

# Chardon 15kV Cold Shrink Outdoor Termination Design Test Report

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Report Number:

RN-R1302

Test Start Date:

2016 / 08 / 24

Test Complete Date:

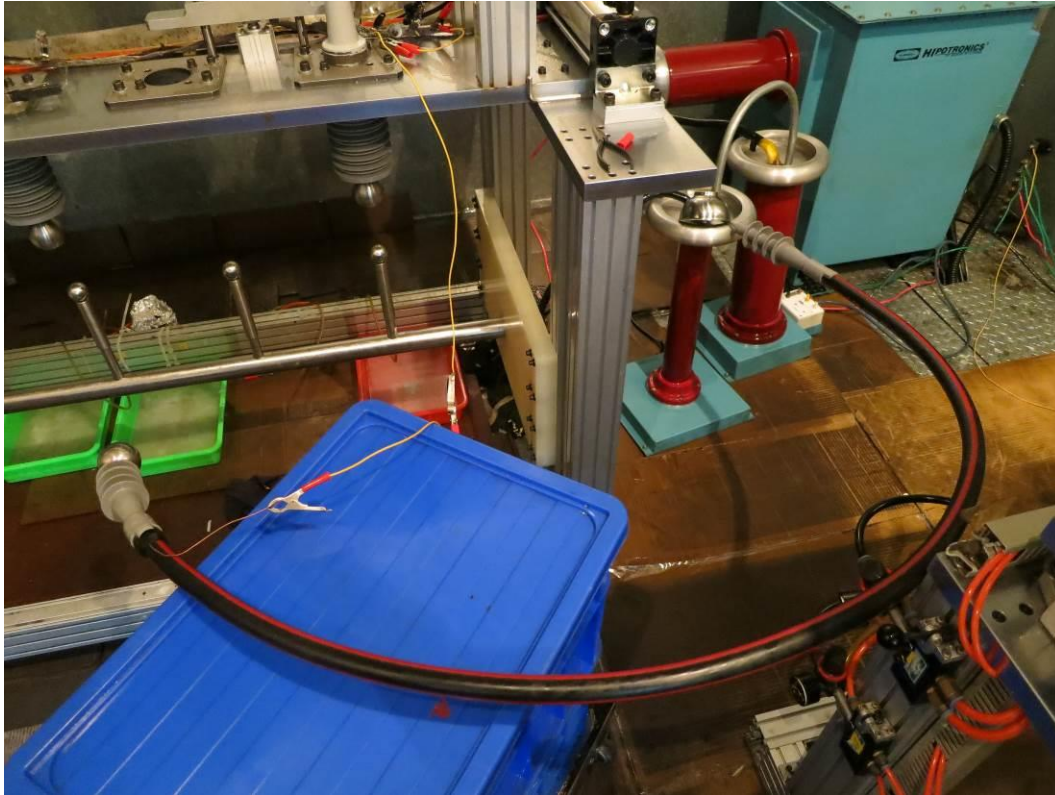
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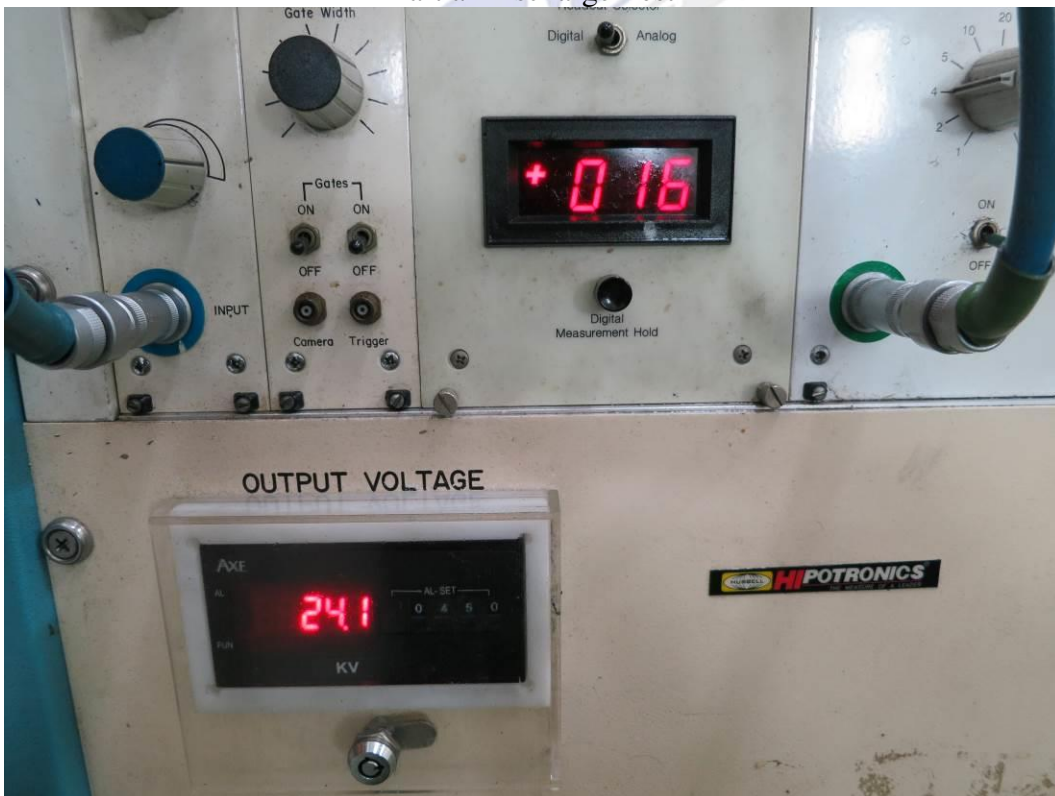
## Table of Contents

