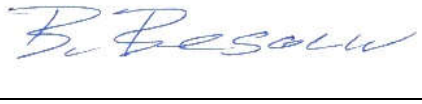
Hubbell Power Systems, Inc.
8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

Report G16-03-01

ANSI/IEEE Design Test Report
15 kV Class 200 A
Fused Loadbreak Elbow

This design test report records the results of laboratory tests performed on the 15 kV Class 200 A Fused Loadbreak Elbow which met or exceeded all applicable requirements of these standards:

IEEE Std. 386-2006, "IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V"
IEEE Std. 592-1990, “IEEE Standard for Exposed Semiconducting Shields on High-Voltage Cable Joints And Separable Insulated Connectors.”



Bas van Besouw
Engineering Manager

Eric Huang
Product Engineer

Peter Swales
Business Unit Director

David E. Crotty
Senior Product Manager

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

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7.4 PARTIAL DISCHARGE TEST

Test Procedure

The test voltage shall be raised to 20% above the partial discharge minimum extinction voltage of 11kV. If the partial discharge peak value exceeds 3pC, the test voltage shall be lowered to the partial discharge minimum extinction voltage level of 11kV and maintained at this level for at least 3 seconds but not more than 60 seconds. Partial discharge readings taken during this period shall not exceed 3pC.

Test Results

All samples tested met the requirements of Section 7.4 of IEEE Std. 386 - 2006. Table 1 shows individual results of the Partial Discharge Test results.

Sample	Result
A1 – Hi Tech Fuse	14kV / 0.1pC
A2 – CPS Fuse	14kV / 0.1pC
A3 – CPS Fuse	14kV / 0.1pC
A4 – CPS Fuse	14kV / 0.1pC
A5 – Hi Tech Fuse	14kV / 0.2pC
A6 – Hi Tech Fuse	14kV / 0.2pC
A7 – CPS Fuse	14kV / 0.2pC
A8 – CPS Fuse	14kV / 0.2pC
A9 – Hi Tech Fuse	14kV / 0.2pC
A10 – CPS Fuse	14kV / 0.8pC

Table 1

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Fax: (330) 336-9252

7.5 DIELECTRIC TESTS

Test Procedure

7.5.1 AC withstand voltage test

The test voltage shall be raised to 34kV$_{rms}$ in not more than 30 seconds. The connector shall withstand the specified test voltage for 1 minute without flashover or puncture.

7.5.2 DC withstand voltage test

The test voltage shall have a negative polarity and shall be raised to 53kV in not more than 30 seconds. The connector shall withstand the specified test voltage for 15 minutes without flashover or puncture.

7.5.3 Impulse withstand voltage test (BIL)

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

Test Results

All samples tested met the requirements of Section 7.5 of IEEE Std. 386 - 2006. Table 2 shows individual results of the Dielectric Test results.

Sample	AC – 34kV$_{rms}$ (1 Minute)	DC – 53kV (15 minutes)	95kV crest (3 Pos. 3 Neg.)
A1 – Hi Tech Fuse	Passed	Passed	Passed
A2 – CPS Fuse	Passed	Passed	Passed
A3 – CPS Fuse	Passed	Passed	Passed
A4 – CPS Fuse	Passed	Passed	Passed
A5 – Hi Tech Fuse	Passed	Passed	Passed
A6 – Hi Tech Fuse	Passed	Passed	Passed
A7 – CPS Fuse	Passed	Passed	Passed
A8 – CPS Fuse	Passed	Passed	Passed
A9 – Hi Tech Fuse	Passed	Passed	Passed
A10 – CPS Fuse	Passed	Passed	Passed

Table 2

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
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7.6 SHORT-TIME CURRENT TEST

Test Procedure

The connector shall be mounted in a manner approximating service conditions. Hold-down bails shall be used with 200A dead-break elbows. Short-time current tests may be made at any voltage up to the rated voltage of the connector. The rms value of the first major loop of a current wave shall be not less than 10kA for 0.17 seconds and 3.5kA for 3 seconds. The magnitude shall be measured in accordance with IEEE Std. C37.09 *"IEEE Standard Test Procedure for AC High-voltage Circuit Breakers Rated on a Symmetrical Current Basis".*

Connectors shall withstand the current without separation of interfaces or impairing the ability to meet the other requirements of the standard.

