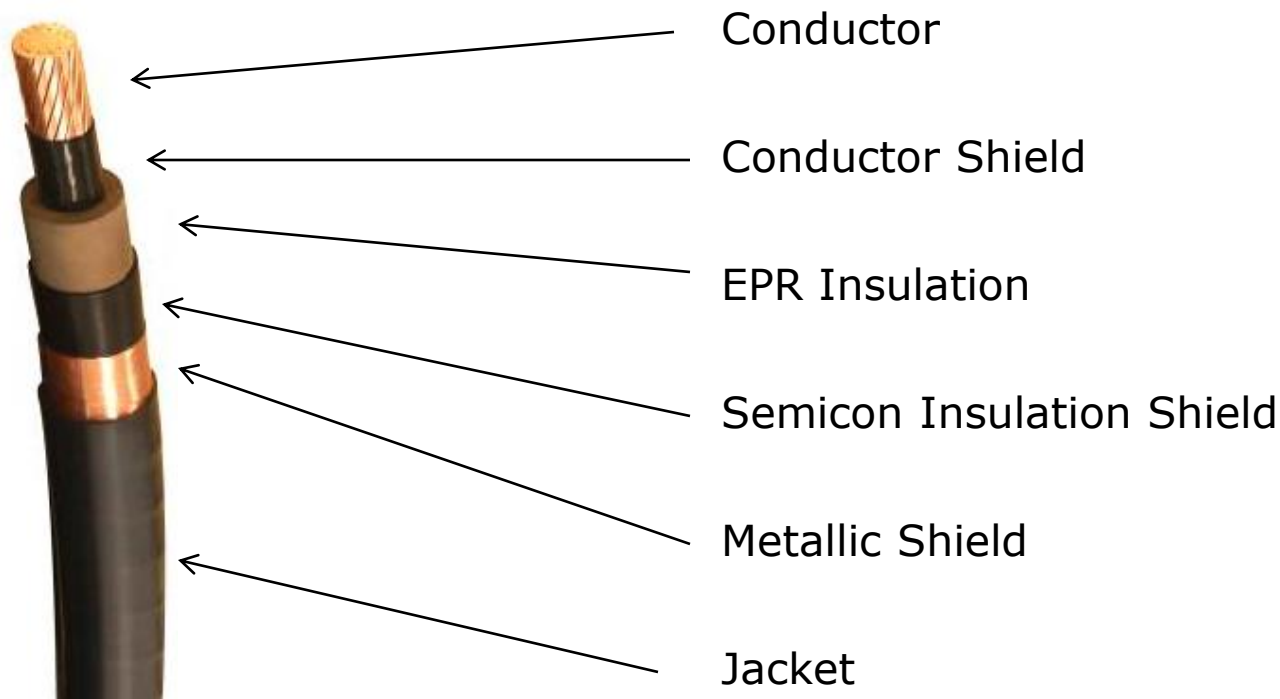
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- ***Concluded that:***
 - “Most of the EPR insulation failures were related to ***manufacturing defects, physical installation damage, or post-installation damage*** combined with wetting, indicating that early failure of wet EPR is related to a flaw rather than wetting alone. No wet failures of brown EPR have been identified to-date. (The one failure on a brown EPR circuit was related to a poorly made splice rather than failure of the insulation). Key insights from these two findings are that brown EPR insulation is not prone to early failure and, if no failures have occurred at a site in the first 35 or more years of operation, the installation was not subject to manufacturing or installation-induced flaws.”
 - “For XLPE, early failures have been recognized and this is the insulation system for which watertreeing is a concern.”

