25kV 200A Deadbreak Bushing Insert Connector Design Test Report

Report Number:	Test Start Date:	Test Complete Date:
RN-R7507	2016 / 02 / 01	2016 / 03 / 02

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1. Partial Discharge - Deadbreak BI

Object

To verify the connectors that the parts meet ANSI/IEEE Standard 386-2006 25kV partial discharge requirement of 19kV/3pC.

Testing Samples

Deadbreak Bushing Insert	CHARDON 25-DBI200	10 PCS

Mating Parts

Deadbreak Elbow	CHARDON 25-DE200T
Elbow Test Rod	25kV#C Testing Rod Φ22.30mm

Procedure and Testing Spec

The test voltage shall be raised to 20% above the corona voltage level of 19kV. If corona exceeds 3pC, the test voltage shall be lowered the corona voltage level of 19kV and maintained at this level for at least 3 seconds but not more than 60 seconds. Corona readings taken during this period shall not exceed 3 pC.

Results

Sample number	Corona voltage level
A1	23 kV / 0.7 pC
A2	23 kV / 0.7 pC
A3	23 kV / 0.7 pC
A4	23 kV / 0.7 pC
A5	23 kV / 0.7 pC
A6	23 kV / 0.7 pC
A7	23 kV / 0.7 pC
A8	23 kV / 0.7 pC
A9	23 kV / 0.7 pC
A10	23 kV / 0.7 pC

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2. AC Withstand Voltage Test - Deadbreak BI

Object

To verify the connectors that the parts meet ANSI/IEEE standard 386-2006 25kV AC withstand requirement of 40kV/ 1 min.

Testing Samples

Deadbreak Bushing Insert	CHARDON 25-DBI200	10 PCS

Mating Parts

Deadbreak Elbow	CHARDON 25-DE200T
Elbow Test Rod	25kV#C Testing Rod Φ22.30mm

Procedure and Testing Spec

The test voltage shall be raised to the value of 40kV in 30 seconds. The test sample shall withstand the specified test voltage for 1 minute without flashover or puncture.

Results

Sample number	40kV/1min AC withstand voltage
A1	PASS
A2	PASS
A3	PASS
A4	PASS
A5	PASS
A6	PASS
A7	PASS
A8	PASS
A9	PASS
A10	PASS

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3. DC Withstand Voltage Test – Deadbreak BI

Object

To verify the connectors that the parts meet the ANSI/IEEE Standard 386-2006 25kV DC withstand voltage testing spec of 78kV/15 min.

Testing Samples

Deadbreak Bushing Insert	CHARDON 25-DBI200	10 PCS

Mating Parts

Deadbreak Elbow	CHARDON 25-DE200T
Elbow Test Rod	25kV#C Testing Rod Φ22.30mm

Procedure and Testing Spec

The test voltage shall have a negative polarity and shall be raised to the value of 78kV. The connector shall withstand the specified test voltage for 15 minutes without flashover or puncture.

Results

Sample number	-78kV/15min DC withstand voltage
A1	PASS
A2	PASS
A3	PASS
A4	PASS
A5	PASS
A6	PASS
A7	PASS
A8	PASS
A9	PASS
A10	PASS

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4. Impulse Withstand Testing – Deadbreak BI

Object

To verify the connectors that the parts meet ANSI/IEEE Standard 386-2006 25kV impulse withstand testing requirements of 1.2×50μs ±125kV wave., 3 positive and 3 negative full-wave impulses.

Testing Samples

Deadbreak Bushing Insert	CHARDON 25-DBI200	10 PCS

Mating Parts

Deadbreak CAP	CHARDON 25-DIC200
Bushing Well	Elliott 200 Amp Bushing Well #1101-225B

Procedure and Testing Spec

The test voltage shall be 1.2/50μs wave having the crest value (BIL) of 125kV. The connector shall withstand 3 positive and 3 negative full-wave impulses without flashover or puncture.

Results

Sample number	1.2×50μs±125kV Impulse withstand voltage
A1	PASS
A2	PASS
A3	PASS
A4	PASS
A5	PASS
A6	PASS
A7	PASS
A8	PASS
A9	PASS
A10	PASS