Test Results

All samples tested met the requirements of Section 7.6 of IEEE Std. 386 - 2006. Table 3 shows individual results of the Short-time Current Test results.

Sample Number	Current (kA)	Duration (s)	Result
A11	6.5	3.01	Passed
	11.9	.24	Passed
A12	6.5	3.01	Passed
	11.9	.24	Passed
A13	6.5	3.01	Passed
	11.7	.24	Passed
A14	6.5	3.01	Passed
	11.7	.24	Passed

Table 3

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7.10 CURRENT-CYCLING TEST

7.10.1 Accelerated Thermal Test

Test Procedure

Four connectors shall be assembled in series on AWG No. 1/0 insulated aluminum conductors having a length of 91cm (36 in). The cable shall be 15kV rated cables with insulation thickness of 175mils.

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 183cm (72in). The control cable shall be the same type and size as the cable used to join the connectors under test. Equalizers used shall be in accordance with ANSI Std. C119.4 - 2011, "*Connectors for Use between Aluminum-to-Aluminum and Aluminum-to-Copper Conductors*".

The bushing bus shall be a flat, rectangular, bus bar 356mm (14in) long, 102mm (4in) wide, and 10mm (3/8in) thick.

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 4h and off 2h for each cycle. At the end of each current-on cycle, the assembly shall be de-energized and within 3 minutes 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 3500A ± 300A_{rms} shall be applied to each sample for a minimum of 3 seconds.
The temperature of the following current transfer points shall be measured.

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

The DC resistance of the connector system was measured. The DC resistance measurements were made between the adjacent elbow cable equalizer and the bushing well stud of each sample.

Test Results

All samples tested met the requirements of Section 7.10.1 of IEEE Std. 386 - 2006. Tables 4 and 5 show individual results of the test results. All temperatures in °C.

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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
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	48.0	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	49.0	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	62.1	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	48.0	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	47.0	53.4	63.7	46.9	54.1	103.7	32.1	9.1
Max. Delta	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)	5.0 (37)	4.6 (27)	7.6 (7)	100.8 104.5	29.4 33.3	7.9 9.2

Table 4

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

Cycle	Ambient (°C)	A15 (mΩ)		A16 (mΩ)		A17 (mΩ)		A18 (mΩ)	
9	32.2	.69	2.3%	.69	2.3%	.67	3.0%	.66	.6%
20	29.9	.67	.6%	.65	3.7%	.64	1.5%	.64	2.5%
32	32.8	.66	2.1%	.67	.6%	.65	0%	.67	2.1%
40	32.0	.69	2.3%	.69	2.3%	.66	1.5%	.66	.6%
50	32.1	.66	2.1%	.67	.6%	.63	3.25	.65	.9%
Average		.674		0.674		0.650		.656	

Table 5

7.10.2 Thermal Test with off-axis operation

Test Procedure

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 Std. 386 - 2006.

The elbow shall be disassembled with a 12.7mm (0.5in) wide pulling band, as shown in Figure 21 of IEEE Std. 386 - 2006 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 shall be 15kV rated cables with insulation thickness of 175mils.

7.10.2.1 Mechanical operation

The elbow shall be rotated about the probe axis a minimum of 10° in both the clockwise and counterclockwise directions by means of a suitable live-line tool. The tool shall be approximately parallel with the axis of the probe.

The connector shall then be opened five times with the force applied to the pulling band and closed five times with the force applied to the operating eye. The force required to open or close the elbow shall be parallel to the axis of the probe. The applied force shall be sufficient to completely close the connector.

7.10.2.2 Current Cycling Test

A control cable, used for the purpose of obtaining conductor temperature, shall be installed in the current cycling loop between two equalizers. Its length shall be 183cm (72in). The control cable shall be the same type and size as the cable used to join the connectors under test. The current shall be adjusted so that the temperature on the conductor of the control cable is 90°C ± 5°C. The current shall be applied for eight continuous cycles, each cycle consisting of 3 hours on and 3 hours off. Equalizers used shall be in accordance with ANSI Std. C119.4 - 2011. Current-cycling tests shall be conducted at an ambient temperature of 15°C to 35°C in a space free of drafts.

