15kV 200A Loadbreak Fuse Elbow Design Test Report

Report Number:	Date:
RN-R2601	9/3/2015

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Table of Contents

1. Partial Discharge Test – Fuse Elbow 2
2. AC Withstand Voltage Test - Fuse Elbow 3
3. DC Withstand Voltage - Fuse Elbow 4
4. Impulse Withstand Voltage Test - Fuse Elbow 5
5. Short-time Current Test - Fuse Elbow 7
6. Loadbreak Fuse Elbow Cable Pull-Out Test 10
7. Loadbreak Fuse Elbow Operating Force Test 11
8. Loadbreak Fuse Elbow Operating Eye Test 13
9. Loadbreak Fuse Elbow Test Point Cap Test 14
10. Loadbreak Fuse Elbow Test Point Test 16
11. 15kV200A Loadbreak Fuse Elbow Shielding Test 18
12. Current-cycling Test –Fuse Elbow 20
13. Accelerated Sealing Life Test –Fuse Elbow 28
14. Current-cycling test – Thermal test with off-axis Operation 31
15. Switching and Fault-closure 35

APPENDIX -External Test Report Summary 36

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1. Partial Discharge Test – Fuse Elbow

Object

To verify the connectors that the parts meet ANSI/IEEE Standard 386-2006 15kV partial discharge requirement of 11kV/3pC.

Testing Samples

Fuse Elbow	15LFE200T	10 PCS

Mating Parts

Bushing Insert	15-LBI200
Bushing Well	Elliott 200 Amp Bushing Well #1101-225B
Fuse Elbow Test Rod	15kV#B Testing Rod

Procedure and Testing Spec

The test voltage shall be raised to 20% above the corona voltage level of 11kV. If corona exceeds 3pC, the test voltage shall be lowered the corona voltage level of 11kV 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 – Hi Tech Fuse	14 kV / 0.1 pC
A2 – CPS Fuse	14 kV / 0.1 pC
A3 – CPS Fuse	14 kV / 0.1 pC
A4 – CPS Fuse	14 kV / 0.1 pC
A5 – Hi Tech Fuse	14.1 kV / 0.2 pC
A6 – Hi Tech Fuse	14.1 kV / 0.2 pC
A7 – CPS Fuse	14.1 kV / 0.2 pC
A8 – CPS Fuse	14.1 kV / 0.2 pC
A9 – Hi Tech Fuse	14.1 kV / 0.2 pC
A10 – CPS Fuse	14.1 kV / 0.8 pC

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2. AC Withstand Voltage Test - Fuse Elbow

Object

To verify the connectors that the parts meet ANSI/IEEE standard 386-2006 15kV AC withstand requirement of 34kV/ 1 min.

Testing Samples

Fuse Elbow	15LFE200T	10 PCS

Mating Parts

Bushing Insert	15-LBI200
Bushing Well	Elliott 200 Amp Bushing Well #1101-225B
Fuse Elbow Test Rod	15kV#B Testing Rod

Procedure and Testing Spec

The test voltage shall be raised to the value of 34kV in 30 seconds. The test sample shall withstand the specified test voltage for 1 minute without flashover or puncture.

Results

Sample number	34kV/1min AC withstand voltage
A1 – Hi Tech Fuse	PASS
A2 – CPS Fuse	PASS
A3 – CPS Fuse	PASS
A4 – CPS Fuse	PASS
A5 – Hi Tech Fuse	PASS
A6 – Hi Tech Fuse	PASS
A7 – CPS Fuse	PASS
A8 – CPS Fuse	PASS
A9 – Hi Tech Fuse	PASS
A10 – CPS Fuse	PASS

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3. DC Withstand Voltage - Fuse Elbow

Object

To verify the connectors that the parts meet ANSI/IEEE standard 386-2006 15kV DC withstand requirement of 53kV/ 15 min.

Testing Samples

Fuse Elbow	15LFE200T	10 PCS

Mating Parts

Bushing Insert	15-LBI200
Bushing Well	Elliott 200 Amp Bushing Well #1101-225B
Fuse Elbow Test Rod	15kV#B Testing Rod

Procedure and Testing Spec

The test voltage shall have a negative polarity and shall be raised to the value of 53kV. The connector shall withstand the specified test voltage for 15 minutes without flashover or puncture.

Results

Sample number	-53kV/15min DC withstand voltage
A1 – Hi Tech Fuse	PASS
A2 – CPS Fuse	PASS
A3 – CPS Fuse	PASS
A4 – CPS Fuse	PASS
A5 – Hi Tech Fuse	PASS
A6 – Hi Tech Fuse	PASS
A7 – CPS Fuse	PASS
A8 – CPS Fuse	PASS
A9 – Hi Tech Fuse	PASS
A10 – CPS Fuse	PASS

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4. Impulse Withstand Voltage Test - Fuse Elbow

Object

To verify the connectors that the parts meet ANSI/IEEE Standard 386-2006 15kV impulse withstand testing requirements of 1.2×50µs ±95kV wave., 3 positive and 3 negative full-wave impulses.

Testing Samples

Fuse Elbow	15LFE200T	10 PCS

Mating Parts

Bushing Insert	15-LBI200
Bushing Well	Elliott 200 Amp Bushing Well #1101-225B
Fuse Elbow Test Rod	15kV#B Testing Rod

Procedure and Testing Spec

The test voltage shall be 1.2/50µs wave having the crest value (BIL) of 95kV. The connector shall withstand 3 positive and 3 negative full-wave impulses without flashover or puncture.

Results

Sample number	1.2×50µs±95kV Impulse withstand voltage
A1 – Hi Tech Fuse	PASS
A2 – CPS Fuse	PASS
A3 – CPS Fuse	PASS
A4 – CPS Fuse	PASS
A5 – Hi Tech Fuse	PASS
A6 – Hi Tech Fuse	PASS
A7 – CPS Fuse	PASS
A8 – CPS Fuse	PASS
A9 – Hi Tech Fuse	PASS
A10 – CPS Fuse	PASS

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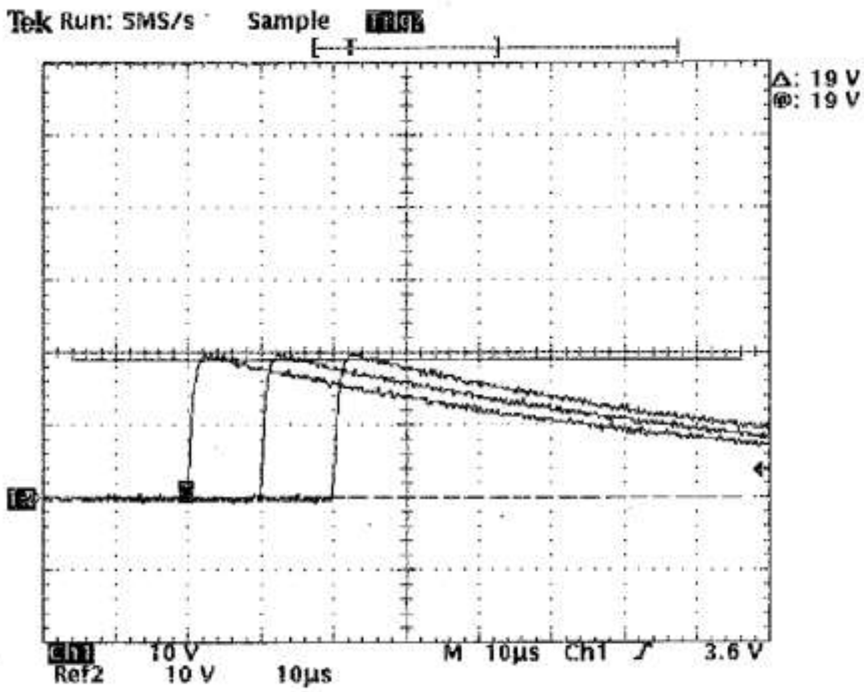

Fig 4-1 Positive Wave – (Data Amplification: 5,000)