1.	Partial discharge.....	2
2.	AC voltage 1 min dry withstand test.....	4
3.	AC voltage 10 s wet withstand test.....	6
4.	DC voltage 15 min dry withstand test.....	8
5.	Impulse withstand test(at ambient temperature).....	10
6.	Impulse withstand test(at elevated temperature).....	13
7.	Partial discharge.....	16
8.	Cyclic aging in air.....	18
9.	Partial discharge.....	22
10.	AC voltage 5 h dry withstand test.....	24
11.	AC voltage 5 min dry withstand test.....	26
12.	Impulse withstand test(at ambient temperature).....	28
13.	Partial discharge.....	31
14.	Radio influence voltage .....	33
15.	Leak test .....	36
16.	Pressure leak test.....	40
17.	Salt spray test .....	43





Partial Discharge Test



Partial Discharge Testing in Progress





AC Withstand Voltage Test



AC Withstand Voltage Testing in Progress





AC Withstand Voltage Test



AC Withstand Voltage Testing in Progress





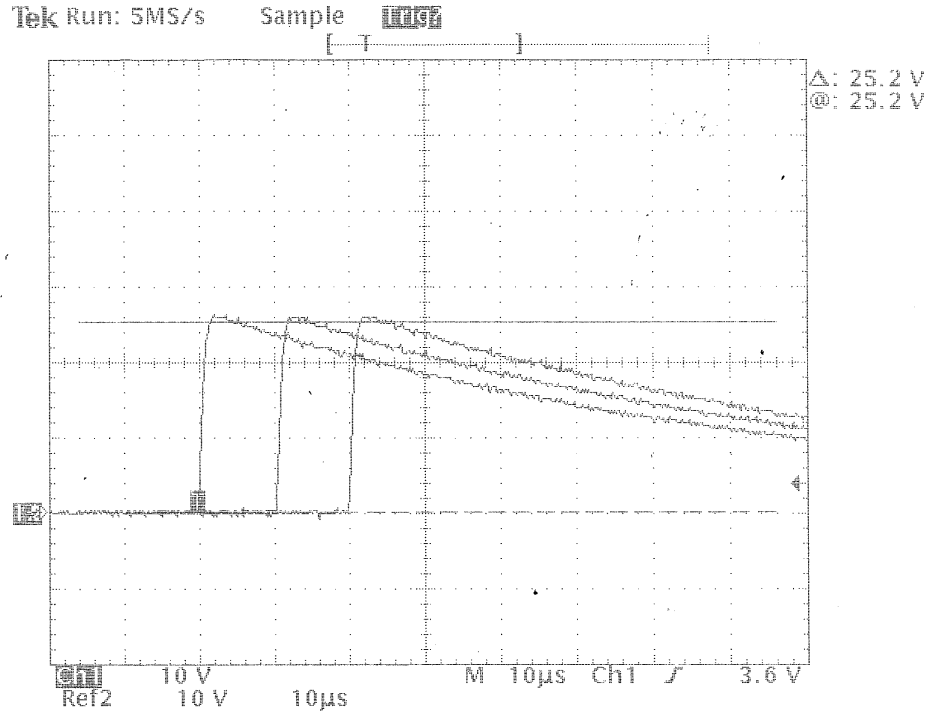


DC Withstand Voltage Test

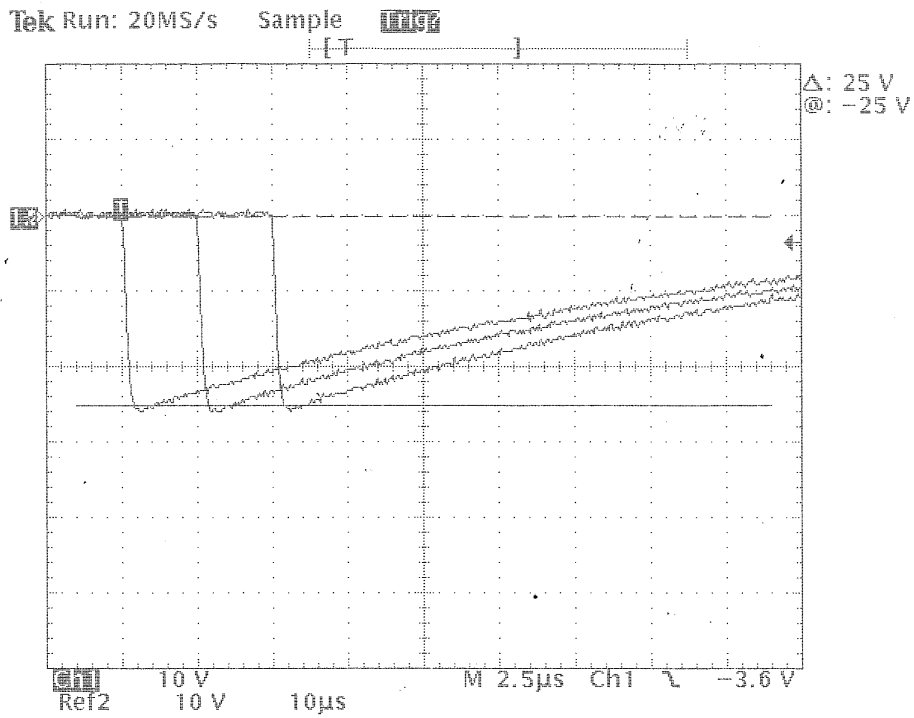


DC Withstand Voltage Test in Progress





Impulse Withstand – Positive Wave



Impulse Withstand Testing – Negative Wave

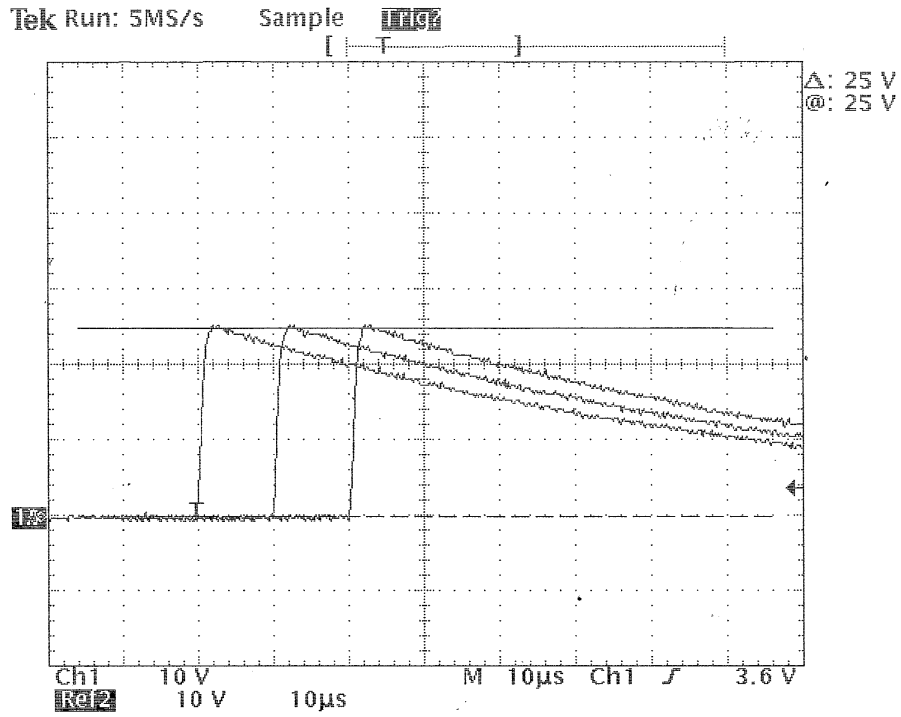


Impulse Withstand Test I

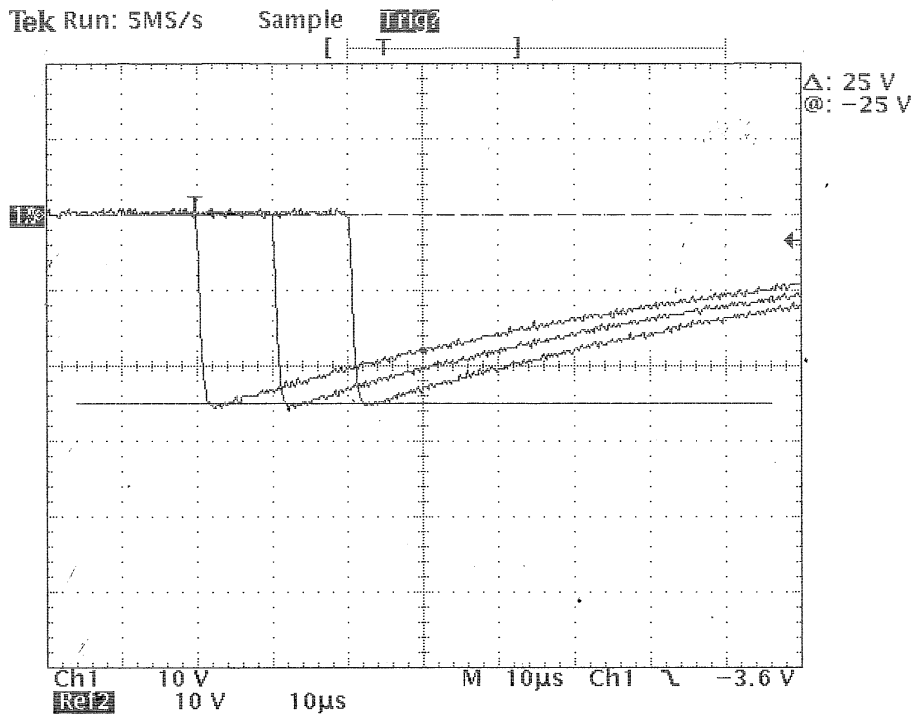


Impulse Withstand Test II





Impulse Withstand – Positive Wave



Impulse Withstand Testing – Negative Wave



Impulse Withstand Test I



Impulse Withstand Test II







Partial Discharge Test



Partial Discharge Testing in Progress

## 8. Cyclic aging in air

### Object

The purpose of this accelerated test is to demonstrate that 200 A insulated connectors can carry rated current under usual service conditions. Successful completion of the test shall be considered as evidence that the connector meets its rating.

### Testing Samples and Mating Parts

Chardon Termination	15-CSTO	4 PCS
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### Mating Parts

200 A Test Cable Equalizers	15 kV 1/0 AWG - Aluminum Aluminum Equalizers Size : 106mm(L)20mm(OD)10.1mm(ID)