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Fax: (330) 336-9252

Thermal couple installation areas:
a) At the compression lug
b) At the midpoint of the bushing contact

Test Results

All samples tested met the requirements of Section 7.10.2 of IEEE Std. 386 - 2006. Table 6 shows individual results of the test results. All temperatures in °C.

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

Cycle	A9		A10		A19		A20		Cable Temp.	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
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
Average	68.2	4.9	5.6	4.8	3.0	4.4	6.4	5.3	100.1	7.0

Table 6

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

7.12 ACCELERATED SEALING LIFE TEST

Test Procedure

Four samples shall be assembled on AWG No. 1/0 aluminum conductors. The four connector assemblies shall be placed in an oven having 121°C temperature and remain there for three weeks. After this time has elapsed, the four samples shall be removed from the oven and each operated once by using the operating eye or an appropriate location on the axis of the separable interface.

The four connector assemblies shall then 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 conductor of the control cable to 90°C ± 5°C for 1 hour.
The assemblies shall be de-energized and within 3 minutes, submerged in 25°C ± 10°C conductive water (5000Ω-cm maximum) to a depth of 30cm (1ft) for 1 hour.

After the 50th cycle, the connector and cable assembly shall withstand a design impulse test in accordance with section 7.5.3 of IEEE Std. 386 – 2006.
The test point, if provided, shall be capable of passing the voltage test specified in 7.17.2 of IEEE Std. 386 – 2006.

Test Results

All samples tested met the requirements of Section 7.12 of IEEE Std. 386 - 2006. Table 7 shows individual results of the Accelerated Sealing Life Test.

Sample	PD Before Acc. Life Sealing Test	AC Withstand Before Acc. Life Sealing Test	Imp Withstand Before Acc. Life Sealing Test	Imp Withstand Before Acc. Life Sealing Test	Test Point Indication
A1	14Kv / 0.1pC	34kV / 1m Pass	1.2/50µS ±95kV 3 Shots Each Pass	1.2/50µS ±95kV 3 Shots Each Pass	8kV
A2	14Kv / 0.1pC	34kV / 1m Pass			8kV
A3	14Kv / 0.1pC	34kV / 1m Pass			8kV
A4	14Kv / 0.1pC	34kV / 1m Pass			8kV
Remark	• Cable Temp：88.9~94.1℃ • Water Temp：25.9~29.6℃ • Resistance of Water：3482 Ω-cm • Depth of Water：60 cm • Test Point Voltage Testing is applied with 10.0kV				

Table 7

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

7.13 CABLE PULL-OUT TEST

Test Procedure

Four connector/cable assemblies shall be tested. 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 min without impairing the connector's ability to meet the other requirements of this standard.

Test Results

All samples tested met the requirements of Section 7.13 of IEEE Std. 386 - 2006. Table 8 shows individual results of the Cable Pull-out Test.

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

Table 8

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

7.14 OPERATING FORCE TEST

Test Procedure

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.

The temperature of the components shall be 20°C, +25°C, and +65°C, respectively, for three separate tests. Each test shall consist of closing and then reopening the connector within 10 minutes. The force shall be applied to the operating eye parallel to the axis of the probe at a rate of 13cm/min (5in/min).

The forces required to open or close the connector shall be between 222N and 890N (50lbf – 200lbf).

Test Results

All samples tested met the requirements of Section 7.14 of IEEE Std. 386 - 2006. Table 9 shows individual results of the Operating Force Test.

Sample	Operating Force (lbf)					
	-20°C		25°C		65°C	
	Open	Close	Open	Close	Open	Close
A21	93.50	181.94	86.04	137.28	97.90	166.98
A22	144.76	168.52	116.16	133.54	130.02	174.46
A23	124.96	151.14	76.78	156.42	155.98	115.28
A24	119.46	167.20	126.28	172.92	113.30	122.76

Table 9

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

7.15 OPERATING-EYE TEST

Test Procedure

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.