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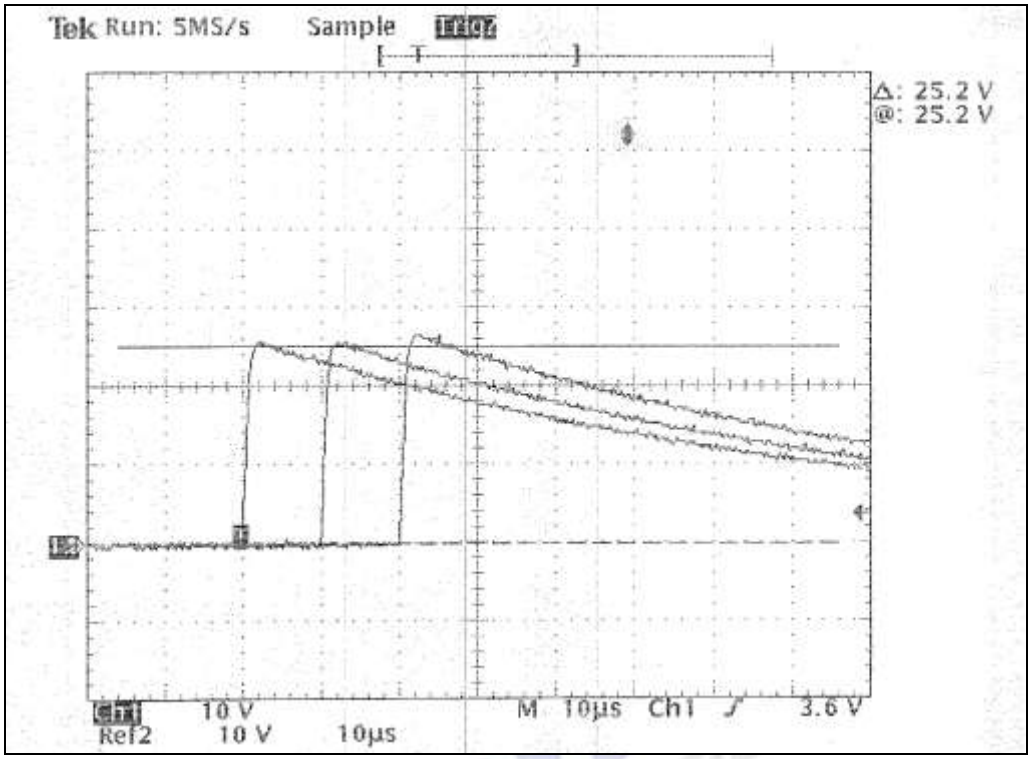
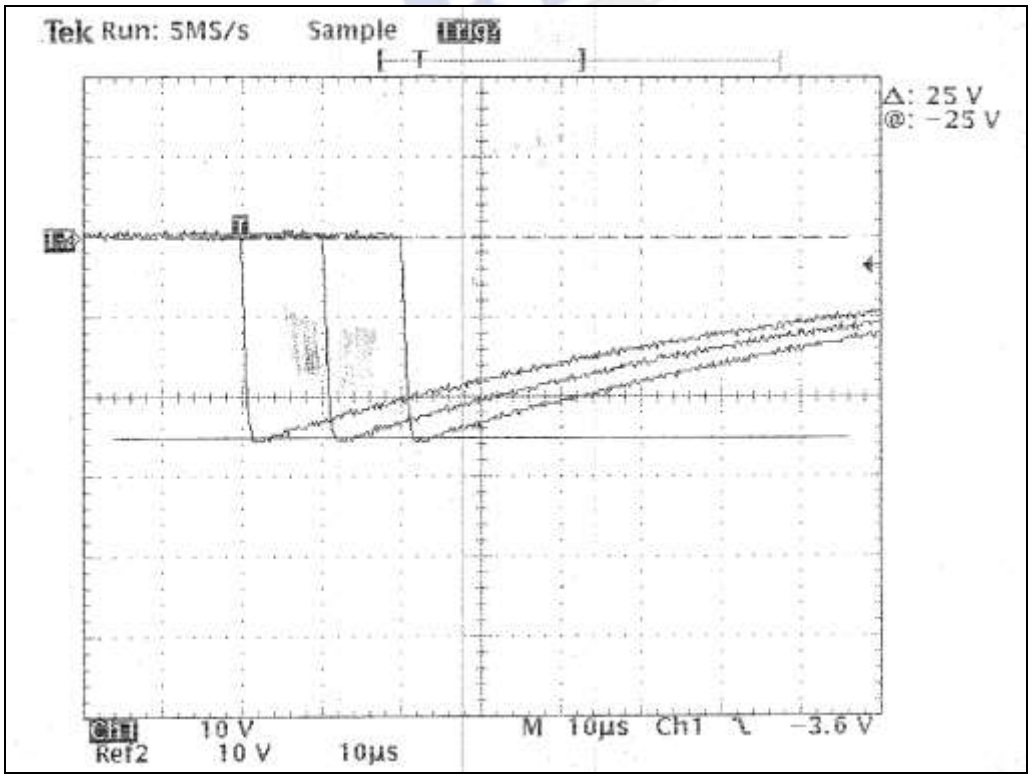


Impulse Withstand – Positive Wave



Impulse Withstand Testing – Negative Wave

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5. Short-time Current Testing – Deadbreak BI

Object

To verify the connectors that the parts meet ANSI/IEEE Standard 386-2006 200A short-time current test requirements.

Testing Samples

Deadbreak Bushing Insert	CHARDON 25-DBI200	10 PCS

Mating Parts

Deadbreak Elbow	CHARDON 25-DE200T
Cable Conductor Type	1/0 AWG(Aluminum)

Procedure and Testing Spec

The rms value of the first major loop of a current wave shall be not less than the value specified in Table 2 multiplied by 1.3 (X/R=6) for 200 A connectors The magnitude shall be measured in accordance with ANSI/IEEE C37.09.
Connectors shall withstand the current without separation of interfaces or impairing the ability to meet the other requirements of the standard.

Results

10kA/0.29sec

Sample number	1st Cycle Current (peak)	1st Cycle Current (rms)	Current (rms)	Time	Verification	Result
A11&A12	18.62kA	13.16kA	10.7kA	0.27 sec	Normal	PASS
A13&A14	18.49kA	13.07kA	10.7kA	0.27 sec	Normal	PASS

3.5kA/3sec

Sample number	1st Cycle Current (peak)	1st Cycle Current (rms)	Current (rms)	Time	Verification	Result
A11&A12	12.50kA	8.66kA	6.89kA	3.05 sec	Normal	PASS
A13&A14	13.95kA	9.86kA	6.84kA	3.07 sec	Normal	PASS