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### Testing Spec

a) The test specimen shall be prepared for test in accordance with 8.1 items b), c), e), and f) in the standard.

b) Each test specimen shall be assembled as follows:

1) For single-phase terminations in insulation classes up to and including 46 kV, a total of four terminations shall be tested with two on one length of power cable and two on another. For single-phase terminations in insulation classes above 46 kV, a minimum of two terminations shall be tested with one on each end of a power cable. A minimum of 2 m (6 ft) of cable shall be used between terminations.

2) For one piece, three-phase terminations, a total of two samples shall be tested on one length of power cable. A minimum of 2 m (6 ft) of cable shall be used between terminations.

The test configurations, shown in Figure 2 and Figure 3, are only examples of how the test may be performed. Other test setups may be used to obtain the same goal.

For large, higher voltage cables, more than 2 m (6 ft) of cable may be required to prevent the conductor temperature midway between the terminations from being influenced by the terminations. Up to 5 m (approximately 15 ft) may be required.

c) Testing shall be in accordance with 8.2 and the following:

1) Applied test voltage for Class 1A extruded dielectric cable terminations shall be in accordance with column 7 of Table 1 or Table 2.

2) Applied test voltage for Class 1B and 1C laminated dielectric cable terminations shall be in accordance with column 6 of Table 3.

3) Voltage shall be applied continuously to the test specimens for a 30-day period.

4) Load current, in addition to voltage, shall be applied to the test specimens. During the current-on period, the cable conductor temperature midway between the terminations shall be within 5 °C of the cable's maximum rated emergency operating temperature for a

period of 6 h. During the current-off period, the conductor temperature midway between the terminations shall drop to within 5 °C of the ambient air temperature.