After the tensile and rotational forces are applied, each elbow shall be subjected to the Partial Discharge Test. All tests shall be performed at ambient temperature of 25°C ± 5°C.

Test Results

All samples tested met the requirement of Section 7.15 of IEEE Std. 386 - 2006. Table 10 shows individual results of the Operating-eye Test.

Sample	Static Force (500lbf)	Rotational Force (120lbf-in)	Partial Discharge Test
A5	Pass	Pass	Pass
A6	Pass	Pass	Pass
A7	Pass	Pass	Pass
A8	Pass	Pass	Pass

Table 10

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

7.16 TEST-POINT CAP TEST

7.16.1 Test-Point Cap Operating Force Test

Test Procedure

A tensile force shall be gradually applied to the test point cap in the direction parallel with the probe axis at 20°C, +25°C, and +65°C.

Test Results

All samples tested met the requirements of Section 7.16.1 of IEEE Std. 386 - 2006. Table 11 shows individual results of the Test-point Cap Operating Force Test.

Sample	Operating Force (lbf)					
	-20°C		25°C		65°C	
A21	29	26	31	31	23	23
A22	40	28	34	34	19	24
A23	25	27	26	26	20	17
A24	34	27	36	36	23	26

Table 11

7.16.2 Test-Point Cap Operating Withstand Test

Test Procedure

A tensile force of 445N (100lbf) shall be applied to the test point cap operating eye for 1 minute at 20°C, +25°C, and +65°C.

Test Results

All samples tested met the requirements of Section 7.16.2 of IEEE Std. 386 - 2006. Table 12 shows individual results of the Test-point Cap Operating Withstand Test.

Sample	100 lbf Pull Force		
	-20°C	25°C	65°C
A11	Pass	Pass	Pass
A12	Pass	Pass	Pass
A13	Pass	Pass	Pass
A14	Pass	Pass	Pass

Table 12

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

7.17 TEST-POINT TESTS

7.17.1 Test-point Capacitance Test

Test Procedure

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.

Test Results

All samples tested met the requirements of Section 7.17.1 of IEEE Std. 386 - 2006. Table 13 shows individual results of the Test-point Capacitance Test.

Sample	Test-point to Conductor (pF)	Test point and shield to the capacitance between test point and conductor shall not exceed 12.0
A1	7.87	10.304
A2	7.80	10.236
A3	7.68	10.229
A4	7.71	10.003
A5	8.29	10.650
A6	7.85	10.048
A7	7.78	10.441
A8	7.63	10.089
A9	7.70	10.005
A10	7.84	10.358

Table 13

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8711 Wadsworth Road
Wadsworth, OH 44244
Tel: (330) 335-2361
Fax: (330) 336-9252

7.18 SHIELDING TEST

IEEE Std. 592-4.2 Shield Resistance Test

Test Procedure

The test procedure and requirements were in accordance with IEEE Std. 592-1990, "IEEE Standard for Exposed Semiconducting Shields on Pre-molded High-Voltage Cable Joints and Separable Insulated Connectors".

The resistance of the semi-conducting shield of 25 kV 200 A dead-break elbow test samples was measured using the voltmeter - ammeter method. The voltage was measured with the current adjusted to 1.0mA ± 0.2mA. The current connections were made on the shield at the farthest shield extremity, using a circumferential connection at both locations to give a uniform current distribution. Resistance measurements were made on un-aged test specimens and samples that had been oven aged for 504 hours at 121°C. Resistance measurements were made with the test specimen temperature at 20°C and 90°C.

Test Results

All samples tested met the requirements of Section 7.18 of IEEE Std. 386 - 2006. Table 14 shows individual results of the Shield Resistance Test.

Sample	Un-aged		Aged	
	27°C	90°C	27°C	90°C
A11	2476Ω	1085Ω	1953Ω	1543Ω
A12	2868Ω	1080Ω	1708Ω	1766Ω
A13	3035Ω	1195Ω	1342Ω	1243Ω
A14	2353Ω	1124Ω	2195Ω	3057Ω

Table 14