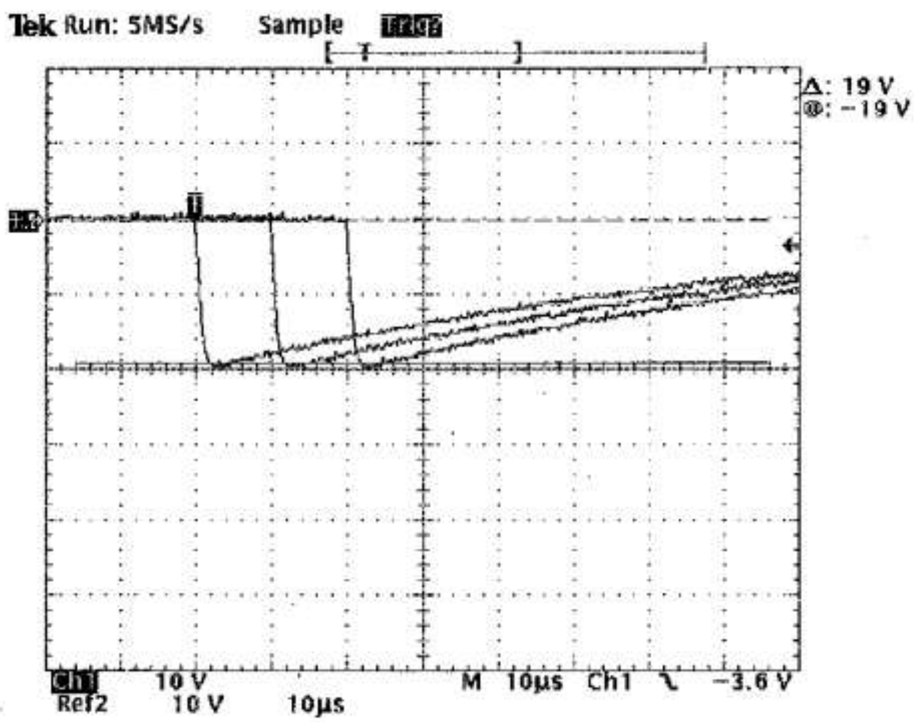

Fig 4-2 Negative Wave – (Data Amplification: 5,000)

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5. Short-time Current Test - Fuse Elbow

Object

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

Testing Samples

Fuse Elbow	15LFE200T	4 PCS

Mating Parts

Bushing Well	Elastimold K1601PC-S2-R	2 PCS
Bushing Extender	Hubbell 625BE	
Cable Conductor Type	1/0 AWG	

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/0.17sec

Sample number	1st Cycle Current (peak)	Current (rms)	Time	Verification	Result
A11&A12	22.2 kA	11.9 kA	0.24 sec	Normal	PASS
A13&A14	21.0 kA	11.74 kA	0.24 sec	Normal	PASS

3.5kA/3sec

Sample number	1st Cycle Current (peak)	Current (rms)	Time	Verification	Result
A11&A12	12.96 kA	6.53 kA	3.01 sec	Normal	PASS
A13&A14	11.86 kA	6.47 kA	3.01 sec	Normal	PASS

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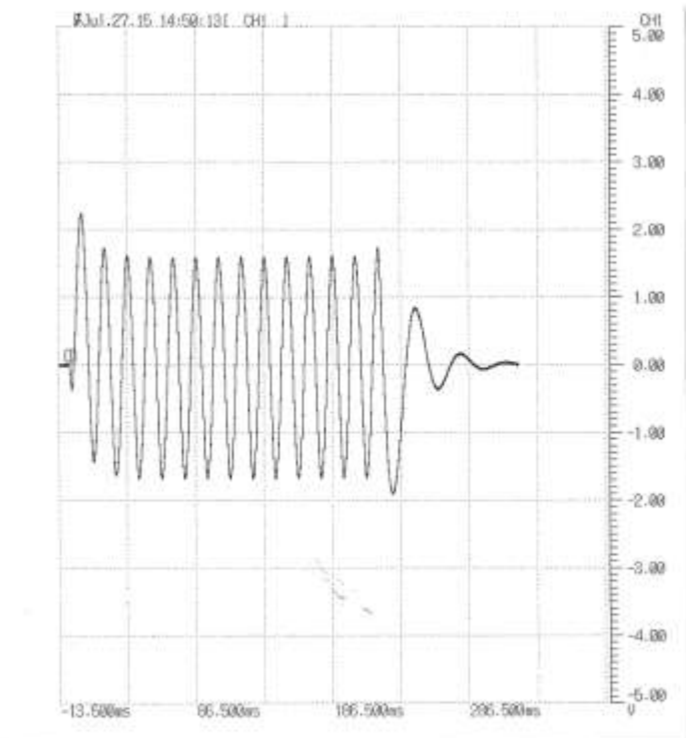
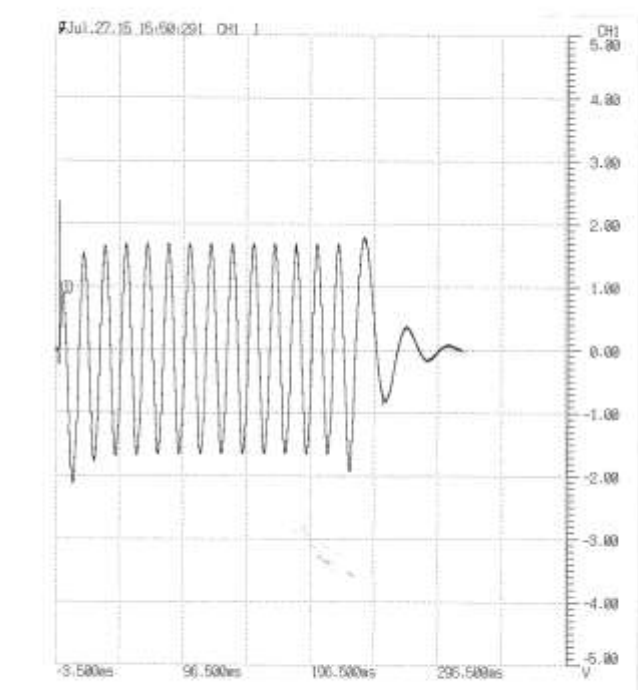
Waveforms



10kA/0.17sec – A11&A12



10kA/0.17sec – A13&A14

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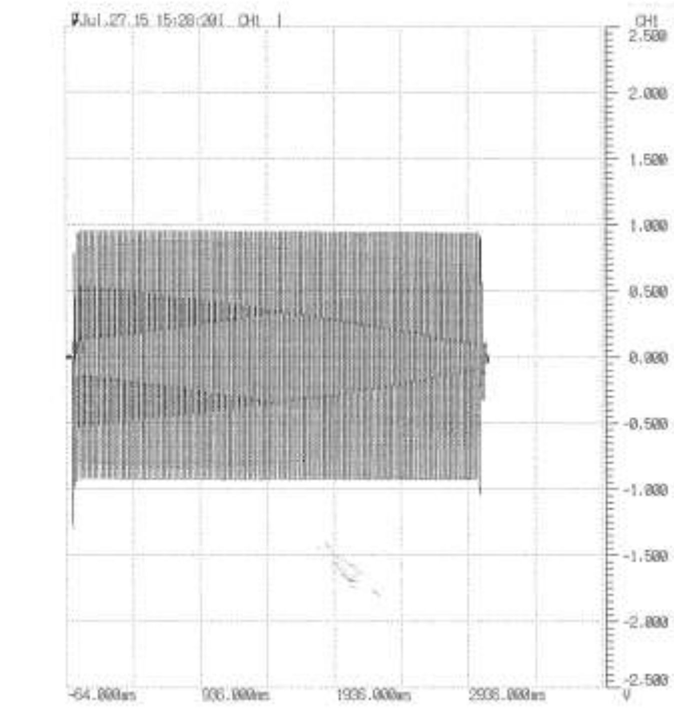
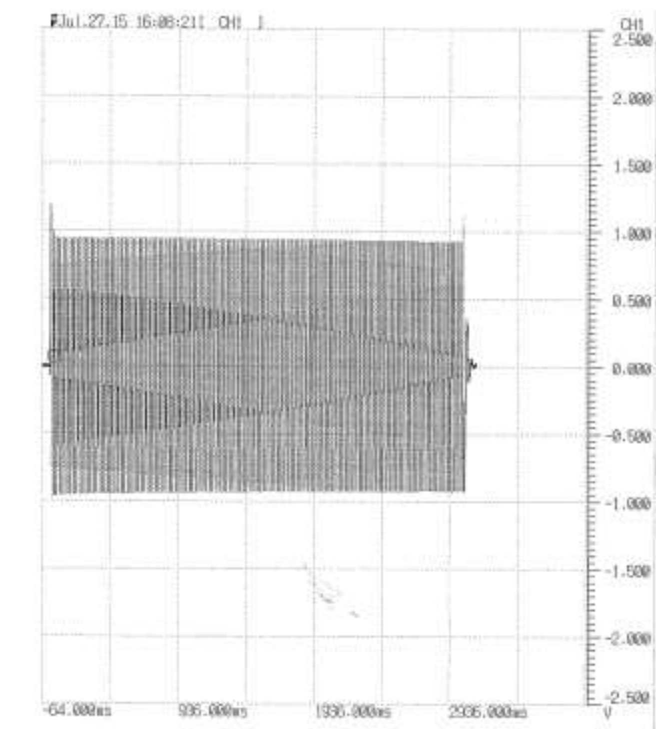


3.5kA/3sec - A11&A12



3.5kA/3sec - A13&A14

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6. Loadbreak Fuse Elbow Cable Pull-Out Test

Object

To verify the compression lug and cable assembly that the parts can meet ANSI/IEEE Standard 386-2006 Cable Pull-Out Test requirements.