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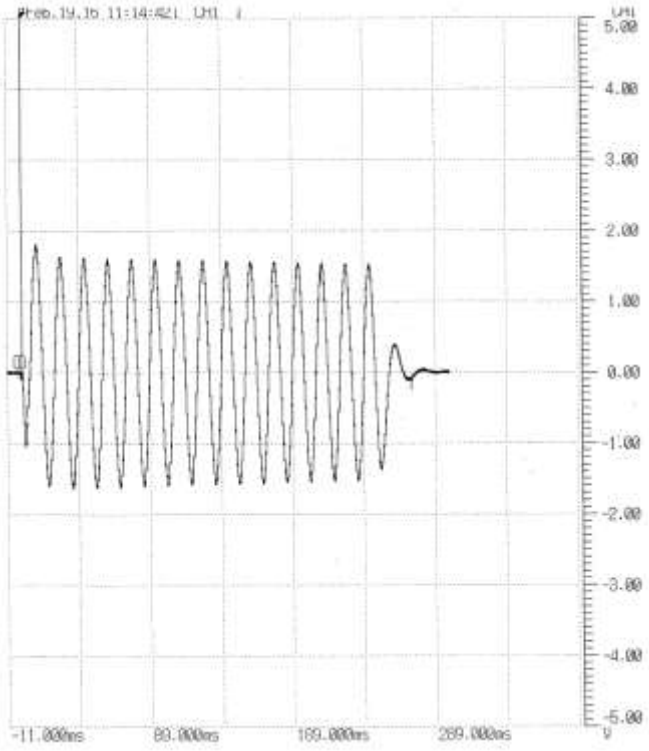
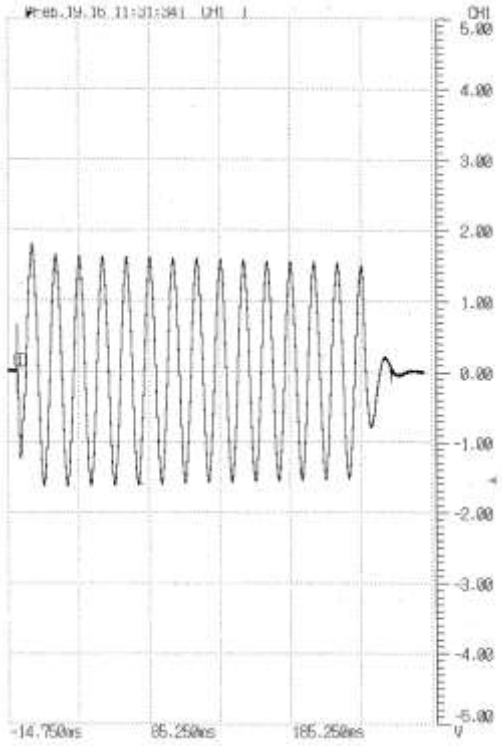


A11&A12 10kA/0.27sec



A13&A14 10kA/0.27sec

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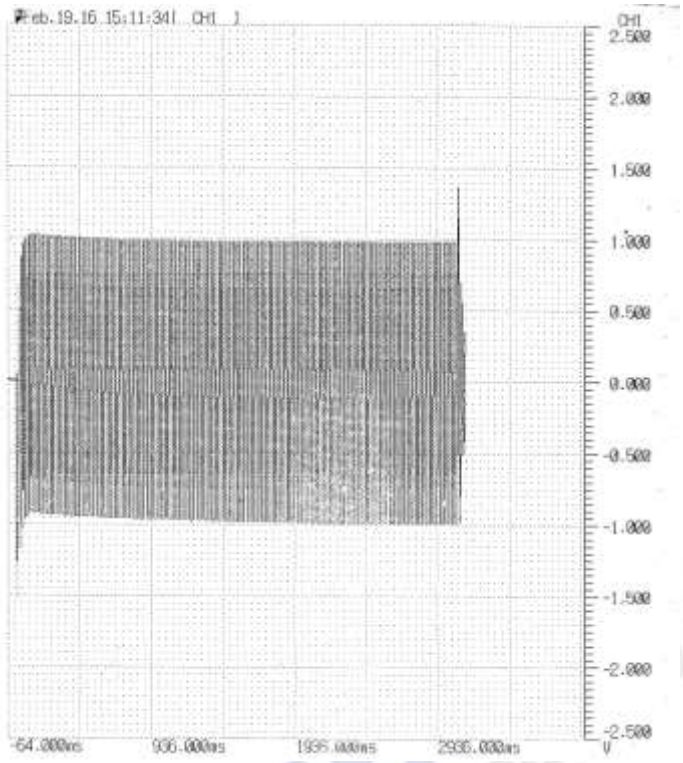
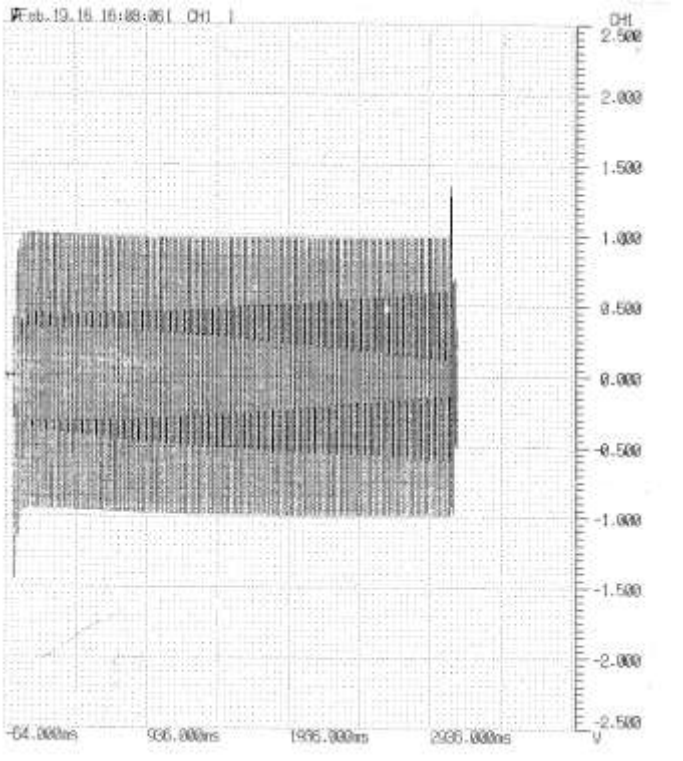


A1&A2 3.5kA/3.05sec



B1&B2 3.5kA/3.07sec

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6. Current Cycling – Accelerated Thermal Test

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

Bushing Insert	CHARDON 25-DBI200	4 PCS
Elbow	CHARDON 25-DE200T	4 PCS

Mating Parts

Cable Conductor Type	1/0 AWG(Aluminum)
Cable Insulation Thickness	220 mil
Conductor	200A Bi-Metal Lug
Equalizers	Aluminum Equalizers Size： 106mm(L)20mm(OD)10.1mm(ID)
Bushing Bus	356mm(L), 102mm(W),10mm(T)

Testing Spec

A control cable, used for the purpose of obtaining conductor temperature, shall be installed in the heat cycle loop between two equalizers. Its length shall be 183 cm (72 in). The control cable shall be the same type and size as the cable used to join the connectors under test.

