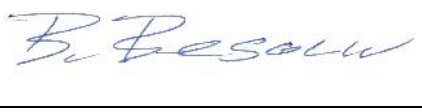
Hubbell Power Systems, Inc.
8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

Report G16-05-05

ANSI/IEEE Design Test Report
Cold Shrink 15 kV Terminations

This design test report records the results of laboratory tests performed on the Cold Shrink 15 kV Terminations which met or exceeded all applicable requirements of this standard:

IEEE Std. 48-2009, "IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV".



Bas van Besouw
Engineering Manager

Eric Huang
Product Engineer

Peter Swales
Business Unit Director

David E. Crotty
Senior Product Manager

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1.0 DESCRIPTION OF SAMPLES

The following cold shrink components were subjected to design tests:
On No. 2 AWG Al, 220 mils EPR insulated cable:

- Class 1A outdoor terminations, type 15TW1

On 1000 kcmil Al, 175 mils TR-XLPE insulated cable:

- Class 1A outdoor terminations, 15TW5

The accessories were installed on two different cables, both produced by Prysmian, each having water blocked aluminum conductor, extruded conductor and insulation shields, extruded insulation, bare copper shield and polyethylene jacket. Particular construction details of each cable are presented in Table 1.

Conductor Size	Conductor Material	Insulation Thickness-mils	Insulation Material	Type of Copper Shield
2 AWG	Al	220	EPR	Neutral Wires
1000 kcmil	Al	175	TR-XLPE	LC
Outer Diameter (Inch)				
	Conductor	Insulation	Insulation Shield	Jacket
2 AWG	.282	.770	.850	1.060
1000 kcmil	1.070	1.505	1.610	1.960

Table 1

Aluminum Pfisterer shear bolt connectors for joint assemblies and Richards aluminum crimped lugs for terminations were employed. The type and crimping tools used are provided in Table 2.

Conductor Size	Pfisterer Connector	Connector Tool	Lug	Lug Crimping Tool
2 AWG	RJSM 25/150	Hex key 5mm	Al7-2N	Burndy Hypress Y35 Die U243, Index 243 EEI 8A
1000 kcmil	RJSM 300/630	Hex key 8mm	Al28-2N	Black & Blue Die Alcoa 6030AH

Table 2

Each set of samples, for No. 2 AWG and 1000 kcmil conductors, comprised of 3 samples; each of the samples had two outdoor terminations installed. A dummy was created with outdoor terminations, so that temperature of the component undergoing qualification could be checked.

The tests were performed following a test sequence, harmonized for both terminations and joints, which is described in IEEE 48. Individual assemblies (samples) were about 18 ft long each. The cable length between the termination bottoms was about 15 ft.

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The dummy was provided with thermocouples attached to the cable conductor and termination lugs, so that the temperature of all the components could be measured directly and controlled. In addition, thermocouples were attached to the outside of the outer surface of the insulation shield and jacket of the cable.

2.1 PARTIAL DISCHARGE TEST

These tests were performed five times. Partial discharge tests were executed by slowly increasing the test voltage to 15.6 kV. This step is to be followed by reducing the voltage to 13 kV. At this lowered voltage all partial discharges should extinguish. In actuality, all samples were PD free at 15.6 kV. The test sensitivity (although slightly different at different measurement sessions) was substantially better than the required level of 5 pC.

Test Results
All samples tested met the requirements of Section 8.4.1.11 of IEEE Std. 48 - 2009.

2.2 AC WITHSTAND TESTS DRY

AC withstand tests were performed at 50 kV for 1 minute. In all cases the samples withstood these voltages without developing a disruptive discharge.

Test Results
All samples tested met the requirements of Section 8.4.1.2 of IEEE Std. 48 - 2009.

2.3 AC WITHSTAND TESTS WET

These tests were conducted on the terminations in accordance with conventional procedure described in IEEE Std. 4-1995. Each termination was tested individually.

The spray nozzle was adjusted to produce an average precipitation rate of 5 mm/min. During calibrations, a collecting vessel was placed at the location to be occupied by the test object. The spray was directed at an angle of approximately 45°, which position was confirmed by individual measurement of the vertical and horizontal components of the flow. The specimens were sprayed with ambient temperature de-ionized water having a resistivity in the range of 160 to 200 Ω-m.

After pre-wetting for 1 minute, an AC voltage of 45 kV was applied. Each of the terminations withstood this voltage for 10 seconds without failure or flashover.

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Test Results
All samples tested met the requirements of Section 8.4.1.3 of IEEE Std. 48 - 2009.

2.4 DC WITHSTAND TESTS

Two test assemblies were connected at a time to the DC power supply and were subjected to a stress of 75 kV for 15 minutes. Each of the terminations withstood this voltage without failure or flashover.

Test Results
All samples tested met the requirements of Section 8.4.1.5 of IEEE Std. 48 - 2009.

2.5 IMPULSE WITHSTAND TESTS

These tests were repeated two times: at room temperature and once more with the cable conductor heated to 130 °C. The test assemblies, forming a close loop, were tested one at a time. An additional loop, incorporating the dummy sample, was used for hot impulse tests. The dummy was used for temperature control and monitoring.

Heating currents in the main test loop and in the dummy were adjusted to 250 A for No. 2 AWG conductor and 1250 A for 1000 kcmil conductor.

The impulse shape parameters (front and tail times) were: 1.3 µs and 51 µs for No. 2 AWG conductor assemblies; 1.5 µs and 55 µs for the accessories installed on 1000 kcmil conductor, respectively. Every time the tests were performed, 10 positive and 10 negative impulses at 110 kV were applied. All samples withstood these stresses without incident.

Test Results
All samples tested met the requirements of Section 8.4.1.6 of IEEE Std. 48 - 2009.

2.6 HEAT CYCLING TESTS

In each case, the heating currents in the dummy and actual test loop were tuned to be equal to each other and a temperature controller was employed to maintain the dummy cable conductor temperature at 130 °C during heating periods. The samples were subjected to 30 heat cycles with 8-hours current-on and 16-hours current-off periods. The actual test samples were continuously energized at AC voltage of 26 kV, while the dummy was grounded.

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Overall, the test samples of both sets passed the heat cycling test problem free. No trend in the temperature of components was noted that could indicate their deterioration or thermal runaway.

Test Results
All samples tested met the requirements of Section 8.4.2 of IEEE Std. 48 - 2009.

2.7 LEAK TESTS

Four terminations were submerged in tanks filled with tap water, connected in series and subjected to 10 heat cycles with 8-hours current-on and 16-hours current off periods. Temperature of the cable conductor during heating periods was maintained at 130 °C. Upon completion of the 10 heat cycles, the terminations were allowed to air dry and then were subjected to a voltage of 17.4 kV. The test was discontinued, without failure, after 1 hour under this voltage.

Test Results
All samples tested met the requirements of Section 8.4.3 of IEEE Std. 48 - 2009.