If this condition cannot be met, then every five cycles the current (and voltage) shall remain off for 24 h. The load cycle shall be resumed at the end of the 24 h period. (This procedure may be followed even if the 5 °C condition can be met if a test facility prefers not to run the tests during the weekend.)

The test specimens shall complete 30 load cycles. If the 48 h off period is used, it is not considered in the test cycles.

The cable's emergency rating temperature should be determined by reference to applicable AEIC, NEMA, or ICEA cable specifications or to the cable manufacturer in the case of special use cables.

Temperature can be determined by reading the jacket temperature midway between terminations and comparing it to a "dummy" cable equivalent, where both jacket and conductor temperature have been determined. Equivalent current loadings can also be useful.

5) Partial discharge extinction voltage test level shall be determined for each specimen before the 30 load cycle test period is started and after completion of the 30 load cycle test period. Partial discharge levels shall be determined in accordance with 8.4.1.1.

6) After completion of the cyclic aging test and partial discharge (corona) extinction voltage test level, each specimen shall be tested with lightning impulse voltage (10 shots at each polarity) in accordance with 8.2, 8.4.1.6, and the values specified in one of the following:

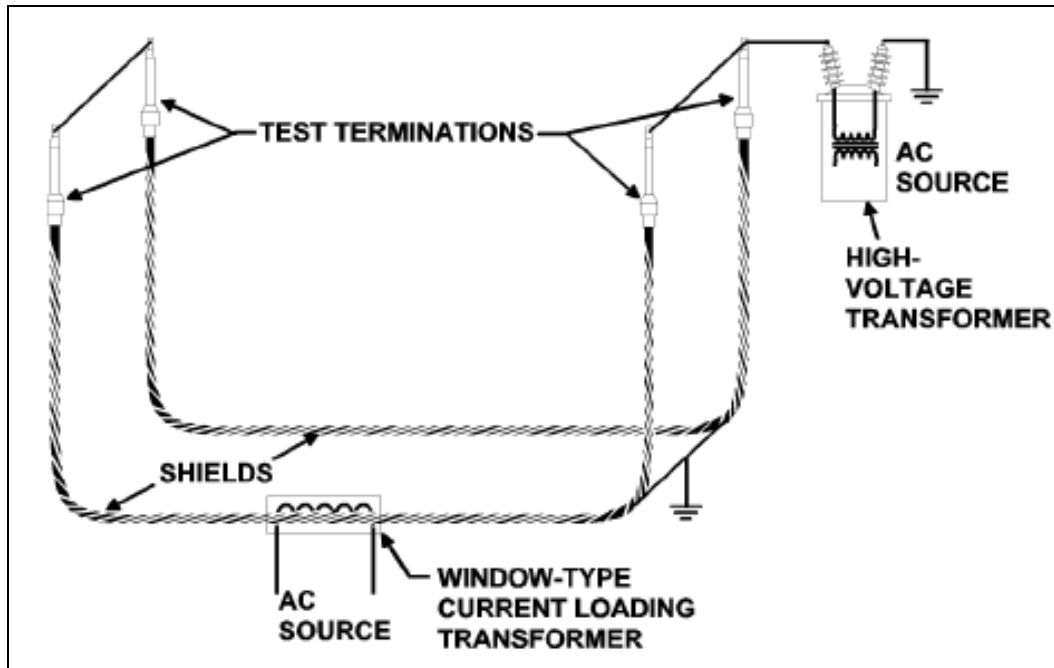
- i) Table 1, column 6, for extruded dielectric cable terminations rated 2.5 kV to 46 kV.
- ii) Table 2, column 6, for extruded dielectric cable terminations rated 69 kV to 500 kV.
- iii) Table 3, column 9, for laminated dielectric cable terminations.

d) Class 1B and 1C terminations shall show no visual indications of fluid leakage at the completion of the cyclic aging test. If the two specimens (one specimen for 46 kV and above or for a three-phase specimen) withstand all of the above specified test conditions for the specified time, they shall be considered as having passed the test.

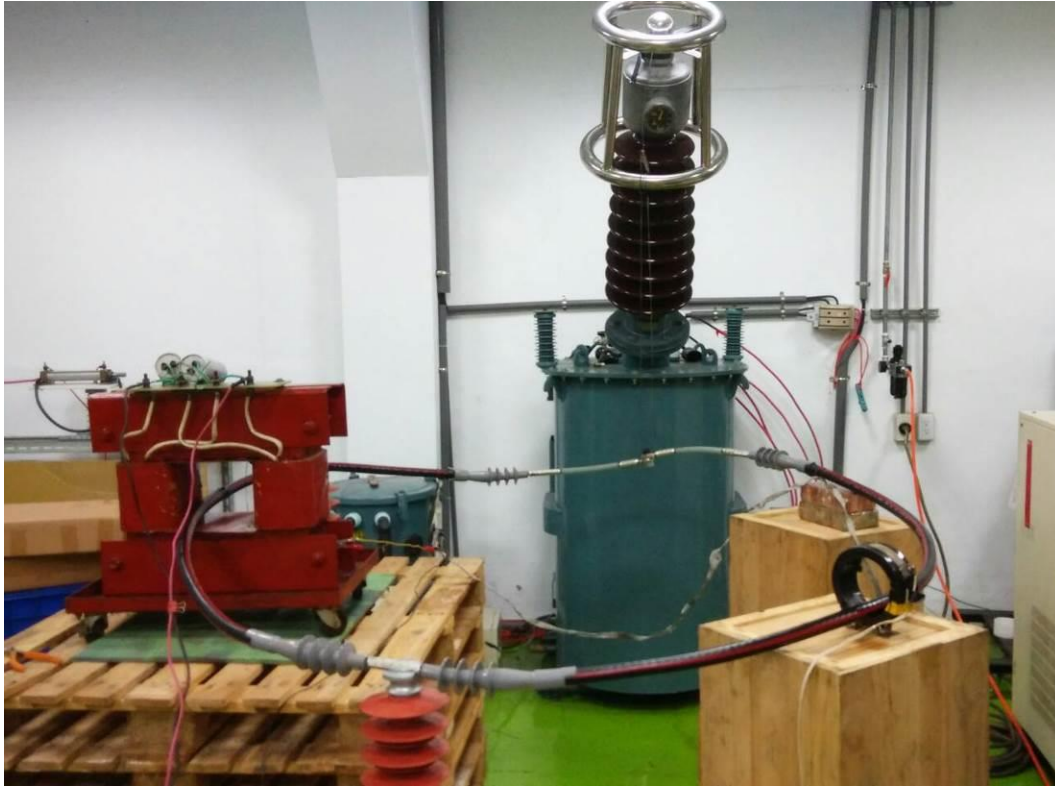
If the test is interrupted or otherwise affected, the cycle(s) affected shall be repeated. If dielectric breakdown occurs in any test specimen, all test specimens shall be considered as having failed.