Four connectors shall be assembled in series on AWG No 1/0 insulated aluminum conductors having a length of 91 cm (36 in). The cable insulation thickness shall be selected according to its voltage class (see Table 10 of IEEE 386).Equalizers used shall be in accordance with ANSI C119.4.The bushing bus shall be a flat, rectangular, bus bar 356 mm (14 in) long, 102 mm (4 in) wide, and 10 mm (3/8 in) thick. The bushing wells shall be mounted 31 cm (12 in) apart centered along the midline of the bus bar. The bushing well studs shall be tightened to the bus bar using an installation torque of 9 N·m ± 1 N·m (80 lbf·in ± 10 lbf·in).

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Unless otherwise specified by the manufacturers, the elbow male contact probe shall be threaded into the elbow compression lug using an installation torque of 9 N·m ± 1 N·m (80 lbf·in ± 10 lbf·in).

Current-cycling tests shall be conducted at an ambient temperature of 15 °C to 35 °C in a space free of drafts.

The current-cycle amperes shall be adjusted during the current-on period of the first five cycles to result in a steady-state temperature rise of 100 °C to 105 °C on the control conductor. This current shall then be used during the remainder of the test current-on periods, regardless of the temperature of the control conductor.

The test shall consist of 50 current cycles, with the current on 4 h and off 2 h for each cycle. At the end of each current-on cycle, the assembly shall be de-energized and within 3 min be submerged in water at 5 °C ± 5 °C for the remainder of the current-off cycle. At the end of the 10th, 25th and 40th cycles (± 2 cycles), after the samples have returned to room temperature, a short time ac current of 3500 A ± 300 A rms shall be applied to each sample for a minimum of 3 s.

The temperature of at least the following current transfer points shall be measured at the end of each cycle with the current on:

a) Probe to compression lug
b) Probe to female contact
c) Female contact structure to metallic housing (piston contact)
d) Between bushing insert and bushing well.

These temperatures shall not exceed the temperature of the control conductor.

The temperature differences between the control conductor and the connector shall show a condition of stability from the fifth cycle to the end of the test. Stability is indicated when the change in the individual differences is not more than 10 °C from the average of the measured differences in this interval for this connector.

The dc resistance of the connector system shall be measured at the end of cycles 10, 20, 30, 40, and 50 (± 2 cycles). The dc resistance measurements shall be made between the elbow cable equalizer and the bushing stud after the connector system has stabilized at ambient temperature. Ambient temperature shall be measured by devices located within 61 cm (2 ft.) of the test loop but in a location that minimizes the effect of thermal convection. The ambient temperature shall be recorded at the same time as each set of resistance measurements, and the resistance shall be corrected to 20 °C. The dc resistance shall be stable over the period of measurement. Stability is achieved when any resistance measurement, including allowance for instrument accuracy, does not vary more than ± 5% from the average of all the measurements in this interval.

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Results

Temperature Sensor Area ：a-compression lug/ probe b-probe/louver contact

Unit ℃

Cycle#	A15		A16		A17		A18		cable	Room Temp	Water Temp
	a.	b.	a.	b.	a.	b.	a.	b.			
6	40.8	37.4	46.3	43.8	40.5	34.8	43.8	38.6	100.7	19.6	6.4
7	41.8	39.0	47.1	39.9	40.3	36.7	45.0	40.0	100.6	19.4	6.3
8	42.0	39.1	47.6	40.2	40.5	36.8	46.2	40.6	100.5	19.3	6.5
9	41.9	39.4	48.9	41.0	40.7	36.5	47.7	41.5	100.7	19.6	6.6
10	43.4	40.5	46.2	41.5	41.8	38.0	48.4	41.8	100.5	19.7	6.3
11	42.8	40.5	46.3	40.6	43.8	38.9	48.2	42.3	100.8	19.6	6.7
12	44.6	41.8	45.7	40.2	46.4	41.7	50.4	44.5	100.5	19.7	6.5
13	41.9	39.3	46.1	40.7	42.0	37.8	49.2	42.9	100.2	19.7	6.3
14	45.5	43.4	47.2	41.2	47.8	42.4	50.7	44.7	100.5	19.8	6.6
15	45.9	42.9	46.6	41.2	46.4	41.8	50.3	44.7	100.7	19.7	6.7
16	45.2	42.5	46.0	41.6	46.3	41.1	50.2	44.4	100.5	19.6	6.7
17	46.2	43.6	46.7	42.0	46.0	40.5	49.9	43.8	100.2	19.7	6.9
18	46.5	43.5	46.8	42.5	47.1	43.0	50.1	44.9	100.9	19.5	7.0
19	46.9	44.4	47.1	43.4	49.1	42.6	51.0	45.0	101.3	19.4	6.8
20	46.2	43.4	47.8	43.6	48.3	42.7	50.7	44.8	100.7	19.2	7.0
21	49.6	46.2	48.9	44.3	51.8	45.3	51.2	45.2	100.8	20.6	7.0
22	49.0	46.0	48.6	44.7	51.3	45.6	54.0	48.3	100.4	22.2	6.6
23	49.6	46.9	49.6	47.0	50.4	43.9	52.5	46.4	100.5	21.3	6.7
24	46.8	44.2	50.1	46.9	51.3	44.1	50.7	44.8	100.8	20.3	6.8
25	49.0	46.5	50.8	46.5	49.7	42.7	50.4	44.1	100.9	19.7	6.5
26	41.4	38.9	45.8	41.3	41.2	37.2	43.9	40.0	100.6	19.4	6.6
27	41.5	39.0	46.5	41.7	42.3	37.5	44.3	40.1	100.6	18.8	6.7
28	41.5	38.7	46.2	41.6	42.0	37.3	43.8	39.8	100.7	17.7	6.5
29	42.8	39.8	47.6	42.8	42.9	37.6	44.3	39.3	100.9	17.2	6.4
30	42.5	39.7	47.4	42.6	42.9	38.1	44.4	39.5	101.1	17.4	6.8
31	42.6	39.6	47.5	42.9	44.8	39.2	45.1	40.5	101.4	17.5	6.9
32	43.0	40.3	48.1	43.2	45.2	39.9	44.2	40.2	101.4	18.3	7.0
33	44.1	41.0	48.3	44.1	47.2	40.9	45.7	41.0	100.1	18.7	6.4
34	43.8	40.5	48.3	43.8	46.4	40.8	45.0	40.8	100.3	18.6	6.6