Testing Samples

Fuse Elbow Compression Lug	Chardon 200A BiMetal Connector 1/0	4 PCS

Mating Parts

Cable	1/0 AWG Aluminum Cable

Procedure and Testing Spec

The purpose of this test is to determine if the connection between the cable conductor and compression lug of the connector is capable of withstanding a tensile force of 890 N (200 lbf).

The compression lug shall be held in a manner that will not affect the strength of the connection. The tensile force shall be applied to the cable conductor.

The connection shall withstand the applied force for 1 minute without impairing the connector's ability to meet the other requirements of this standard.

Results

Sample number	Measurement	Result
C1	202 lbf	PASS
C2	205 lbf	PASS
C3	203 lbf	PASS
C4	204 lbf	PASS

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7. Loadbreak Fuse Elbow Operating Force Test

Object

To verify the force of the elbow connector operating force when mating with bushing insert that the force meets NSI/IEEE Standard 386-2006 operating force requirement.

Testing Samples

Fuse Elbow	15LFE200T	4 PCS

Mating Parts

Bushing Insert	15-LBI200	4 PCS
Cable	1/0 AWG(Al)	

Procedure

The purpose of this test is to demonstrate that the force necessary to operate a connector meets the requirements of 6.2.(222 N - 890 N (50 lbf - 200 lbf) for connectors without hold-down bails)
The elbow shall be assembled with a probe and compression lug and the connector system shall be lubricated in accordance with the manufacturer's instructions.

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Results

	Sample number	Open	Close	Result
Room Temperature 27℃	A21	86.04 lbf	137.28 lbf	PASS
	A22	116.16 lbf	133.54 lbf	PASS
	A23	76.78 lbf	156.42 lbf	PASS
	A24	126.28 lbf	172.92 lbf	PASS

-20 ℃	A21	93.5 lbf	181.94 lbf	PASS
	A22	144.76 lbf	168.52 lbf	PASS
	A23	124.96 lbf	151.14 lbf	PASS
	A24	119.46 lbf	167.2 lbf	PASS

65 ℃	A21	97.9 lbf	166.98 lbf	PASS
	A22	130.02 lbf	174.46 lbf	PASS
	A23	155.98 lbf	115.28 lbf	PASS
	A24	113.30 lbf	122.76 lbf	PASS

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8. Loadbreak Fuse Elbow Operating Eye Test

Object

To verify the elbow operating eye that the part meet ANSI/IEEE Standard 386-2006 requirements.

Testing Samples

Fuse Elbow 15LFE200T 4 PCS

Mating Parts

Testing Fixture

Procedure and Testing Spec

The purpose of this test is to demonstrate that the operating eye meets the requirements of 6.2 at 25°C ±5°C.
A tensile force shall be gradually applied to the operating eye in the direction of normal operation. The operating eye shall withstand the force for 1 minute.
A rotational force shall be applied with a suitable live-line tool to the operating eye in a clockwise direction and in a counter-clockwise direction.
Some distortion of the operating eye is acceptable provided the connector is serviceable after the test and meets the corona voltage-level requirement specified in Table 1 of IEEE standard 386-2006.

Results

Sample number	500 lbf /min	120 lbf-in rotational force	PD Testing
A5	PASS	PASS	14kV/0.8 pC
A6	PASS	PASS	14.3 kV/2 pC
A7	PASS	PASS	14kV/2.1 pC
A8	PASS	PASS	14kV/0.9 pC

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9. Loadbreak Fuse Elbow Test Point Cap Test

Object

To verify the test point cap of the elbow that the part meets ANSI/IEEE Standard 386-2006 requirement.

Testing Samples

Fuse Elbow	15LFE200T	4 PCS
Test Point Cap		4 PCS

Testing Fixture

Procedure and Testing Spec

The purpose of this test is to demonstrate that the removal force of the test point cap meets the requirements of 6.5.2 and the cap operating eye is capable of withstanding the maximum operating force

Results

	Sample number	Pull Force (8 lbf – 49 lbf)		100 lbf Pulling	Result
Room Temperature 27℃	A21	31 lbf	31 lbf	PASS	PASS
	A22	34 lbf	34 lbf	PASS	PASS
	A23	26 lbf	26 lbf	PASS	PASS
	A24	36 lbf	36 lbf	PASS	PASS

-20 ℃	A21	29 lbf	26 lbf	PASS	PASS
	A22	40 lbf	28 lbf	PASS	PASS
	A23	25 lbf	27 lbf	PASS	PASS
	A24	34 lbf	27 lbf	PASS	PASS

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65 ℃	A21	23 lbf	23 lbf	PASS	PASS
	A22	19 lbf	24 lbf	PASS	PASS
	A23	20 lbf	17 lbf	PASS	PASS
	A24	23 lbf	26 lbf	PASS	PASS

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10. Loadbreak Fuse Elbow Test Point Test

Object

To verify the elbow test point meeting the ANSI/IEEE Standard 386-2006 testing requirement.

Testing Samples

Fuse Elbow	15LFE200T	10 PCS

Mating Parts

LCR Meter	CHENHWA 1012F
Testing Fixture	

Procedure and Testing Spec

The purpose of this test is to verify that the capacitance values of the test point meet the requirements of 6.5.1. of IEEE 386.

The connector shall be installed on a cable of the type for which it is designed to operate, and the shielding shall be grounded in the normal manner. The capacitances from test point to cable and test point to ground shall be measured with suitable instruments and proper shielding techniques. The measured values shall be within the tolerances specified in 6.5.1. of IEEE 386.

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Results

Sample number	Test point and the conductor shall be at least 1.0 pF.		Test point and shield to the capacitance between test point and conductor shall not exceed 12.0		Result
A1	7.87 pF	8.07 pF	10.304	10.670	PASS
A2	7.80 pF	6.93 pF	10.236	9.045	PASS
A3	7.68 pF	7.70 pF	10.229	10.510	PASS
A4	7.71 pF	8.20 pF	10.003	10.398	PASS
A5	8.29 pF	8.15 pF	10.650	10.710	PASS
A6	7.85 pF	8.10 pF	10.048	10.341	PASS
A7	7.78 pF	7.89 pF	10.441	10.360	PASS
A8	7.63 pF	8.22 pF	10.089	10.490	PASS
A9	7.70 pF	8.03 pF	10.005	10.518	PASS
A10	7.84 pF	7.89 pF	10.358	10.077	PASS

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11. 15kV200A Loadbreak Fuse Elbow Shielding Test

Object

To verify the outer conductive layer of the connector that the material meet ANSI/IEEE Standard 386-2006 requirement of shielding test

Testing Samples

Fuse Elbow 15LFE200T 4 PCS

Procedure

Shield Resistance. The shield resistance measured between the cable entrance and the farthest extremity of the shield from the cable entrance shall be 5000Ω or less.

Results

Temperature	Sample number	5000Ω max	Result
27 ℃	A11	2476Ω	PASS
	A12	2868Ω	PASS
	A13	3035Ω	PASS
	A14	2353Ω	PASS

Temperature	Sample number	5000Ω max	Result
90 ℃	A11	1085Ω	PASS
	A12	1080Ω	PASS
	A13	1195Ω	PASS
	A14	1124Ω	PASS

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Temperature	Sample number	5000Ω max	Result
27 ℃ (Air oven aged for 504 h at 121 ℃)	A11	1953Ω	PASS
	A12	1708Ω	PASS
	A13	1342Ω	PASS
	A14	2195Ω	PASS

Temperature	Sample number	5000Ω max	Result
90 ℃ (Air oven aged for 504 h at 121 ℃)	A11	1543Ω	PASS
	A12	1766Ω	PASS
	A13	1243Ω	PASS
	A14	3057Ω	PASS

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12. Current-cycling Test –Fuse Elbow

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

Fuse Elbow	15LFE200T	4 PCS

Mating Parts

Bushing Well	Chardon 200A Bushing Well CH200BW	4 PCS
Cable Conductor Type	1/0 AWG Aluminum Cable	
Cable Insulation Thickness	175 mil	
Conductor	Chardon 200A BiMetal Connector 1/0	
Equalizers	Aluminum ：106mm(L), 20mm(OD), 10.1mm(ID)	
Bushing Bus	356mm(L),102mm(W),10mm(T)	

Procedure and 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).

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).

