In-Service Performance of EPR Cables Installed in the *Memphis Light Gas and Water* Electrical Distribution System

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Abstract: This paper provides background related to the decision by Memphis Light Gas and Water (MLGW) to install EPR insulated cables rather than HMWPE and XLPE cables. This decision has been justified by the 25 year performance history of EPR cables, supported by field aging studies at MLGW.

Introduction

The earliest URD customers at Memphis Light Gas and Water (MLGW) were served by PILC cable which was expensive and time-consuming to install, although it has a good service history at MLGW. The first extruded dielectric URD cables at MLGW were installed in 1967. These were high molecular weight polyethylene (HMWPE) with a #2 AWG copper conductor, 240 mils of HMWPE insulation, and a copper concentric neutral. The cables were unjacketed and direct buried. These cables were operated at 12 kV and 23 kV phase-to-phase. The first extruded dielectric feeder cables employed 240 mils of XLPE dielectric with a 750 kcmil Al conductor, copper concentric neutral and were mostly installed in ducts with some direct buried. These cables also operated at system voltages of 12 and 23 kV.

Failure Rates of Early Polyethylene-Insulated Cables

By 1973, with only 6 years of field service, the HMWPE cables had a yearly failure rate of 4.24 failures/100 conductor miles. By 1976, the yearly failure rate had increased to 16 failures/100 conductor miles. This large and increasing failure rate resulted in specifying XLPE cable dielectric for all cables.

By 1980, yearly failure rate for the XLPE cable was about 3 failures/100 conductor miles. The HMWPE yearly failure rate peaked in 1983 at 87 failures/100 conductor miles for URD cable, while the XLPE failure rate peaked in 1985 at 11 failures/100 conductor miles for feeders.

Move to Life Cycle Cost Purchasing

A change of company President in 1978 resulted in a shift in emphasis for underground electric system designs to consider "life cycle cost" rather than "initial cost". As a result, MLGW attempted to determine which cable designs and materials had an established history of in-service reliability. After significant research, MLGW selected an EPR-based cable design which had 16 years of in-service history with nearly flawless reliability. Emphasis was also placed on highly reliable splices, terminations, connectors, transformers, and system design. The "post 1980" system design and components were used to retrofit the 1967-1979 system, with approximately $50 million spent to improve reliability and bring the URD system to "post 1980" standards. The inflation adjusted retrofit cost was 7 to 8 times the initial installation cost.

Post-1980 Service History

Since 1980, MLGW has suffered 4 lightning induced cable failures, two of which caused substantial damage to other equipment, such as pad-mounted transformers, arresters, etc. In addition 4 failures have resulted from squirrel "eat-ins", and 2 failures resulted from severe overloading of the cable, which was subjected to 160% of full load current for several days. Two failures were caused by damage during installation and 4 failures were caused by damage on the reel before installation. Dig-ins are undocumented. This results in a yearly failure rate of about 0.16 failures/100 conductor miles, which does not include failures of splices, terminations, connectors, or failures caused by abuse of the cable (overloading and mechanical damage).

As a result of the high reliability of the EPR cable used by MLGW, commissioning tests are not economically viable as they are unlikely to eliminate service failures. Although the reliability of splices and terminations is not as great as that of the cable, the reliability is very high. While commissioning tests might detect workmanship errors in splicing and terminating, the cost for such testing would be many times greater than the in-service repairs which result from not conducting the tests.

MLGW Field Aging Test Project

In 1984, MLGW started a field aging test project on cables insulated with three different types of EPR dielectric. The cables employed 260 and 175 mil insulation walls with a #2 AWG copper conductor and were energized at 23 kV system voltage (13.23 kV to ground). Twelve thousand feet of each EPR type in each wall thickness was installed. The 260 mil wall cable operated at 86 V/mil maximum stress and 51 V/mil average stress, while the 175 mil wall cable operated at 112 V/mil maximum stress and 76 V/mil average stress. The cable was unjacketed and installed in a wet conduit. AC breakdown tests were carried out on the field-aged cables removed at 0, 2, 5, and 9 years. Additional tests were performed on the MLGW "standard" cable at 10 and 14 years. The AC breakdown values stabilized near 400 V/mil, as seen in Table 1.

Conclusions

The EPR cable which MLGW started purchasing around 1980 has a near-flawless 25 year service history with a cable failure rate in the range of 0.16 failures/100 conductor miles. As a result of this excellent service history, no commissioning or routine testing has been required. MLGW feels that the additional cost for "premium" cable is a small part of the cost of the installed system and is a small price to pay when replacement costs are in the range of seven times the installation cost.

MLGW's field aging studies indicate that AC breakdown fields have stabilized in the range of 400 V/mil. In the near future, additional cables will be removed, which will provide AC breakdown field data after about 22 years of field aging.

Table 1
Average AC Breakdown Field (V/mil)

260 Mil Wall Cables			
Service Age (Years)	Mfr "A"	Mfr "B"	Mfr "C"
0	685	384	485
2	473	424	501
5	596	354	354
9	405	358	389
10		396	
14		362	
175 Mil Wall Cables			
Service Age (Years)	Mfr "A"	Mfr "B"	Mfr "C"
0	816	452	536
2	726	452	433
5	517	483	451
9	422	416	391

Note: This information was originally made public in a "presentation format" at the Fall 2005 Insulated Conductor Committee Meeting (IEEE/PES/ICC) Educational Program.