Shielded MV Cable Design



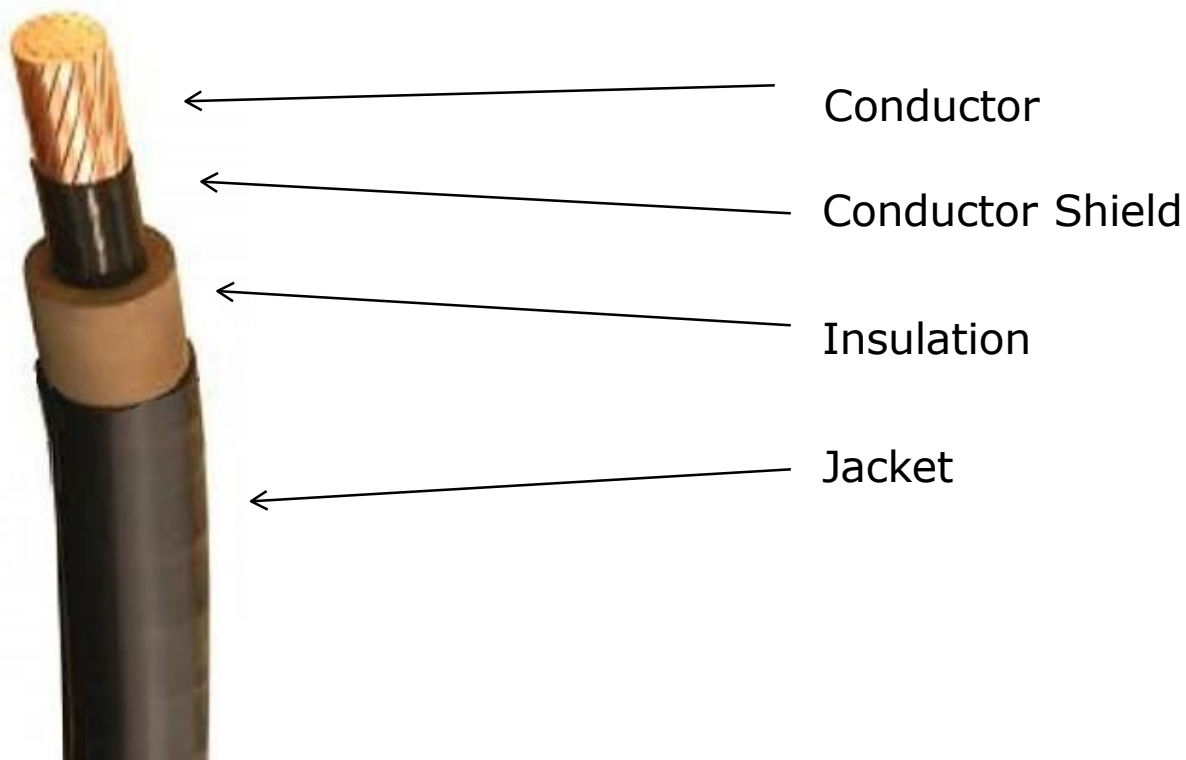
NEI 06-05 Medium Voltage Underground Cable White Paper