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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) Probe to compression lug
b) Probe to female contact
c) Female contact structure to metallic housing (piston contact)

Unit:℃

Cycle#	A15			A16			A17			A18			Cable	Room Temp	Water Temp
	a	b	c	a	b	c	a	b	c	a	b	c			
6	59.7	49.5	54.3	62.5	49.0	53.8	61.2	45.9	53.7	56.3	44.3	44.2	101.9	32.0	7.9
7	58.9	48.5	53.0	61.5	48.3	52.1	60.5	44.3	52.3	56.0	44.2	44.0	102.3	32.0	8.5
8	59.3	48.8	52.9	61.6	48.7	52.0	61.0	45.0	52.4	55.9	44.0	44.1	102.0	32.2	9.0
9	60.4	47.5	50.6	65.7	49.4	54.2	65.5	47.3	55.4	64.6	47.9	53.9	103.4	31.9	8.1
10	58.2	45.8	48.6	63.9	48.0	52.2	63.1	46.8	53.6	63.0	46.6	52.1	101.1	31.1	8.6
11	59.7	46.9	50.1	65.4	50.1	54.2	64.3	47.9	55.4	65.0	48.0	54.0	101.6	32.2	8.8
12	59.9	46.8	50.8	65.3	50.5	53.9	64.8	48.3	55.6	65.5	48.8	53.7	103.1	32.4	8.6
13	60.7	47.0	50.5	65.8	49.8	53.6	66.4	48.5	55.7	66.2	46.0	46.0	103.8	31.8	8.5
14	60.5	47.3	49.8	61.2	47.2	47.5	66.0	49.0	56.1	66.3	48.8	53.5	102.9	30.9	9.0
15	59.9	47.5	49.3	60.7	47.5	47.3	65.9	48.3	55.8	65.8	48.6	53.9	103.0	32.1	9.1
16	57.8	44.8	48.5	59.3	46.8	45.6	65.0	48.0	54.4	65.1	48.1	53.1	102.7	31.3	8.9
17	56.8	44.1	46.9	58.6	45.2	44.9	64.3	48.0	53.8	64.7	48.3	48.3	104.1	30.3	8.8
18	57.5	43.9	46.8	57.5	44.9	43.9	64.9	46.8	54.0	64.9	47.7	50.5	103.2	29.4	8.9
19	58.0	44.3	46.9	57.0	44.9	43.4	65.5	48.0	54.9	65.9	48.1	53.4	103.8	30.8	9.2
20	58.4	45.0	46.9	57.3	44.8	43.5	65.7	47.8	55.0	65.8	47.8	51.9	103.8	29.9	9.1
21	58.3	44.4	46.6	56.1	44.4	42.4	65.8	46.5	54.1	66.0	47.5	50.7	104.2	29.9	9.1
22	58.2	44.3	46.9	56.0	44.3	42.5	65.7	47.2	54.4	65.9	47.3	52.0	102.6	30.2	8.9
23	56.5	44.9	46.0	54.1	44.0	42.0	63.7	46.9	53.5	63.8	46.5	53.2	101.8	30.4	9.2
24	58.7	44.9	47.0	51.1	45.0	42.9	66.4	48.9	55.2	66.3	48.3	55.0	102.4	30.1	9.0
25	58.6	44.8	46.8	55.2	44.9	42.1	66.0	48.1	54.9	66.1	48.1	54.8	101.4	29.9	8.9
26	58.4	44.8	46.6	55.0	44.5	41.9	66.6	48.3	55.1	66.0	48.2	55.0	100.9	31.0	8.9
27	61.5	48.2	49.8	58.2	47.1	46.0	68.0	51.2	57.8	67.9	51.4	57.8	102.0	32.1	9.1
28	57.8	45.1	46.1	54.7	43.6	42.5	63.9	47.7	54.8	64.6	48.0	53.1	103.6	31.2	9.0
29	55.5	43.2	44.6	52.6	42.3	40.9	62.0	46.5	52.6	62.2	46.7	51.2	102.8	31.3	9.0
30	57.4	44.5	46.2	54.1	43.8	41.6	64.9	48.0	54.9	64.9	48.0	54.0	103.1	32.8	9.1
31	59.9	43.2	48.2	55.7	45.8	44.0	67.0	50.2	56.7	66.4	50.0	56.4	101.5	32.9	8.9
32	58.9	45.8	47.5	55.0	44.5	42.8	66.3	49.6	55.5	66.4	49.3	55.5	102.9	32.0	9.2

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33	58.5	45.1	45.9	54.8	43.4	42.0	66.7	49.1	55.8	65.9	49.0	55.7	101.8	32.0	9.0
34	57.8	44.6	45.9	53.9	43.5	41.9	65.5	48.2	55.0	64.8	48.6	54.9	103.6	33.2	8.8
35	59.2	46.3	47.7	55.7	46.2	43.7	66.3	50.1	56.7	66.3	50.0	56.0	104.5	33.3	9.0
36	58.5	45.5	46.3	55.5	44.8	43.1	66.5	49.9	56.5	66.5	49.8	56.7	101.1	32.5	9.2
37	61.2	46.3	47.4	58.2	45.2	43.9	70.1	51.2	58.9	70.0	51.2	57.9	102.6	32.2	8.9
38	57.3	44.4	45.5	54.4	43.7	42.4	64.2	48	55.8	64.2	48.4	53.2	102.2	32.7	8.6
39	58.4	45.7	46.5	55.0	44.6	43.2	64.5	48.7	56.3	64.3	48.2	51.7	103.1	31.5	9.2
40	55.3	43.1	44.2	50.1	42.0	40.1	61.8	46.2	52.7	61.8	46,7	51.3	102.4	32.0	9.0
41	54.5	43.5	43.6	50.2	41.7	40.0	62.2	46.2	52.2	61.9	46.0	52.0	101.5	31.1	8.9
42	58.1	44.5	45.9	53.7	44.0	41.5	65.9	49	55.6	66.6	48.3	55.3	100.8	30.9	9.1
43	57.4	44.3	45.5	53.3	43.3	41.6	64.3	48.4	55.1	64.8	48.2	52.8	100.9	31.0	9.1
44	55.6	42.8	44.0	51.6	41.4	39.9	62.8	46.3	52.7	62.13	45.7	52.1	101.4	31.8	9.2
45	56.5	43.2	44.5	52.3	42.2	40.6	62.9	46.8	53.5	64.0	46.6	53.3	101.6	31.4	8.7
46	56.8	44.0	45.0	53.1	42.8	41.4	64.0	47.6	54.0	65.8	47.2	53.0	102.1	30.8	9.2
47	57.3	44.4	45.2	53.8	43.2	42.0	64.2	48	54.6	64.3	48.5	53.9	102.5	31.6	9.0
48	58.0	44.5	45.2	54.2	43.3	41.7	64.1	47.3	54.7	65.9	47.8	53.3	103.6	32.0	9.1
49	56.6	44.6	49.2	53.0	42.4	41.1	65.2	46.9	53.6	66.2	47.3	54.2	104.5	31.7	8.9
50	56.9	45.0	50.1	54.2	43.1	42.0	64.0	47	53.4	63.7	46.9	54.1	103.7	32.1	9.1
Average	58.2	45.3	47.5	56.6	45.1	44.6	64.8	47.9	54.8	64.6	46.8	51.6	102.6	31.5	8.9
Max Temp Delta (cycle #)	3.7 (41)	4.2 (6)	6.8 (6)	9.2 (13)	5.4 (12)	9.6 (11)	5.3 (37)	3.3 (37)	4.1 (37)	5 (37)	4.6 (27)	7.6 (7)	100.8 ~ 104.5	29.4 ~ 33.3	7.9 ~ 9.2
Remark	By comparing the measured temperature of each cycle and average temperature, the delta is within 10℃, meeting IEEE 386 standard.														

Resistance Measurement Unit：mΩ

Date	Week #	Room Temp	A15		A16		A17		A18	
8/5	8	32.2	0.69	2.3%	0.69	2.3%	0.67	3.0%	0.66	0.6%
8/8	20	29.9	0.67	0.6%	0.65	3.7%	0.64	1.5%	0.64	2.5%
8/11	30	32.8	0.66	2.1%	0.67	0.6%	0.65	0%	0.67	2.1%
8/13	39	32.0	0.69	2.3%	0.69	2.3%	0.66	1.5%	0.66	0.6%
8/16	50	32.1	0.66	2.1%	0.67	0.6%	0.63	3.2%	0.65	0.9%
Average			0.674		0.674		0.65		0.656	
Remark			The temperature number collected in each cycle is within 10% of average number, meeting IEEE 386 standard							