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35	42.6	39.6	47.9	42.5	46.7	41.0	45.8	40.7	100.6	18.4	6.8
36	42.7	39.8	47.7	42.8	47.8	41.8	45.9	41.2	100.4	18.7	6.6
37	43.3	40.4	48.2	43.4	48.4	42.1	44.9	40.7	100.9	18.4	6.7
38	43.7	40.9	49.6	44.6	51.2	43.8	46.9	42.4	100.6	18.5	6.5
39	45.6	42.8	51.8	46.0	53.0	45.9	48.7	44.7	100.3	18.4	6.8
40	46.4	43.4	51.8	46.4	53.7	45.7	48.5	44.1	100.3	18.3	6.8
41	45.5	42.3	51.7	45.9	52.9	44.9	47.7	43.1	101.9	17.7	7.3
42	45.0	41.5	52.0	45.8	55.1	46.9	48.8	44.3	101.7	17.5	7.0
43	45.6	41.8	52.6	45.4	56.2	46.7	48.3	43.8	101.5	17.4	7.2
44	45.2	41.6	51.8	45.8	55.7	40.2	46.4	41.5	101.4	17.3	7.2
45	46.4	43.1	53.9	47.0	56.0	46.2	48.2	43.8	101.0	17.5	6.9
46	45.4	41.9	52.7	46.8	56.3	46.5	48.1	43.1	101.2	17.5	6.8
47	46.8	42.8	53.3	47.9	56.5	46.3	47.2	42.4	100.9	17.2	6.9
48	45.6	42.0	53.2	47.5	56.6	47.1	48.3	42.9	100.7	17.1	6.7
49	47.5	44.2	54.8	48.6	57.3	49.5	49.0	44.8	100.3	17.6	6.7
50	46.9	43.4	54.4	47.8	57.0	49.2	49.8	44.3	100.5	17.9	6.8
Average	44.7	41.8	49.0	43.8	48.5	42.0	47.9	42.7	100.8	18.8	6.7
Max Temp Delta (Cycle	4.3℃ (25)	4.7℃ (25)	5.8℃ (49)	3.6℃ (8)	8.2℃ (49)	7.5℃ (49)	6.1℃ (22)	5.6℃ (22)	100.1 ~ 101.9	17.1 ~ 22.2	6.3 ~ 7.3
Remark	Temp difference does not vary more than 10 ℃, meets the requirement of the standard.										

Resistance Measurement Unit：mΩ

Date	Week #	Room Temp	Equalizers-I1 / Bushing Well-I1		Equalizers-I2 / Bushing Well-I2		Equalizers-I3 / Bushing Well-I3		Equalizers-I4 / Bushing Well-I4	
2/11	9	19.6	0.53	0.99%	0.54	0.99%	0.63	0.96%	0.54	0.99%
2/13	20	19.2	0.53	0.99%	0.55	1.01%	0.65	0.99%	0.55	1.01%
2/16	28	17.7	0.54	1.00%	0.55	1.01%	0.66	1.01%	0.55	1.01%
2/19	40	18.3	0.54	1.00%	0.54	0.99%	0.67	1.02%	0.55	1.01%
2/22	50	17.9	0.55	1.02%	0.55	1.01%	0.67	1.02%	0.54	0.99%
Average			0.538		0.546		0.656		0.546	

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Short-time Current 3500A/3 sec

25kV200A Bushing Insert 2016-Feb-11 9th Cycle
3.5kA/3sec X/R 6

Sample Number	1st Cycle Current (peak)	1st Cycle Current (rms)	Current (rms)	Time	Verification	Result
A15&A16	7.54kA	5.33kA	4.15kA	3.06 sec	Normal	PASS
A17&A18	7.28kA	5.14kA	4.27kA	3.04 sec	Normal	PASS

25kV200A Bushing Insert 2016-Feb-15 24rd Cycle
3.5kA/3sec X/R 6

Sample Number	1st Cycle Current (peak)	1st Cycle Current (rms)	Current (rms)	Time	Verification	Result
A15&A16	7.36kA	5.20kA	4.08kA	3.05 sec	Normal	PASS
A17&A18	7.43kA	5.25kA	4.13kA	3.06 sec	Normal	PASS

25kV200A Bushing Insert 2016-Feb-19 40th Cycle
3.5kA/3sec X/R 6

Sample Number	1st Cycle Current (peak)	1st Cycle Current (rms)	Current (rms)	Time	Verification	Result
A15&A16	7.51kA	5.31kA	4.45kA	3.03 sec	Normal	pass
A17&A18	7.46kA	5.27kA	4.36kA	3.05 sec	Normal	pass