**Results**

Temperature & Test Voltage	Cable (°C)	Room Temp (°C)	Test Voltage (kV)
Max	131.2	30.9	26.7
Min	130.4	28.1	26.2



Test Setup Diagram



Cyclic Aging in Air Test



Cyclic Aging Testing in Progress





Partial Discharge Test



Partial Discharge Testing in Progress



## 10.AC voltage 5 h dry withstand test

### Object

To verify the connectors that the parts meet ANSI/IEEE standard 48-2009 15 kV AC withstand requirement of 31 kV / 5 hrs.

### Testing Samples

Chardon Termination	15-CSTO	4 PCS
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### Mating Parts

200 A Test Cable	15 kV 1/0 AWG - Aluminum
Equalizers	Aluminum Equalizers Size :
	106mm(L)20mm(OD)10.1mm(ID)

### Procedure and Testing Spec

The test specimen shall be prepared for test in accordance with 8.1 items a), b), c), e), and f) and tested in accordance with 8.2 and the values specified in one of the following in the standard:

- a) Table 1, column 9, for extruded dielectric cable terminations rated 2.5 kV to 46 kV.

If the test specimen withstands the specified test voltage for the specified time, it shall be considered as having passed the test. If the test is interrupted, the total duration of voltage application shall be increased by twice the duration of each interruption.

### Results

Sample number	31 kV / 5 hrs AC withstand voltage
A1	PASS
A2	PASS
A3	PASS
A4	PASS



AC Withstand Voltage Test



AC Withstand Voltage Testing in Progress

## 11. AC voltage 5 min withstand test

### Object

To verify the connectors that the parts meet ANSI/IEEE standard 48-2009 15 kV AC withstand requirement of 39 kV / 5 min.

### Testing Samples

Chardon Termination	15-CSTO	4 PCS
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### Mating Parts

200 A Test Cable	15 kV 1/0 AWG - Aluminum
Equalizers	Aluminum Equalizers Size :
	106mm(L)20mm(OD)10.1mm(ID)

### Procedure and Testing Spec

The test specimen shall be prepared for test in accordance with 8.1 items a), b), c), e), and f) and tested in accordance with 8.2 and the values specified in one of the following in the standard:

a) Table 1, column 8, for extruded dielectric cable terminations rated 2.5 kV to 46 kV.

If the test specimen withstands the specified test voltage for the specified time, it shall be considered as having passed the test. If flashover occurs, the test shall be repeated. If the repeat test also results in flashover or other dielectric breakdown, the test specimen shall be considered as having failed. If the specimen passes the repeat test, the test specimen shall be considered as having passed the test.

### Results

Sample number	39 kV / 5 min AC withstand voltage
A1	PASS
A2	PASS
A3	PASS
A4	PASS



AC Withstand Voltage Test



AC Withstand Voltage Testing in Progress

## 12. Impulse withstand test(at ambient temperature)

### Object

To verify the connectors that the parts meet ANSI/IEEE Standard 48-2009 15 kV impulse withstand testing requirements of  $1.2 \times 50 \mu\text{s} \pm 125 \text{ kV}$  wave., 10 positive and 10 negative full-wave impulses, under the condition of maximum emergency operating conductor temperature of the cable.

### Testing Samples

Chardon Termination 15-CSTO 4 PCS

### Mating Parts

200 A Test Cable 15 kV 1/0 AWG - Aluminum  
Equalizers Aluminum Equalizers Size :  
106mm(L)20mm(OD)10.1mm(ID)

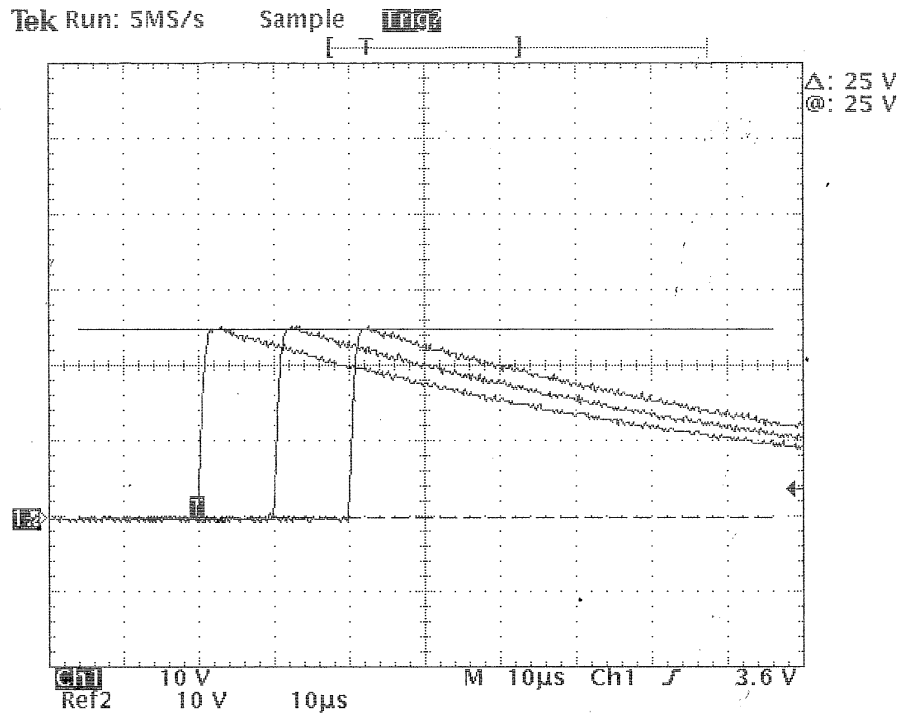
### Procedure and Testing Spec

The test voltage shall be  $1.2 / 50 \mu\text{s}$  wave having the crest value (BIL) of 110 kV. The connector shall withstand 10 positive and 10 negative full-wave impulses without flashover or puncture.