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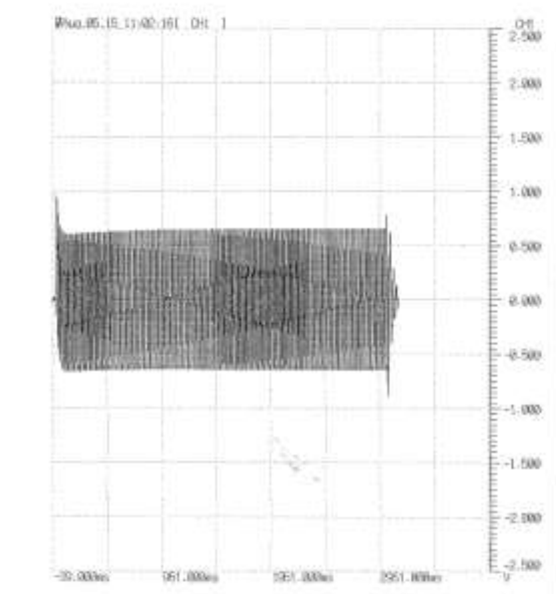
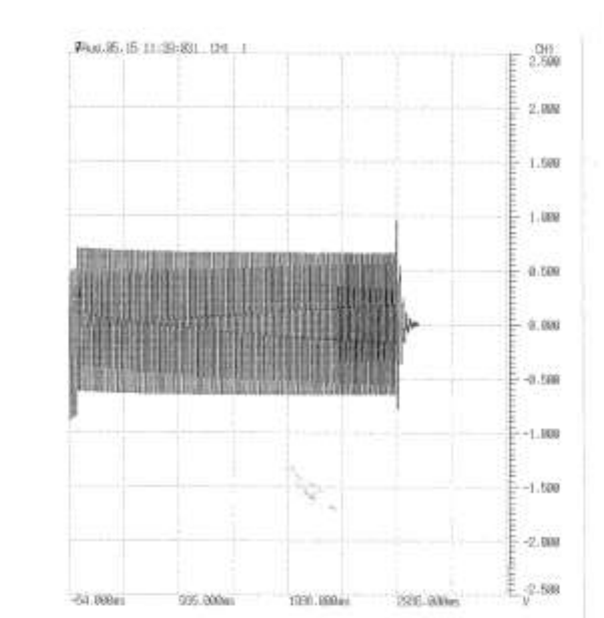
Test Data and Waveforms

Short-time Current 3500A/3 sec X/R 6

15kV200A Fuse Elbow 20150805 8th cycles

Sample number	1st Cycle Current (peak)	Current (rms)	Time	Verification	Result
A15&A16	9.5 kA	4.55 kA	3.01 sec	Normal	PASS
A17&A18	8.96 kA	4.58 kA	3.01 sec	Normal	PASS





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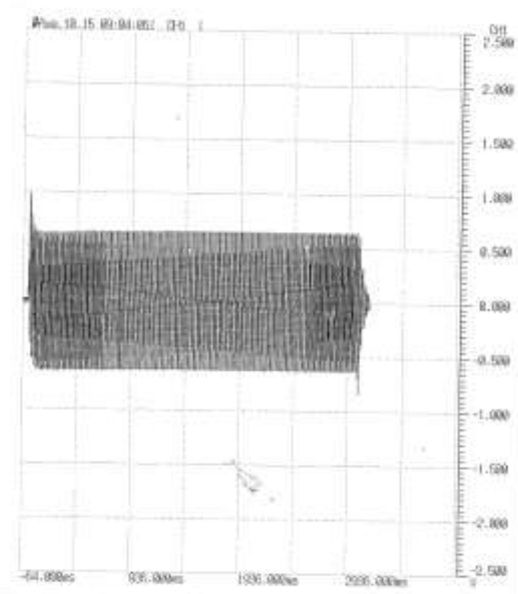
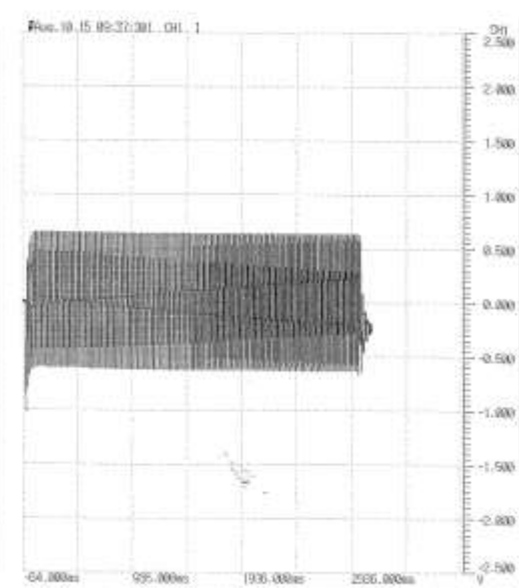
Short-time Current 3500A/3 sec X/R 6

15kV200A Fuse Elbow 20150810 27th cycles

Sample number	1st Cycle Current (peak)	Current (rms)	Time	Verification	Result
A15&A16	9.86 kA	4.44 kA	3.01 sec	Normal	PASS
A17&A18	10..11 kA	4.42 kA	3.01 sec	Normal	PASS





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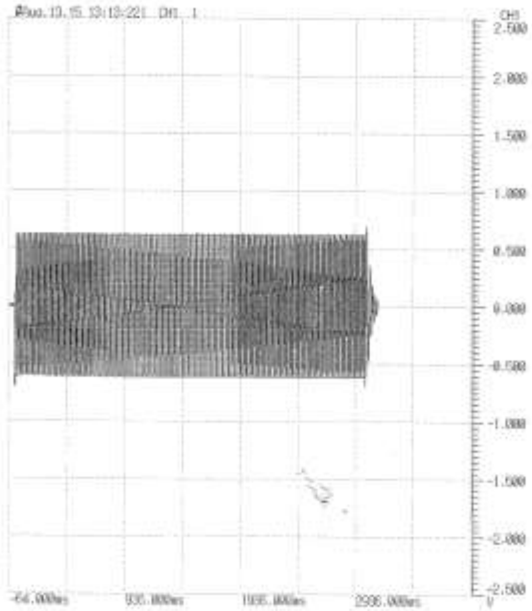
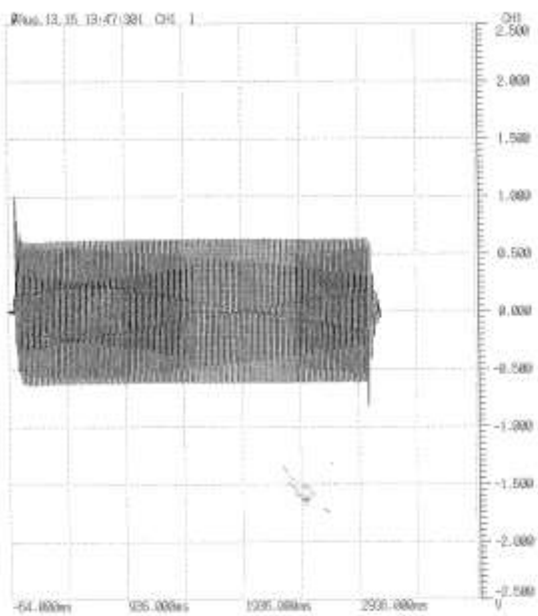
Short-time Current 3500A/3 sec X/R 6

15kV200A Fuse Elbow 20150813 39th cycles

Sample number	1st Cycle Current (peak)	Current (rms)	Time	Verification	Result
A15&A16	6.96 kA	4.34 kA	3.01 sec	Normal	PASS
A17&A18	10.04 kA	4.33 kA	3.01 sec	Normal	PASS





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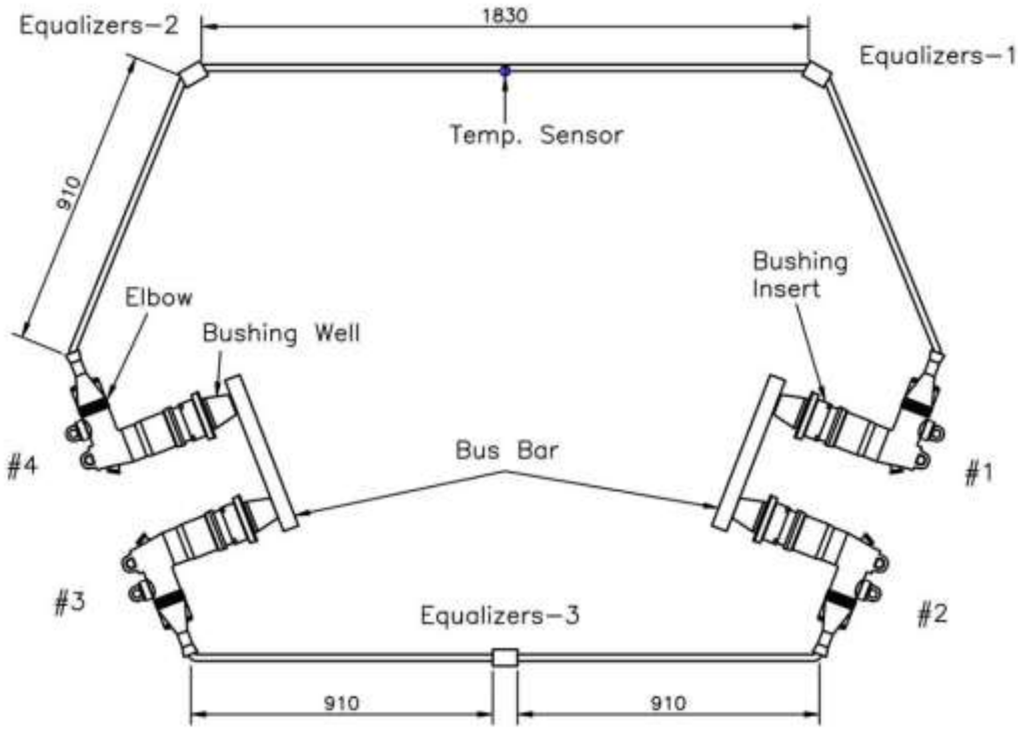