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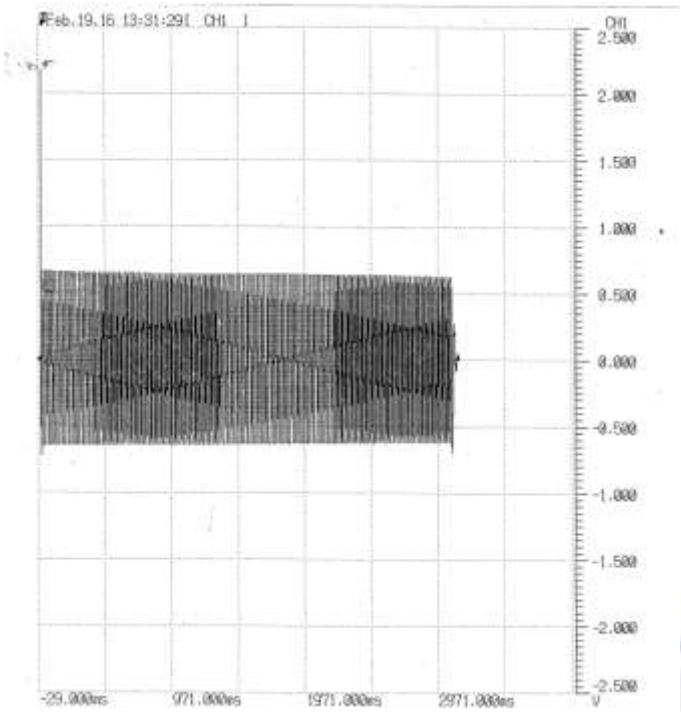
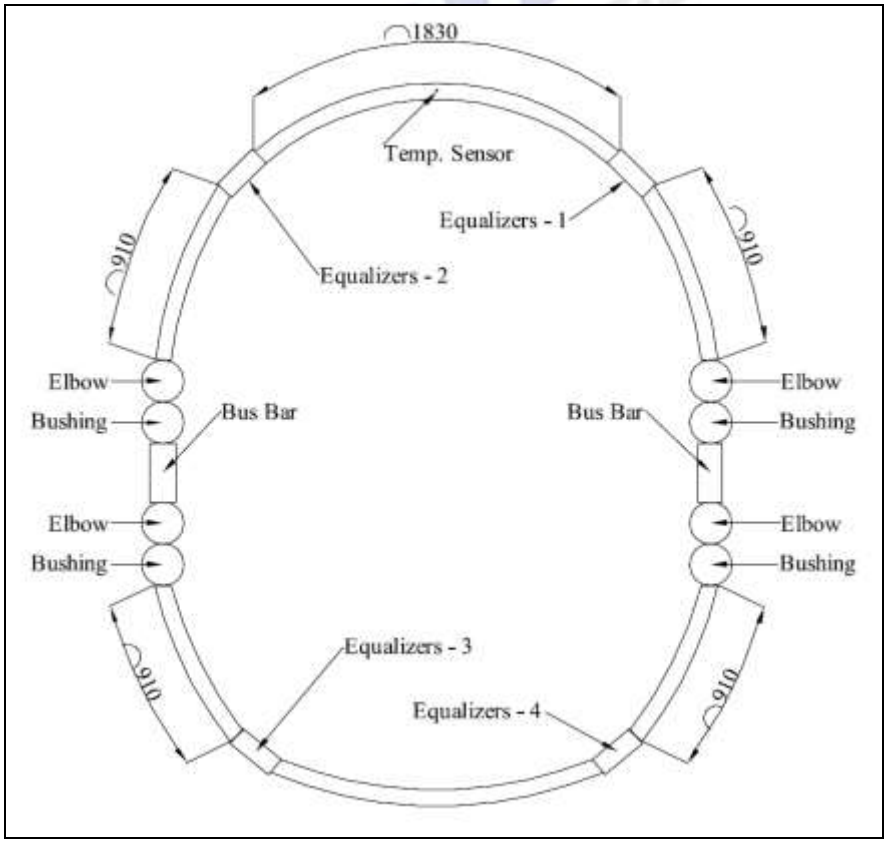


3.5kA/3sec Short-time Current



Test Setup Diagram

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7. Accelerated Sealing Life Test

Object

To verify the connector can maintain a long-tern seal at all interfaces to prevent the entrance of moisture.

Testing Samples and Mating Parts

Bushing Insert	CHARDON 25-DBI200	4 PCS
Elbow	CHARDON 25-DE200T	4 PCS

Mating Parts

Cable Conductor Type	1/0 AWG(Aluminum)
Cable Insulation Thickness	220 mil
Conductor	200A Bi-Metal Lug
Equalizers	Aluminum Equalizers Size： 106mm(L)20mm(OD)10.1mm(ID)
Bushing Bus	356mm(L), 102mm(W),10mm(T)

Procedure

1. The four connector assemblies shall be placed in an oven having 121 °C temperature and remain there for three weeks.
2. After the time has elapsed, the four samples shall be subjected to 50 cycles of the following sequence of operations: The assemblies shall be heated in air using sufficient current to raise the temperature of the connector of the control cable to 90 °C ± 5 °C for 1 hour.
3. The assemblies shall be de-energized and within 3 min, submerged in 25 °C ± 10 °C conductive water (5000 Ω-cm maximum) to a depth of 30 cm (1 ft) for 1 hour.
4. After 50^{th} cycle, the connector and cable assembly shall withstand a design impulse test of IEEE 7.5.3(1.2*50μS impulse wave of 125kV, 3 positive and 3 negative) and test point voltage test.(During the impulse test, the bushing well and bushing bus were soaked into the silicone oil.)