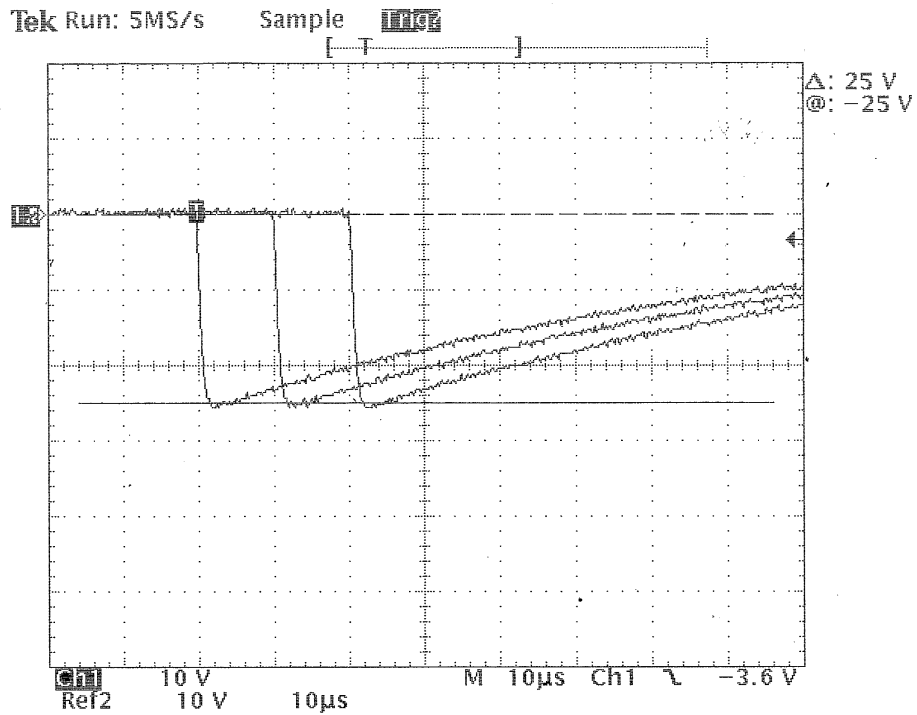
Ten consecutive impulses at each polarity shall be applied to the test specimen with the conductor temperature of the cable at ambient temperature, and then again with the cables at elevated temperature. The elevated temperature is based on the maximum emergency operating conductor temperature of the cable. The cable emergency operating temperature shall be determined by reference to the applicable standard (see Table 7 in the standard). If a flashover or other dielectric breakdown does not occur, the test specimen shall be considered as having passed the test. If two or more of the applied impulse waves cause flashover, the specimen shall be considered as having failed. If one of the applied impulses causes flashover, ten additional impulses shall be applied. If flashover or other dielectric breakdown does not occur, the specimen shall be considered as having passed the test.

### Results

Sample number	$1.2 \times 50 \mu\text{s} \pm 125 \text{ kV}$ Impulse withstand voltage
A1	PASS
A2	PASS
A3	PASS
A4	PASS



Impulse Withstand – Positive Wave



Impulse Withstand Testing – Negative Wave



Impulse Withstand Test

CHARDON GROUP

## 13. Partial discharge

### Object

To verify the connectors that the parts meet ANSI/IEEE Standard 48-2009 / IEC HD 629.1 S1-1996 15 kV partial discharge requirement of 20 kV / 10 pC.

### Testing Samples

Chardon Termination                              15-CSTO                              4 PCS

### Mating Parts

Test Cable    15 kV 1/0 AWG - Aluminum  
Equalizers    Aluminum Equalizers Size :  
   106mm(L)20mm(OD)10.1mm(ID)

### Procedure and Testing Spec

The partial discharge detecting apparatus shall be adjusted to have a sensitivity that will permit detection of discharge pulses of at least 10.0 pC. The test voltage shall be raised to at least 120% of the value listed in Table 4 and Table 11 in IEC HD629 standard. If partial discharge exceeds 10.0 pC, the test voltage shall be lowered to the value listed in column 3 and shall be maintained at this level for at least 3 s but not more than 60 s. The test specimen shall have successfully passed the test if the partial discharge level does not exceed 10.0 pC during this period.

### Results

Sample number	20 kV / 5 pC Corona voltage level
A1	24.3 kV / 1.0 pC
A2	24.3 kV / 1.0 pC
A3	24.3 kV / 1.0 pC
A4	24.3 kV / 1.0 pC





Partial Discharge Test



Partial Discharge Testing in Progress

## 14. Radio influence voltage

### Object

To verify the connectors that the parts meet ANSI/IEEE Standard 48-2009 15 kV Radio influence voltage requirement of 8.7 kV / 100  $\mu$ V.

### Testing Samples

Chardon Termination    15-CSTO    4 PCS

### Mating Parts

200 A Test Cable    15 kV 1/0 AWG - Aluminum  
Equalizers    Aluminum Equalizers Size :  
106mm(L)20mm(OD)10.1mm(ID)

### Procedure and Testing Spec

The test specimen shall be prepared for test in accordance with 8.1 items a), b), c), e), and f) and tested in accordance with 8.2 in the standard and IEC 60270.

The applied test voltage shall be the maximum design voltage-to-ground indicated in column 2 of Table 3 in the standard.