Fig 12-1 Testing Setup Diagram

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13. Accelerated Sealing Life Test –Fuse Elbow

Object

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

Testing Samples

Fuse Elbow	15LFE200T	4 PCS

Mating Parts

Bushing Well	Chardon 200A Bushing Well CH200BW	4 PCS
Cable Conductor Type	1/0 AWG Aluminum Cable	
Cable Insulation Thickness	175 mil	
Conductor	Chardon 200A BiMetal Connector 1/0	
Equalizers	Aluminum：106mm(L), 20mm(OD), 0.1mm(ID)	
Bushing Bus	356mm(L),102mm(W),10mm(T)	

Testing Spec

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 50th 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.)

Results

Sample #	PD Testing Before Acc Life Sealing Test	AC Withstand Testing Before Acc Life Sealing Test	Impulse Testing Before Acc Life Sealing Test	Impulse Testing After Acc Life Sealing Test	Test Point Voltage Testing	
A1	14 kV / 0.1 pC	34kV/1m Pass	±95kV 3 Shots Each, Pass	±95kV 3 Shots Each, Pass	8kV	10kV
A2	14 kV / 0.1 pC	34kV/1m Pass			8kV	11kV
A3	14 kV / 0.1 pC	34kV/1m Pass			8kV	10kV
A4	14 kV / 0.1 pC	34kV/1m Pass			8kV	10.5kV
Remark	Cable Temp：88.9~94.1℃ Water Temp：25.9~29.6℃ Resistance of Water：3482 Ω-cm Depth of Water：60cm Test Point Voltage Testing is applied with 10.0kV					

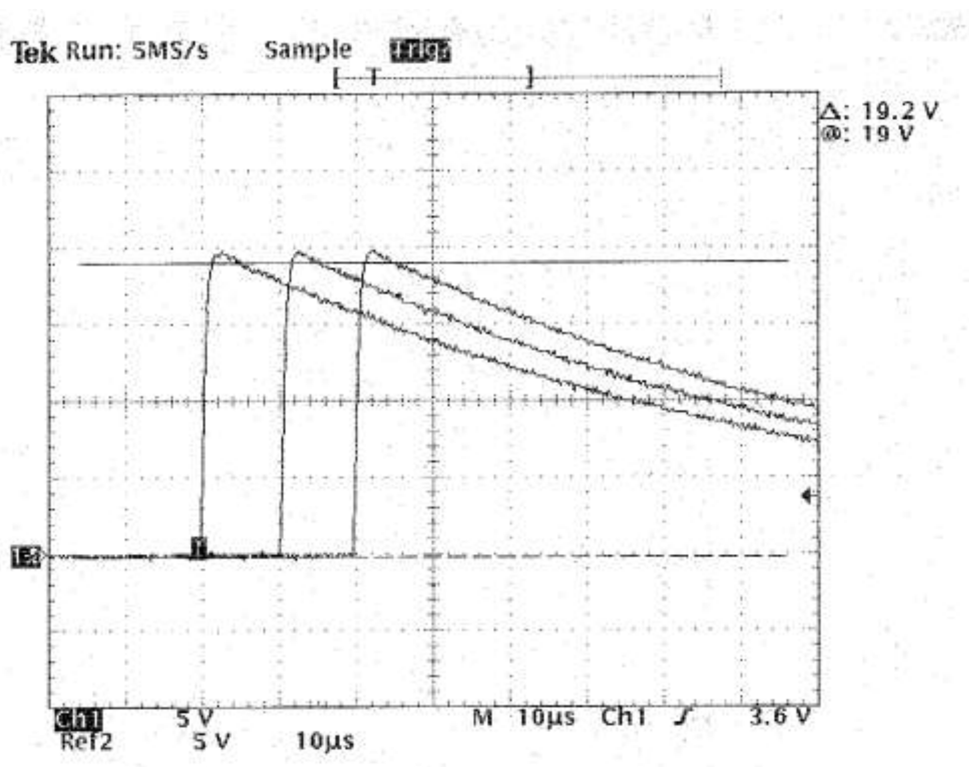

Fig 13-1 Waveform of Impulse Positive Waves after Accelerated life Sealing Test
(Data Amplification: 5,000)

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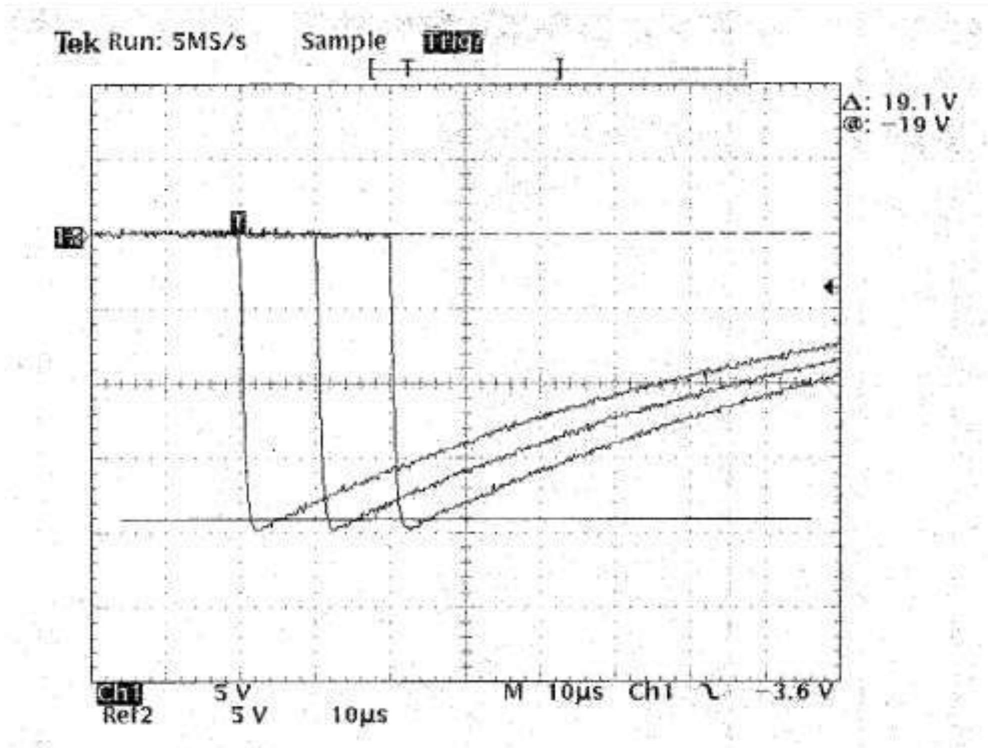

Fig 13-2 Waveform of Negative Waves after Accelerated life Sealing Test(Data Amplification: 5,000)

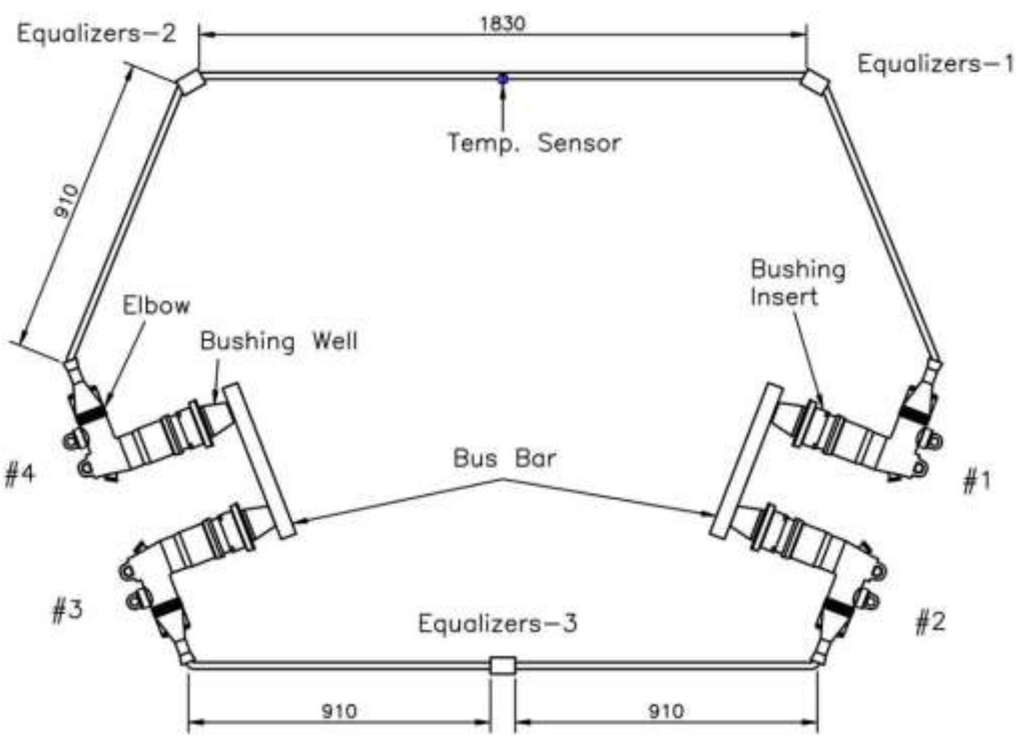

Fig 13-3 Test Setup Diagram

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14. Current-cycling test – Thermal test with off-axis Operation