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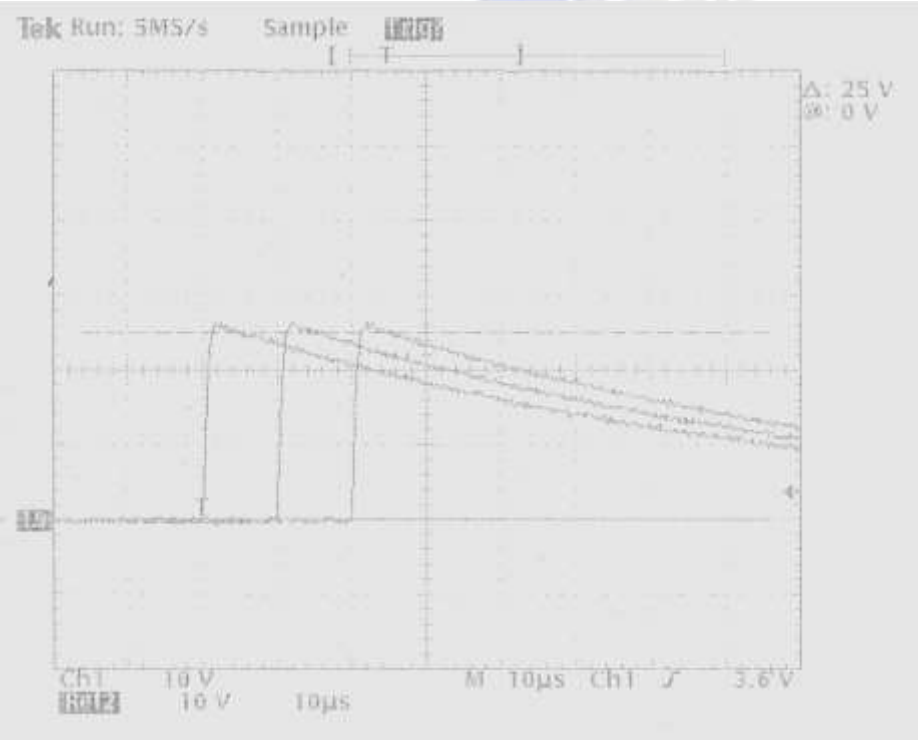
Results

Sample #	PD Testing Before Acc Life Sealing Test	AC Withstand Testing Before Acc Life Sealing Test	Impulse Testing Before Acc Life Sealing Test	PD Testing After Acc Life Sealing Test	Test Point Voltage Testing
A19	25kV0.5pC	40kV/1m Pass	±125kV 3 Shots Each, Pass	±125kV 3 Shots Each, Pass	14.5kV
A20	25kV0.6pC	40kV/1m Pass			13.9kV
A21	25kV0.6pC	40kV/1m Pass			14.0kV
A22	25kV0.6pC	40kV/1m Pass			14.0kV
Remark	● Tested with Bushing Insert and Elbow Assembly ● Cable Temp：91.9~93.8℃ ● Water Temp：17.6~18.2℃ ● Resistance of Water：3145 Ω-cm ● Depth of Water：30 cm ● Test Point Voltage Testing is applied with 15.0kV				



Impulse Testing Waveform before Accelerated Sealing Life Test – Positive Wave

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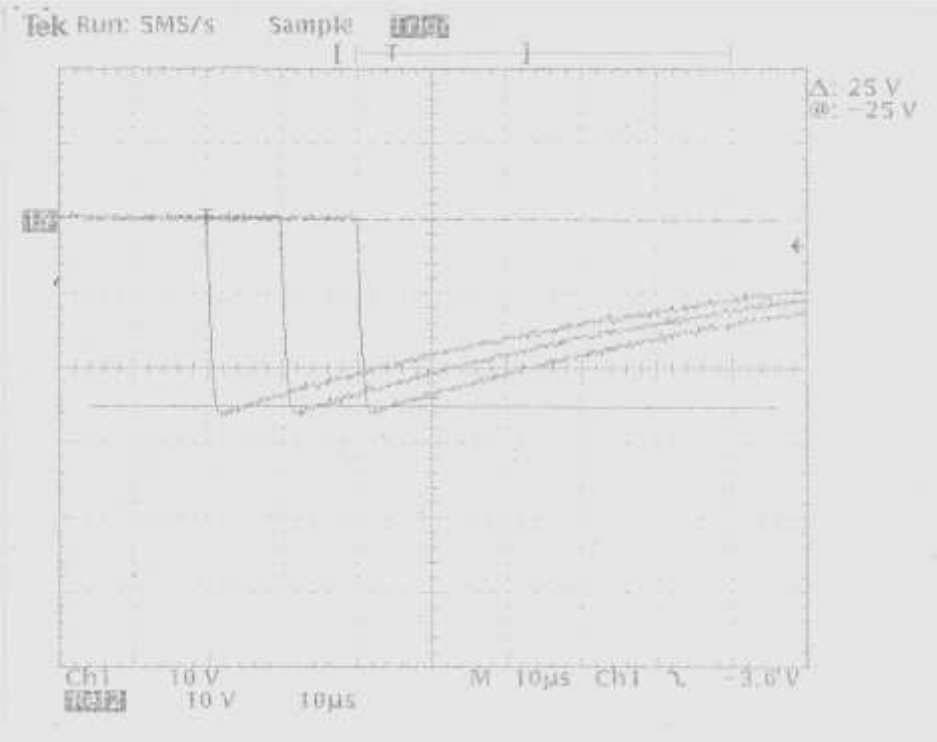
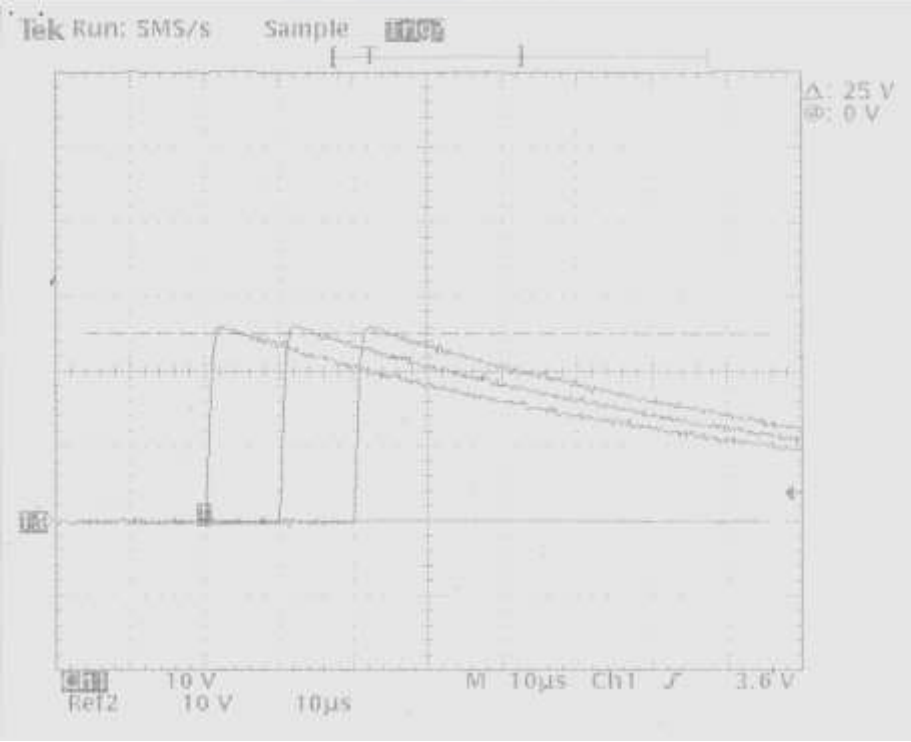