The test specimen shall have successfully passed the test if the RIV does not exceed the values specified (measured at 1 MHz) in Table 3, column 7, for laminated dielectric cable terminations.

### Results

Sample number	8.7 kV / 100 $\mu$ V Radio influence voltage
A1	15 kV / 5 $\mu$ V
A2	15 kV / 5 $\mu$ V
A3	15 kV / 5 $\mu$ V
A4	15 kV / 5 $\mu$ V



Radio Influence Voltage Test



Radio Influence Voltage Testing in Progress I



Radio Influence Voltage Testing in Progress II

CHARDON GROUP

## 15. Leak test

### Object

To verify the connectors that the parts meet ANSI/IEEE Standard 48-2009 15 kV Leak Test of 17.4kV/1hr.

### Testing Samples

Chardon Termination	15-CSTO	4 PCS
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### Mating Parts

200 A Test Cable Equalizers	15 kV 1/0 AWG - Aluminum Aluminum Equalizers Size : 106mm(L)20mm(OD)10.1mm(ID)
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### Procedure and Testing Spec

Leak tests are conducted for two reasons:

- To help assure that the termination seals will prevent leakage of internal fluids (gas or liquid) during pressure rises that occur during normal operational temperature fluctuations. (Pressure leak test)
- To help assure that the termination seals will prevent the ingress of moisture or other environmental contamination during pressure drops (vacuums) that occur during normal operational temperature fluctuations. (Vacuum leak test)

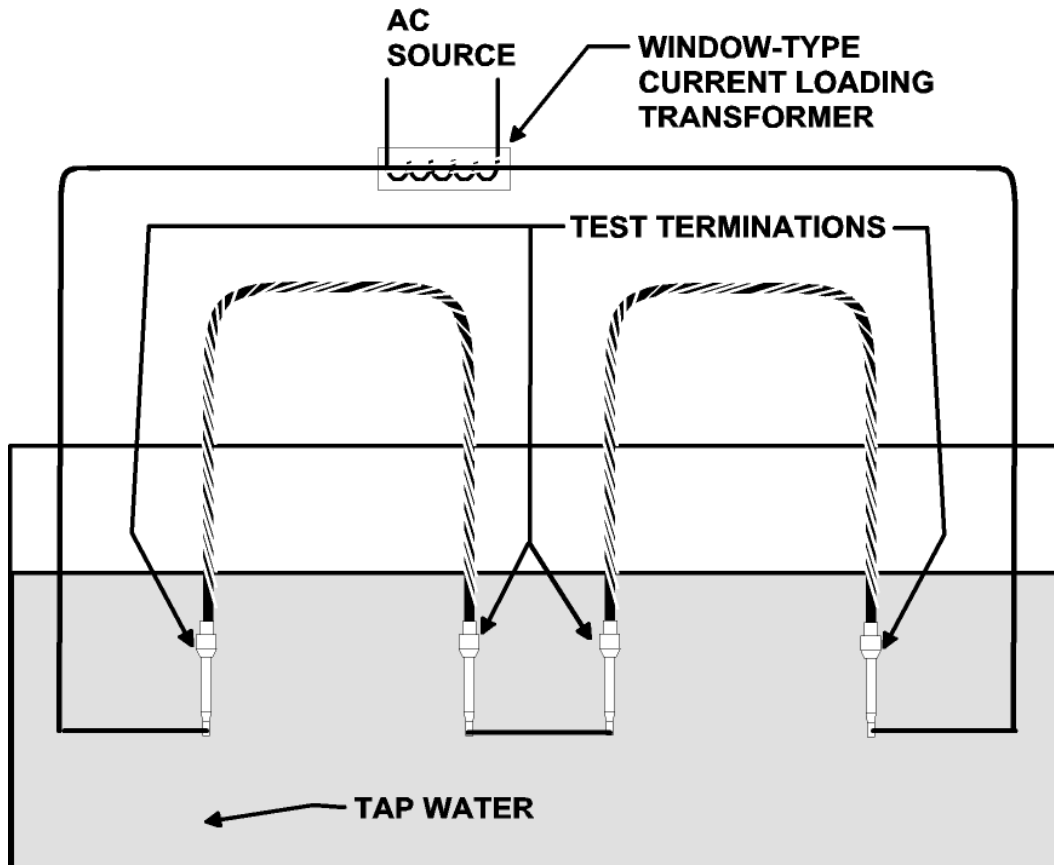
The design characteristics of fluid-filled and non fluid-filled terminations are quite different; therefore separate test procedures are used.

Most distribution class and some transmission class terminations generally do not have a fluid-filled interior so a pressure and/or vacuum test may not be appropriate. However, it is important to assure that moisture will not enter the termination at any interfaces between the termination and the cable. To make this evaluation, the following test is required for terminations that do not have a fluid-filled interior.

- After all other tests are complete, the test terminations shall be placed in a tap water filled reservoir. The water level shall be sufficient to completely cover the terminations. The terminations shall be connected in series and load cycled in the same manner as the 30-cycle test for 10 cycles. Figure 3 shows how this might be accomplished using a water-filled tank. In some cases, it may be more appropriate to place tubes (conduit or pipes) over the terminations and fill them with tap water. The water temperature is not controlled.
- Remove the samples from the water and allow to air dry.
- Perform a room temperature, 1 h withstand test at  $2 V_g$  ac. Where:  $V_g$  = nominal voltage to ground
- Pass/fail criterion: All four terminations shall withstand the 1 h application of voltage without failure.

**Results**

Sample number	17.4 kV / 1 hr
A1	PASS
A2	PASS
A3	PASS
A4	PASS





Leak Test



Leak Testing Samples



Leak Test in Progress



## 16. Pressure leak test

### Object

To verify the connectors that the parts meet NMX-J-199-ANCE Pressure leak test of 50 kPa / 6 hrs.