Object

The purpose of this test is to demonstrate that loadbreak and deadbreak 200 A connectors can carry rated load current after being subjected to an off-axis operating force. Successful completion of these tests shall be considered as evidence that the connector meets its rating.

Testing Samples

Fuse Elbow	15LFE200T	4 PCS

Mating Parts

Bushing Well	Chardon 200A Bushing Well CH200BW	4 PCS
Cable Conductor Type	1/0 AWG Aluminum Cable	
Cable Insulation Thickness	175 mil	
Conductor	Chardon 200A BiMetal Connector 1/0	
Equalizers	Aluminum Equalizers Size：106mm(L), 20mm(OD), 10.1mm(ID)	
Bushing Bus	356mm(L),102mm(W),10mm(T)	

Procedure

The purpose of this test is to demonstrate that loadbreak and deadbreak 200 A connectors can carry rated load current after being subjected toan off-axis operating force. Successful completion of these tests shall be considered as evidence thatthe connector meets its rating.

Each connector shall be subjected to six cycles, each consisting of a mechanical operation as specified in 7.10.2.1 and current cycling as specified in 7.10.2.2. of IEEE 386

The elbow shall be disassembled with a 12.7 mm (0.5 in) wide pulling band, as shown in Figure 21 of IEEE 386 for application of an off-axis force. Grounding tabs or other obstructions may be removed to apply the pulling band. No provision is made for an off-axis closing force since it is not consistently reproducible.

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).

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Results

a) At the compression lug
b) At the midpoint of the bushing contact
c) On the conductor surface at the midpoint of the control table.

Unit :℃

Cycle#	A9		A10		A19		A20		Control Cable	Room Temp
	a	b	a	b	a	b	a	b		
1	67.0	47.5	71.2	55.0	62.6	45.9	65.0	46.2	93.0	27.5
2	60.4	44.8	64.1	51.1	58.8	44.8	60.5	45.5	90.9	28.1
3	60.2	44.3	63.9	50.8	58.4	44.3	60.3	45.3	87.9	28.1
4	71.0	49.8	75.2	58.3	66.0	48.7	67.2	49.3	94.2	30.2
5	66.0	47.0	69.0	54.0	62.7	47.0	61.0	45.9	92.4	30.7
6	68.3	48.6	71.9	56.1	63.8	47.7	63.1	47.1	92.5	29.9
7	68.1	48.0	71.7	55.8	63.5	47.1	62.8	46.4	92.4	29.2
8	68.2	49.1	71.9	56.3	64.4	48.6	63.6	48.1	92.4	30.2
9	68.8	49.7	72.6	56.7	64.9	48.8	64.9	48.0	92.0	30.6
10	68.2	49.0	71.9	56.1	64.3	48.1	64.5	48.3	91.8	30.4
11	67.9	48.4	71.7	55.7	63.8	47.7	64.1	48.0	91.7	29.4
12	68.6	49.4	72.3	56.3	64.9	49.0	65.8	49.5	91.9	30.3
13	69.0	50.0	72.9	56.4	65.4	49.2	65.9	49.9	92.0	30.7
14	68.3	49.5	72.0	55.9	64.4	48.6	65.2	49.1	91.7	30.5
15	68.4	49.2	72.1	56.4	64.3	48.2	65.1	48.9	91.9	30.1
16	68.2	49.5	71.7	56.5	64.3	49.0	65.3	49.5	92.0	30.5
17	68.3	49.5	71.9	56.6	64.3	48.4	65.3	49.2	91.8	30.3
18	68.3	49.1	72.0	56.5	64.1	48.1	65.1	48.8	91.8	29.9
19	68.0	48.9	72.1	56.3	63.9	48.0	64.8	48.6	92.0	29.6
20	68.3	49.3	71.9	56.4	64.3	48.5	65.3	49.3	92.1	30.1
21	68.5	50.0	72.0	56.6	64.7	49.2	65.1	50.0	92.4	31.2
22	68.1	49.2	71.6	56.1	64.0	48.0	64.5	48.9	92.2	30.1
23	68.1	49.1	71.7	56.0	64.0	48.0	64.4	48.7	92.4	29.8
24	68.2	49.4	71.8	56.1	64.3	48.3	64.5	49.2	92.3	30.0
25	68.8	50.1	72.3	56.8	65.2	49.4	65.2	50.2	92.5	31.2

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26	68.4	49.5	71.9	56.4	64.3	48.3	64.6	48.4	92.3	30.2
27	68.2	48.9	71.9	56.0	64.0	47.9	64.3	48.7	92.3	29.6
28	68.4	48.9	72.0	55.9	64.2	47.9	64.4	48.8	94.7	29.4
29	68.5	49.1	72.2	56.0	64.4	48.0	64.7	49.2	94.6	29.8
30	68.5	48.4	71.2	55.4	63.2	47.1	63.8	48.2	92.3	28.7
31	68.9	48.9	72.8	56.1	64.4	47.7	65.0	48.8	92.2	28.4
32	68.0	48.8	71.6	55.8	63.8	47.8	64.3	48.9	92.6	28.9
33	69.2	49.4	73.0	56.3	65.0	48.2	65.5	49.8	93.4	29.1
34	69.4	49.0	73.2	56.4	64.7	47.8	65.3	49.1	93.7	28.4
35	69.1	48.8	72.9	56.0	64.5	47.4	64.9	48.7	93.6	28.0
36	69.2	49.7	72.9	56.5	65.2	48.8	65.6	50.0	93.7	29.2
37	69.6	49.4	73.2	56.5	65.3	48.2	65.7	49.8	93.6	29.5
38	69.0	48.9	72.9	56.2	64.4	47.8	65.3	49.0	93.8	28.1
39	69.0	48.7	72.8	55.8	64.3	47.3	64.9	48.7	93.7	28.0
40	69.1	49.3	72.9	56.2	64.9	48.3	65.1	49.8	93.9	28.6
41	69.0	49.0	72.9	56.0	64.7	47.7	65.0	49.2	93.8	28.4
42	68.9	49.0	72.7	55.9	64.2	47.4	65.0	48.6	93.6	27.9
43	68.8	48.4	72.5	55.6	64.0	46.8	64.6	48.4	93.7	27.4
44	68.8	49.0	72.4	55.8	64.2	47.4	64.7	48.9	93.8	27.9
45	69.0	49.4	72.8	55.9	64.5	47.9	65.3	49.2	93.9	28.3
46	68.6	48.6	72.4	55.4	64.0	47.1	64.4	48.4	93.7	27.8
47	68.7	48.7	72.5	55.6	64.1	47.0	64.3	48.5	93.8	27.7
48	66.8	47.9	70.4	54.5	62.3	46.3	63.6	47.6	94.2	27.9
Ave	68.2	48.8	71.9	55.9	64.0	47.8	64.6	48.6	92.7	29.3
Remark	After six cycles, the average temperature of each thermal couple are not higher than control cable temperature.									

