

## Condition of shielded 5kV pink EPR insulated cables after 25 years of service in wet environment

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There are 100 nuclear power reactors generating 20% of total U.S. electric energy. The average age of the nuclear reactors is about 33 years old. Shielded medium voltage (5kV and 15kV) cables in these plants are insulated with butyl rubber (3%), black EPR (38%), XLPE (13%), brown EPR (13%) and pink EPR (32%), introduced commercially in 1974.

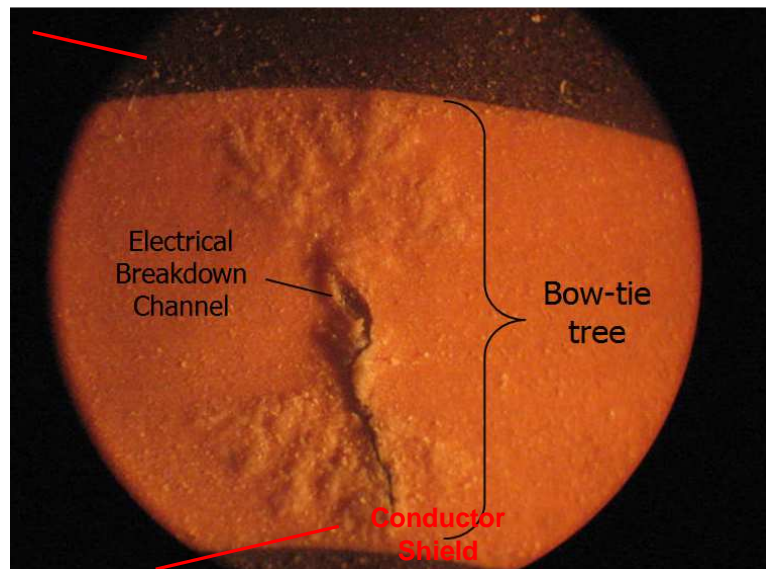
The pink EPR insulation delivers much more reliable service than its predecessor, black EPR, but as with other polymeric insulation, pink EPR is not immune to aging in wet environments, contrary to manufacturer's marketing.

Because of their age the MV cable failures are of great concern, as such events quite often lead to unplanned plant outages costing approximately 1.5 million U.S. dollars per day in lost revenues. Much of the past research focused on XLPE insulations, but EPR's comprise the majority of cables in power plants and has been the focus of EPRI sponsored research at Cable Technology Laboratories since 2006.

The paper will describe the condition of two 3/c cables removed from nuclear plants because of their high and unstable values of 0.1 Hz dissipation factor of one of their phases. The cables were replaced and the removed cables were subjected to laboratory forensic evaluation.

It will be shown that water treeing is responsible for the substantially decreased cable insulation strength. This research also shows that very advanced water trees, spanning nearly the entire insulation wall are detected by 0.1 Hz tangent delta measurements. The ac breakdown strength of such cable insulation in five-minute ac step voltage test has to be 4kV/mm or less, while its average operating stress of the cable is about 1kV/mm. The initial ac strength of pink EPR insulation of the cable was about 28kV/mm.

### Insulation Shield



Photomicrograph of the surface of a pink EPR, cross-cut, insulation wafer at the location of AC break down. Bow-tie type water tree spans the whole insulation wall (3.8 mm) from conductor shield to insulation shield.