### Testing Samples

Chardon Termination	15-CSTO	4 PCS
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### Mating Parts

200A Test Cable	15kV 1/0 AWG - Aluminum
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### Procedure and Testing Spec

The test specimen must be prepared at room temperature in accordance with 7.1 a) 7.1 c) and 7.1 g), must meet the values specified in Table 3, when tested in accordance with the following (the specimen if a rupture does not occur or drain pressure):

For classes terminals 1A or 1B Apply 200 kPa for 1 h at room temperature. If gas pressure is used, the specimen must be immersed in a liquid at a maximum depth of 5 cm, or cover the outer surface with a soap solution. If liquid pressure is used, it must have a maximum viscosity of 27.6 centistokes (125 su (Saybolt Universal)) at 25 ° C. Seal areas should be covered with talc which show the presence of a leak. The test can be performed at 100 kPa for 2 h or 50 kPa for 6 h.

7.1 Preparation of test specimen The terminal must meet the requirements specified in 7.4, 7.5 and 7.6 considering the following function of each:

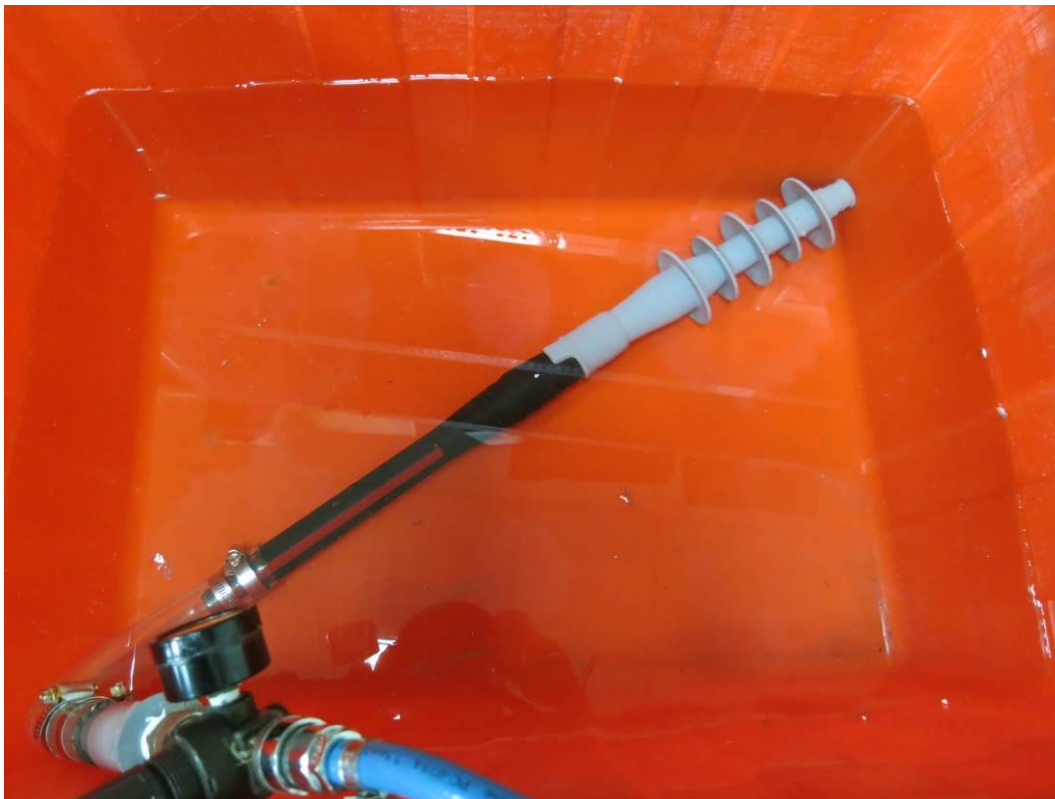
a) It must be completely assembled with metal parts and have provisions for admitting air or other means inside (if liquid medium is used to completely become filled) and have provisions for measuring internal pressures during the test. The units operate with internal pressures, whether such pressures are cable system or a separate source, should be tested at minimum pressure under which the cable system or terminal, is expected to operate in service.

c) must be mushroom and clean.

g) must be fully assembled, with sealed inputs. Terminals for high voltage cables that incorporate collar at the entrance, must be assembled with a mandrel, the seal being made of the material of the collar against the mandrel.

**Results**

Sample number	50 kPa / 6 hrs
A5	PASS
A6	PASS



Pressure Leak Testing Sample



Testing Pressure

CHARDON GROUP

## 17. Salt spray test

### Object

To verify the connectors that the parts meet NMX-J-199-ANCE 15 kV Salt spray test of 10.1 kV / 1000 hrs.

### Testing Samples

Chardon Termination	15-CSTO	2 PCS
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### Mating Parts

200 A Test Cable	15 kV 1/0 AWG - Aluminum
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### Procedure and Testing Spec

Specimens should be powered according to the following:

Test voltage (kV) = creepage distance (mm) / 34.6 = 349 / 34.6 = 10.09V

In addition, they must be within a chamber in which it precipitates a mixed with the following characteristics:

- Water flow:  $0.4 \pm 0.1 \text{ l} / (\text{m}^3 \times \text{h})$ .
- Temperature of  $20^\circ\text{C} \pm 5^\circ\text{C}$ .
- Droplet size of  $5 \mu\text{m}$  to  $10 \mu\text{m}$ .
- Salt content in the water of  $10\text{kg} / \text{m}^3 \pm 0.5 \text{ kg} / \text{m}^3$  (16,000 pS / cm), only for the case of salt spray.

The specimens shall withstand 1000 h of precipitation fog.

It is possible to interrupt 24 h per 24 h of precipitation fog, however, can not be de-energized terminals for more than 15 min period for reasons of inspection. Any period of interruption, either fog or voltage is counted in the 1000 h test.

The specimen is considered approved if no carbon or conductive paths if four or more will not cause overcurrents in the test circuit or Ia test at the end of the cable insulation is not visible in the zone of the terminal.

**Results**

Sample number	10.1 kV / 1000 hr
A7	PASS
A8	PASS



Salt Spray Testing Voltage



Salt Spray Test Samples



Salt Spray Test in Progress