Testing of THERMOLIGN® Dead-End

For

795-kcmil 3M Brand Composite Conductor

Prepared by:

Robert Whapham
Preformed Line Products, Principal Investigator

Scope

This report will cover the description and results of laboratory testing of PLP's THERMOLIGN® Dead-End and 795-kcmil 3M Brand Composite Conductor (also called ACCR – Aluminum Conductor Composite Reinforced) manufactured by 3M.

The specific tests included in this report are:

- Room Temperature Tensile Test
- Sustained Load Test
- Sustained Heat Test
- High Voltage Corona Test

The results for each test are reported separately.

Room Temperature Tensile Test

The room temperature tensile testing of the original 795 Dead-End Assembly design was reported in the 2nd Quarter 3M/DOE Report (page 4). Because the loop of the original Dead-End contained both the Aluminum-Clad Steel and Aluminum Alloy rods, it became too large to fit into standard 40,000# thimble-clevis hardware. Therefore, it became necessary to either design new thimble-clevis hardware or to re-configure the dead-end.

Since the Aluminum-Clad Steel rods of the dead-end have sufficient strength to hold the rated strength of the 795 ACCR, it is not necessary from a strength standpoint to include the aluminum alloy rods in the loop. However, the aluminum alloy rods are required to reduce the overall temperature of the dead-end when the conductor is operating at high temperatures (240C or higher). To solve the loop size issue, and to maintain the same level of aluminum for cooling, a 3-Piece Dead-End design was developed. The new Dead-End Assembly consists of a set of aluminum alloy structural rods, as before, and two separate dead-ends, one with aluminum-clad steel rods and one with aluminum alloy rods. When applied using a standard 40,000# thimble-clevis, the aluminum-clad steel dead-end is attached to the normal groove of the thimble-clevis, and the aluminum alloy dead-end is positioned through the "work hole" in the front of the thimble-clevis (see Figure 1).

See Figure 2 and Table 1 for the results of the room temperature tensile testing of the 3-Piece Dead-End Assemblies for the 795 ACCR Conductor, and a comparison with the original 2-Piece design.

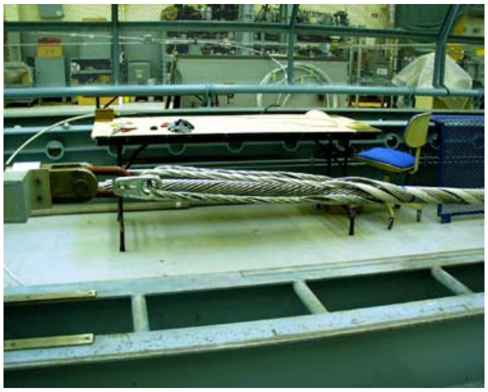

Figure 1 – 3-Piece Dead-End

Figure 2 – Typical Mid-Span Failure

Sample	Type	Max Load	% of RBS	Location of Failure
#1	2-Piece	30,213#	97%	Mid-Span
#2	2-Piece	30,319#	97%	Mid-Span
#3	3-Piece	30,200#	97%	Mid-Span

Table 1 – Room Temperature Tensile Testing of
795 Dead-End Assembly

Sustained Load Test

The purpose of this test is to demonstrate that the Dead-End assembly will hold at a high tension level (77% RBS) at room temperature for an extended period of time (168 continuous hours). This test also provides the opportunity to measure short term creep data for the conductor.

The test samples for this testing consist of a 55 ft. to 65 ft. length of 795 ACCR conductor terminated at both ends with a PLP Dead-End Assembly. The tension was maintained throughout the test period with the 55K Tensile Equipment. A gage length of 30 ft. was established on the conductor between the Dead-End Assemblies to measure elongation (creep) of the conductor throughout the test period.

3M™ has two suppliers of the Al-Zr material used in the outer strands of the ACCR conductor (designated as Type A and Type B).

Sustained high tension tests were successfully conducted at PLP for both the Type A and the Type B conductors. Tables 2 & 3 contain some of the elongation (creep) data from these tests. The Type A sample was held at a load of 20,250# (77% of the reduced RBS), and the Type B sample was held at a load of 23,970# (77% of original RBS).

After completion of the 168 test period, both conductor samples were tensioned in the same 55K Tensile Equipment (10,000# per minute) until a failure occurred. The Type A conductor failed at a load of 31,130# (100% RBS), and the Type B conductor failed at 32,180# (103% RBS). Both samples failed in mid-span.

Hours	Elongation
1/2	0.019%
1	0.021%
3	0.026%
16	0.039%
24	0.049%

Hours	Elongation
47	0.054%
71	0.057%
95	0.060%
159	0.061%
168	0.064%

Table 2 – Elongation for Type A Conductor
(Held at 20,250# Load, Room Temp.)

Hours	Elongation
1/2	0.020%
1	0.027%
5	0.045%
8	0.049%
72	0.073%

Hours	Elongation
80	0.078%
95	0.079%
119	0.082%
147	0.085%
168	0.087%

Table 3 – Elongation for Type B Conductor
(Held at 23,970# Load, Room Temp.)

Sustained Heat Test

The purpose of this test is to demonstrate that the performance of the Dead-End Assembly is not affected by continuous conductor operation at an elevated temperature (240C for 168 hours).

The test span consisted of a 65 ft. length of 795 ACCR conductor terminated on each end with a PLP Dead-End Assembly (3-Piece). A tension of 15% RBS (4,670#) was maintained throughout the test using a tension beam/weight basket (see Figure 3) The conductor was heated to 240C by applying approximately 1,450 Amps of AC current, supplied by the dual power supplies (Figure 4).

Thermo-couple measurements made on the dead-ends showed that the temperature of the dead-end rods did not exceed 105 C, with the conductor maintained at 240C.

Figure 3 – Sustained Heat Test Arrangement

Figure 4 – Dual Power Source

After the completion of the 168 hour test period at 240C, the sample was removed from the Heat Test Area and installed in the 55K Tensile Equipment to determine the maximum load at failure.

When loaded at a rate of 10,000# per minute, the conductor broke at mid-span at a load of 32,210# (103% RBS). During this tensile test , there was no slippage of or damage to the PLP Dead-End Assemblies.

High Voltage (Corona) Test

The purpose of this testing is to verify that the 795 ACCR Dead-End from PLP will have acceptable performance when subjected to typical transmission line voltages.

The testing was conducted at the NEETRAC indoor high voltage laboratory.

The 795 Dead-End Assembly was installed on a single 1.125" tube, mounted vertically in the lab, with the rod ends of the Dead-End Assembly at 12 feet above the ground plane (See Figure 5). Corona onset was observed at a phase-to-phase voltage of 307 KV.

For a single conductor configuration, it may be possible to use a 795 conductor on lines operating at voltages up to 230 KV. The twin 795 configuration would commonly be used on 345 KV lines (400 KV internationally). Even though the Dead-End and Splice Assemblies were tested only in a single configuration, the onset voltages were sufficiently high enough to conclude that the performance would be acceptable at 345 KV in a twin configuration.

Figure 5 – Dead-End Test Arrangement

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