Impulse Testing Waveform before Accelerated Sealing Life Test – Negative Wave



Impulse Testing Waveform after Accelerated Sealing Life Test – Positive Wave

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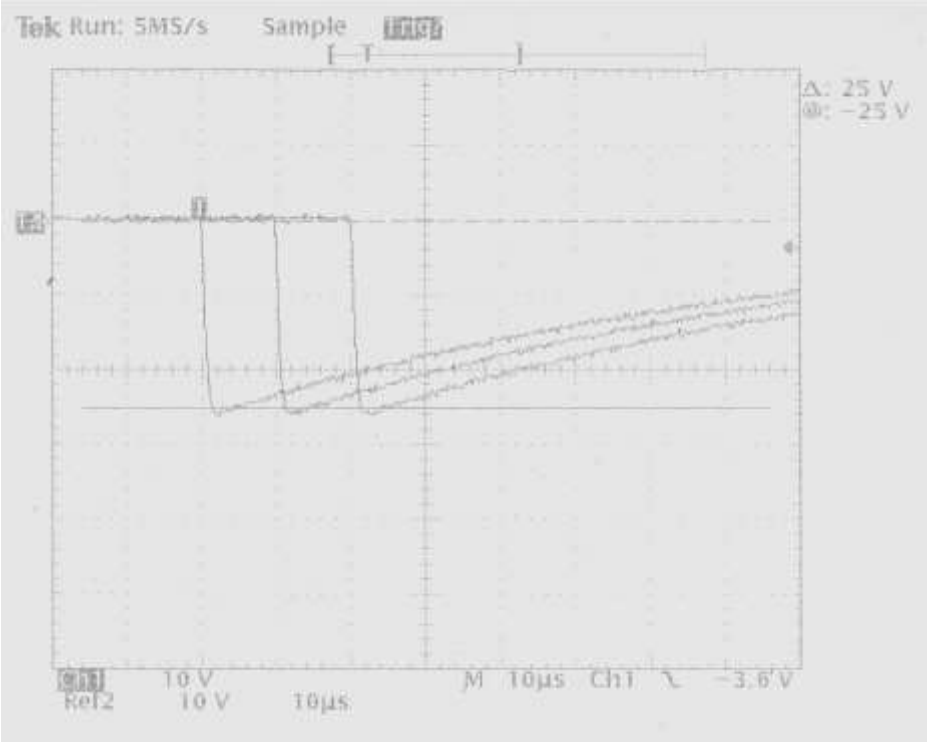
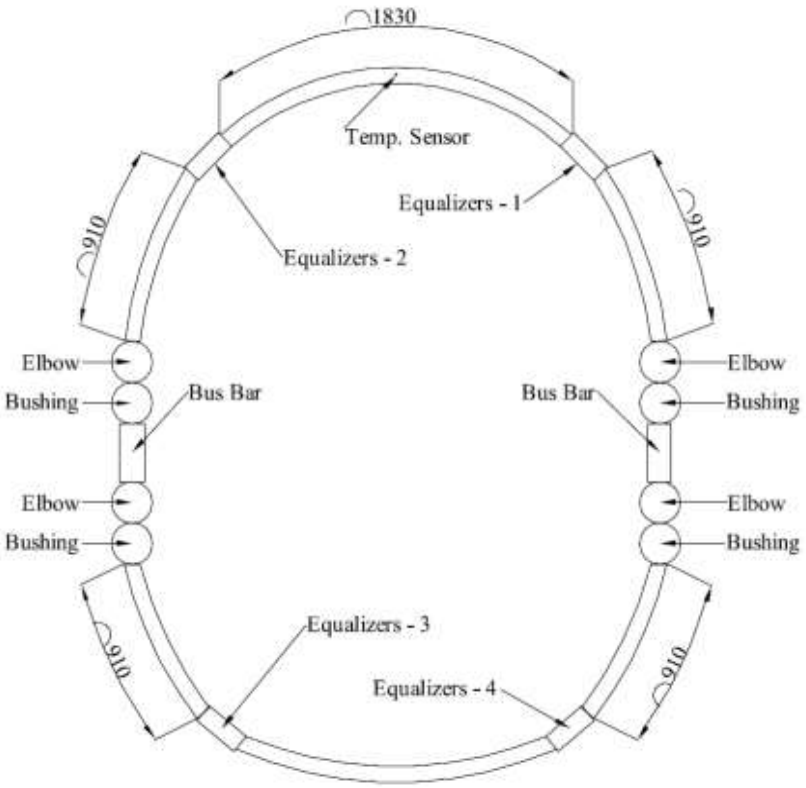


Impulse Testing Waveform after Accelerated Sealing Life Test – Negative Wave



Test Setup Diagram