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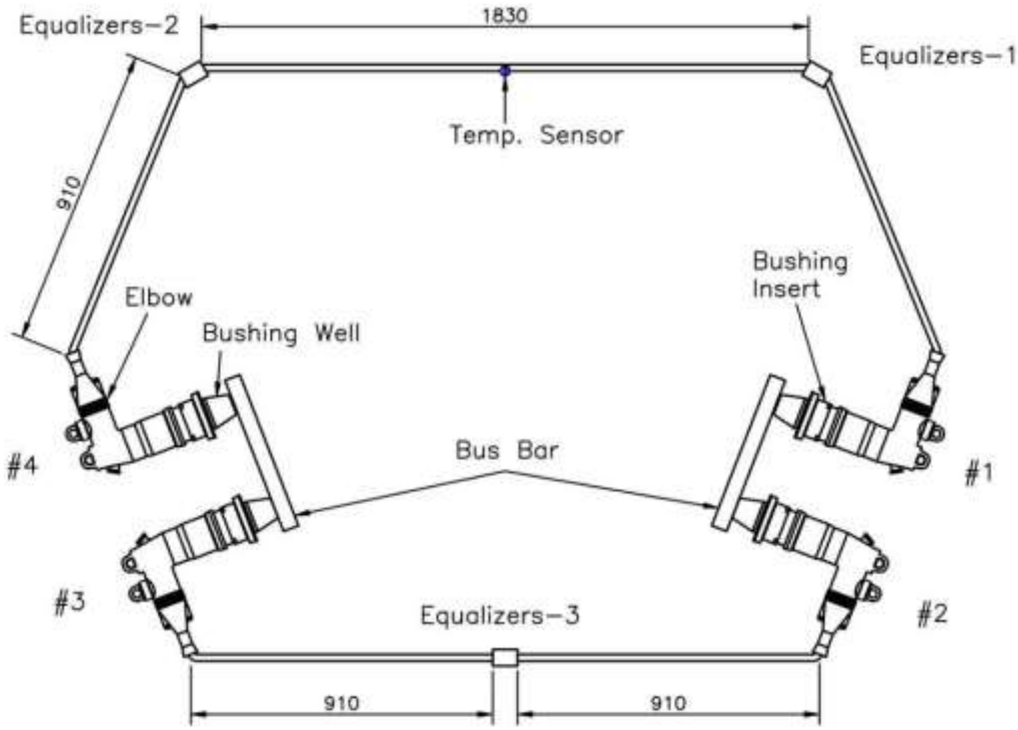

Fig 14-1 Test Setup Diagram

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15. Switching and Fault-closure

Description

The purpose of these tests is to verify that the Loadbreak Bushing Insert and Elbow are capable of closing and interrupting the rated switching current of 200A rms. Additionally, these tests will verify the parts are capable of closing on a 10,000A rms fault current for 0.17 sec. Chardon 15kV Fuse Elbow loadbreak design is identical with Chardon 15kV loadbreak Elbow.

Requirement

The Loadbreak Bushing Insert shall withstand 10 complete switching operations without arcing to ground or impairing its ability to meet the spec of IEE Std 386-2006. The Loadbreak Elbow shall also withstand 10 complete switching without arcing to ground or impairing its ability to meet the spec of IEE Std 386-2006. Failures are permitted; however, none of the failures are permitted in 10 consecutive samples of a maximum lot size of 30.

Procedures

1. Assemble 30 Bushing Inserts and Elbows assemblies on cable.

2 Test all samples in accordance with IEEE Standard 386-2006 sections 7.7 “Switching Test” under the conditions described in Tables 7 and 8, Figure 19(a) of the standard. Each sample is subjected to 10 complete switching operations at 8.3/14.4 kV, 200A using a mechanical fixture.

3. Test all samples that successfully passed 10 switching operations in accordance with IEEE Standard 386-2006 sections 7.8 “Fault-closure Test” under the conditions described in Table 8 and 9, Figure 20(a) of the standard. Each sample is subjected to 1 fault-close operation.

4. The procedure above was repeated with elbow samples from Elastimold and Cooper Industries, in compliance with IEEE 386-2006 standard section 6.4.1 “Complete Interchangeability”

Results

Switching passed; Fault-closure passed. Testing performed at Powertech Labs Inc, Surrey BC Canada.

Chardon – Powertech Report № 20408-D-26
Elastimold Interchangeability – Powertech Test Report № 21435-B-26
Cooper Interchangeability – Powertech Test Report № 20408-C-26

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APPENDIX -External Test Report Summary

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Test Report № 20408-D-26

Project №:	#20408-26	**Test Dates:**	8-15 December 2010
Tested Equipment: **Test voltage:** **Loadbreak current:** **Fault-close current:**	30 sets marked P-1 to P-30, each set consisting of the following: • A loadbreak elbow manufactured by Chardon Taiwan Corporation marked Tyco Electronics 8.3/14.4 kV, 200 A • A loadbreak bushing insert manufactured by Chardon Taiwan Corporation marked Tyco Electronics Loadbreak, 8.3/14.4 kV, 200 A Note: [1)] The test witnesses stated that all products manufactured by Chardon Taiwan Corporation marked Tyco Electronics are identical to those bearing the "CHARDON" marking". 14.4 kV 209 A_{rms} 10.3 kA_{rms}		
Tests performed:	• Switching tests in accordance with Section 7.7. Each set was subjected to 10 x CO operations at 14.4 kV, 209 A_{rms}. • Fault-close tests in accordance with Section 7.8. One operation was performed at 14.4 kV, 10.3 kA_{rms} on each set that passed the switching tests.		
Test result:	The system met both the switching and fault-close requirements.		
Remarks:	The switching tests were performed with a mechanical actuator. The fault-close tests were performed manually, by a lineman. The test samples were identified by the test witnesses as manufactured by Chardon Taiwan Corporation.		

Tested by: — Reviewed by:

14 November 2012

T.Stefanski M.SC., P. Eng.
Head of High Power Lab

J.A. Zawadzki M.Sc., P. Eng.
Director, Power Engineering Labs

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Test Report #20408-D-26 — Page 2 of 14

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Test Report № 21435-B-26

Projects №:	# 20408-26 and # 21435-26	**Test Dates:**	10-14 December 2010 and 19-20 January 2012

Tested Equipment:	**1)** 30 sets consisting of a loadbreak elbow Catalog № 165/6LR manufactured by Elastimold and a loadbreak bushing insert manufactured by Chardon Taiwan Corporation marked Tyco Electronics Loadbreak[1)] 8.3/14.4 kV, 200 A **2)** 11 sets consisting of a loadbreak elbow manufactured by Chardon Taiwan Corporation marked Tyco Electronics[1)] 8.3/14.4 kV, 200 A and a bushing insert Catalog № 1601-A4 manufactured by Elastimold Note: [1)] The test witnesses stated that all products manufactured by Chardon Taiwan Corporation marked Tyco Electronics are identical to those bearing the "CHARDON" marking".
Equipment rating:	8.3/14.4 kV, 200 A
Test voltage:	14.4 kV
Loadbreak current:	205 A_{rms}
Fault-close current:	10.3 kA_{rms}
Tests performed:	• Switching tests in accordance with Section 7.7. Each set was subjected to 10 x CO operations at 14.4 kV, 205 A_{rms}. • Fault-close tests in accordance with Section 7.8. One operation was performed at 14.4 kV, 10.3 kA_{rms} on each set that passed the switching tests.
Test result:	Both systems met the switching and fault-close requirements.
Remarks:	The switching tests were performed with a mechanical actuator. The fault-close tests were performed manually, by a lineman. The tests proved the interchangeability between the above tested parts from Chardon Taiwan Corporation and Elastimold. The Chardon test samples were identified by the test witnesses as manufactured by Chardon Taiwan Corporation.

Tested by:

15 November 2012

T. Stefanski M.Sc., P. Eng.
Head of High Power Lab

Reviewed by:

J.A. Zawadzki M.Sc., P. Eng.
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Test Report № 20408-C-26

Project №:	#20408-26	**Test Dates:**	8-15 December 2010
Tested Equipment:	**1)** 30 sets consisting of a loadbreak elbow Catalog № LE215 manufactured by Cooper and a loadbreak bushing insert manufactured by Chardon Taiwan Corporation marked Tyco Electronics Loadbreak[1], 8.3/14.4 kV, 200 A **2)** 20 sets consisting of a loadbreak elbow manufactured by Chardon Taiwan Corporation marked Tyco Electronics[1] 8.3/14.4 kV, 200 A and a loadbreak bushing insert Catalog № LBI215 manufactured by Cooper Note: [1] The test witnesses stated that all products manufactured by Chardon Taiwan Corporation marked Tyco Electronics are identical to those bearing the "CHARDON" marking".		
Equipment rating:	8.3/14.4 kV, 200 A		
Test voltage:	14.4 kV		
Loadbreak current:	209 A_{rms}		
Fault-close current:	10.3 kA_{rms}		
Tests performed:	• Switching tests in accordance with Section 7.7. Each set was subjected to 10 x CO operations at 14.4 kV, 209 A_{rms}. • Fault-close tests in accordance with Section 7.8. One operation was performed at 14.4 kV, 10.3 kA_{rms} on each set that passed the switching tests.		
Test result:	Both systems met the switching and fault-close requirements.		
Remarks:	The switching tests were performed with a mechanical actuator. The fault-close tests were performed manually, by a lineman. The tests proved the interchangeability between the above tested parts from Chardon Taiwan Corporation and Cooper RTE. The Chardon test samples were identified by the test witnesses as manufactured by Chardon Taiwan Corporation.		

Tested by:

15 November 2012

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