2009 Anderson Island Cable Failure/Repair Summary

On the morning of January 31, 2009, a tree on Anderson Island fell into an overhead distribution line and broke two phase conductors and a neutral conductor. At 5:40 AM that day, the Anderson Island recloser recorded an overcurrent on two phases. Tanner Electric Cooperative (TEC) crews worked on trying to restore power but by that afternoon they concluded that the marine cable may have failed. TEC contacted Cummins Northwest to install temporary diesel generation on the island.

An emergency was declared by Pierce County on Monday February 2, 2009. D. Hittle & Associates, Inc. (DHA) was hired to assist Tanner Electric Cooperative on February 2, 2009. By Wednesday night on February 4, 2009, diesel generators had been brought to the island and restored power to all customers by Tanner Electric Cooperative staff. The DHA team determined an approximate fault location in sufficient detail to proceed with permits and a marine contractor by February 18, 2009. Harbor Offshore, Inc. (a marine contractor) mobilized a large repair barge so that repairs could start Sunday March 15, 2009. Repairs were completed on April 2, 2009 and began carrying load April 3, 2009, 62 days after the initial outage.

The repair effort required identifying the approximate fault location, ordering repair equipment, obtaining Pierce and Thurston County permits, State and federal permits, as well as, mobilizing a marine contractor. In addition gale and small craft conditions caused by storms interfered with the ability to make the repair. Finally, it was found that sand wave movement (over years) had buried the cable near the failed portion to a depth of potentially 25 feet. This prevented the repair team from retrieving the failed section and required the use of over 2,000 feet of new replacement cable to "leap frog" over the buried section of failed cable. Another element of the repair effort was to find, test, and connect as a neutral conductor the old abandoned single phase marine cable to Anderson Island that was installed in the early 1960's. While the single phase cable's insulation had failed around the time of the installation of the three phase cable in 1975, the continuous copper conductor path of the old single phase cable now serves as a low resistance neutral and fault current path.

The marine cable that was repaired was manufactured by Okonite in August, 1975 and installed in late 1975. Instead of a neutral conductor, the cable used a copper tape shield, armor wires and a saltwater return path for neutral and fault currents. During the post fault testing by DHA, it was found that the armor wire was not continuous from one end to the other. The armor count within the cable was not consistent indicating that the original design may not have had continuity. The copper tape shield was also badly corroded and the conductor's EPR insulation was discolored, which possibly compromised its insulating capability. In 2006 the cable was injected with a dielectric compound patented by Novinium, Inc. The injection of marine cables is common, but less common with EPR cables, such as the cable to Anderson Island. Some cable injection companies recommend against injection in concentric neutral cables if there is insufficient neutral capacity.

Samples of the 1976 cable were sent to both Okonite and the University of Connecticut for laboratory analysis. The samples showed evidence that the discoloration of the EPR and the corrosion of the copper tape shield were caused by biological activity. From the laboratory reports, it is unclear whether the stained or "sulfur contaminated" EPR was significantly less able to serve as an insulator required for the Tanner Electric Cooperative primary voltage. AC insulation breakdown strength was sufficient for 12,470 Volt operation, but one test showed a dissipation factor in the discolored insulation. The Okonite and University of Connecticut

samples were approximately 2000 feet apart, which could cause some of variation in test results. The reports did not indicate that the Novinium injection contributed to the failure of the cable.

After reviewing the reports and studying different failure possibilities, DHA is of the opinion that the likely causes of cable failure are combination of weakened EPR insulation (contamination), deteriorated tape shield, and a sharp bend in the cable likely caused by geological issues, such as, sand waves or earthquake/landsides during a high current fault. Marine cables have a lifetime expectancy of 30 to 50 years, so the 34-year old marine cable in question was a candidate for failure due to insulation breakdown with aging. Prior to failure, the cable insulation was injected with Novinium fluid to extend the insulation life. Laboratory results indicate sulfur insulation contamination of the insulation due to marine biological activity and that the insulation dielectric breakdown strength was slightly lower than new cable insulation, but above the minimum required for the 12,470 Volt phase to phase operating conditions. One University of Connecticut finding was that there was a high dissipation factor in the contaminated insulation that could lead to a thermal runaway under certain high current conditions. As such, general insulation failure all by itself is not the likely single cause for the cable failure.

From the bathymetry of the Puget Sound, sand waves of a magnitude of 25 feet high were found in the cable path near the fault and the bottom conditions were quite steep. This could have possibly caused the cable to be sharply bent, which would physically distort and reduce the insulation capacity of the cable at the location of the bend and concentrate electro-mechanical stresses at the bend. In 2001, a 6.8 magnitude earthquake occurred in the Nisqually Delta. Divers and Remote Operating Vehicle video during the repair indicated some earth movement or slides near the cable fault area. Because the area of the fault was not able to be retrieved and evidence of a bend in the cable causing an insulation breakdown could not be physically confirmed. However, during the repair effort from diver observations of exposed cable and the sea floor terrain we do know that there was a sharp “up-down-up” reversal in the cable’s direction in the vicinity of the fault. Either earth movement by sand waves, landslide or earthquake likely played a role in sharply bending the cable near the fault location and potentially damaging insulation at that point.

Another factor is the deteriorated copper tape shield, which served to both relieve and contain electro-mechanical stress on the insulation and as a fault current electrical path. High fault currents and voltage doubling associated with the fault when the tree fell into the Anderson Island overhead lines may have also played a role in the failure of the initial marine cable phase conductor by damaging insulation at its weakest link by either stress or high temperature.

The original repair effort contemplated using approximately 714 feet of spare Okonite armored marine cable. Due to the deep burial of the cable an additional 1400 feet of aluminum URD cable was installed between the points in the cable that could be retrieved by the marine contractor. As a result the repaired cable system, including the 1976 cable with contaminated insulation and deteriorated copper tape shield is a fragile system that D. Hittle & Associates, Inc. feels could last between two years and ten years.

After the repair was completed, the Board of Directors of TEC started studies to replace the cable with a new cable and are in the process of developing environmental permit applications and engineering designs and construction contracts. The current schedule envisions that permit applications will potentially be submitted in September 2009 and local, state and federal permits should be received in early 2010. A new marine cable will be ordered in early 2010 after regulatory permits are received and that the replacement power cable to Anderson Island will be installed before the end of September 2010.

Fault locating from Anderson Island side

Fault locating from Luhr Beach side

Diver entering the water to retrieve cable

Marine cable (discolored insulation and copper tape shield deterioration visible)

Repair of marine cable by splicing new section

Completed splice being put in water