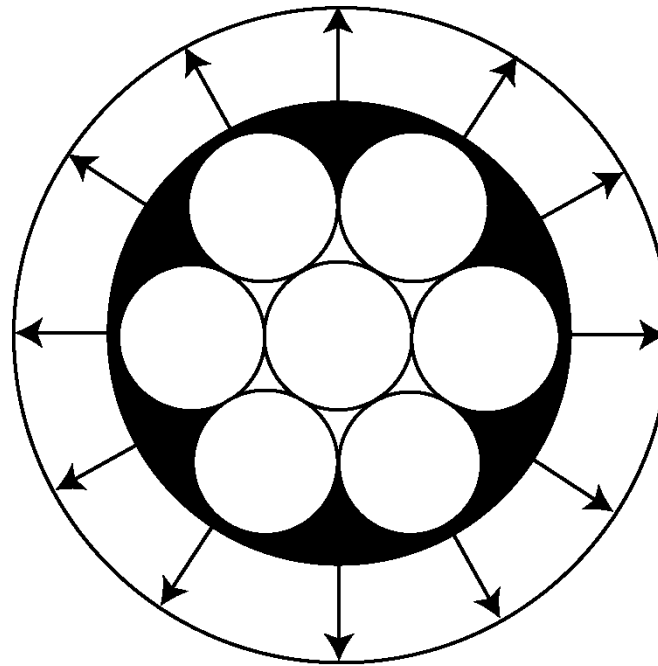
- ***Reported that:***

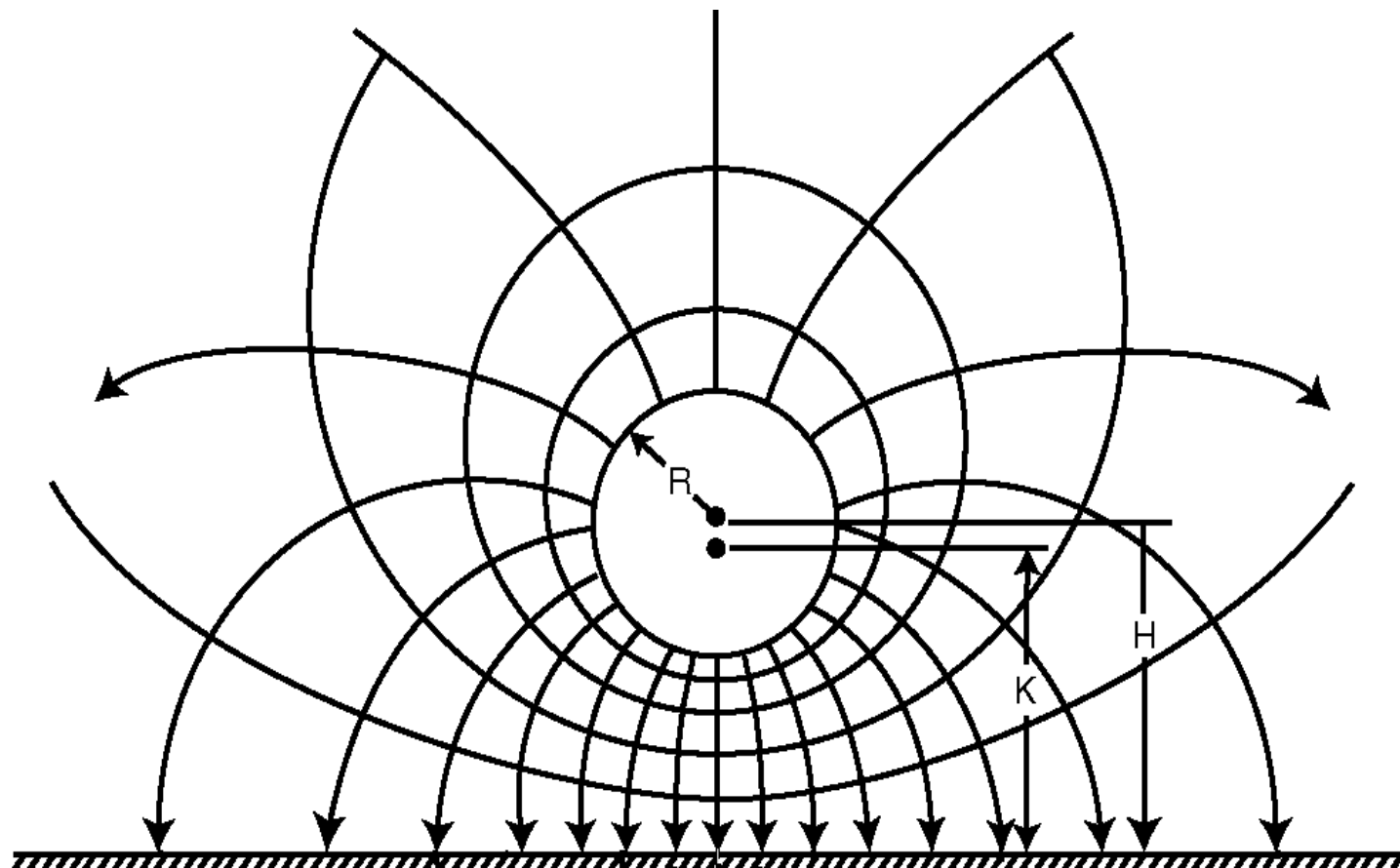
- Excluding the general service cables, ***22 units (30%) reported having a total of more than 271 circuits with unshielded EPR cables.*** Two plants reported having unshielded cables, but did not indicate the quantity. These cables were used in safety, fire protection, operationally important, station black-out, and off-site feed cables.
- The lack of a shield on the EPR cables is ***not a reliability issue***. Circuits without shield represent ***an electrical testing issue***. Electrical testing at high voltage requires a uniform ground plane.
- An insulation shield provides such a ground plane. Circuits without a shield would not have a uniform ground plane and available electrical testing is unlikely to provide useful results.

Nonshielded MV Cable Design

- *Consider a nonshielded design solution:*







Advantages:

- **A nonshielded medium voltage design option:**
 - Designed in accordance with Industry Standards (i.e. **ICEA S-96-659** Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy)
 - Significantly **simpler to splice and terminate** since there is not an insulation shield to remove or a metallic shield with which to contend
 - Easier to install because, generally:
 - smaller OD and lighter weight
 - ½ the allowable bend radius
 - 2 times the allowable sidewall bearing pressure
 - far more flexible than shielded designs
 - **Approximately half of US plants** that originally installed Brown-EPR utilized a nonshielded medium voltage design.
 - The end-user can justify that there are not any current in-service tests that will yield any relevant results. **Performance history and qualification** can be used to justify the cable's condition **without** periodic monitoring.

A Berkshire Hathaway Company



In-service Test	Shielded	Nonshielded
Voltage Withstand	✖	✖ Variable ground plane. Best if performed submerged.
VLF	✖	✖ Variable ground plane. Best if performed submerged.
Partial Discharge	✖	✖ Lacks sensitivity outside of a shielded testing facility.
Impulse	✖	✖ Variable ground plane. Best if performed submerged.
Dissipation Factor (Tan δ)	✖	✖ Not trendable or consistent due to variable ground plane.
TDR, FDR, LIRA, etc.	✖	✖ May have a signal return path on another conductor if installed in a plexed condition.
IR	✖	✖ Not trendable or consistent due to variable ground plane.

Thank You!

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