Hubbell Power Systems, Inc.
1850 Richland Avenue E
Aiken, SC 29801

Report G16-08-03

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

This design test report records the results of laboratory tests performed on the 28 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.”

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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 21.5kV. If the partial discharge peak value exceeds 3pC, the test voltage shall be lowered to the partial discharge minimum extinction voltage level of 21.5kV 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	26kV / 0.2pC
A2 – Hi Tech Fuse	26kV / 0.2pC
A3 – CPS Fuse	26kV / 0.2pC
A4 – CPS Fuse	26kV / 0.3pC
A5 – Hi Tech Fuse	26kV / 0.2pC
A6 – Hi Tech Fuse	26kV / 0.3pC
A7 – CPS Fuse	26kV / 0.2pC
A8 – CPS Fuse	26kV / 0.2pC
A9 – Hi Tech Fuse	26kV / 0.2pC
A10 – CPS Fuse	26kV / 0.3pC

Table 1

7.5 DIELECTRIC TESTS

Test Procedure

7.5.1 AC withstand voltage test

The test voltage shall be raised to 45kV$_{rms}$ 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 88kV 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 140kV. 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 – 45kV$_{rms}$ (1 Minute)	DC – 88kV (15 minutes)	140kV crest (3 Pos. 3 Neg.)
A1 – Hi Tech Fuse	Passed	Passed	Passed
A2 – Hi Tech 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

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
B11	6.5	3.01	Passed
	13.7	.24	Passed
B12	6.5	3.01	Passed
	13.7	.24	Passed
B13	6.4	3.01	Passed
	11.5	.24	Passed
B14	6.4	3.01	Passed
	11.5	.24	Passed

Table 3

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 25kV rated cables with insulation thickness of 260mils.

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	B15			B16			B17			B18			Cable	Room Temp	Water Temp
	a	b	c	a	b	c	a	b	c	a	b	c			
6	56.8	43.6	39.7	54.2	42.3	39.9	61.5	47.9	39.9	55.2	42.6	38.9	100.3	32.0	7.9
7	56.3	43.0	39.4	54.0	42.1	40.0	62.8	49.7	40.3	55.7	42.9	39.0	100.9	32.0	8.5
8	60.4	46.5	41.6	57.7	45.0	41.9	66.1	52.2	43.4	60.9	46.7	41.8	100.7	32.2	9.0
9	56.8	42.5	38.0	54.2	41.4	38.3	63.2	49.1	40.0	56.7	42.6	38.7	102.2	31.9	8.1
10	55.5	41.3	37.4	53.0	40.5	37.7	62.1	48.2	39.4	55.8	42.0	37.9	100.1	31.1	8.6
11	56.4	43.0	39.6	54.5	42.4	40.0	62.1	48.6	40.5	56.1	43.3	39.1	100.5	32.2	8.8
12	56.8	42.9	39.3	54.7	42.2	39.8	62.2	48.0	40.6	56.5	43.1	39.8	101.9	32.4	8.6
13	56.2	41.7	37.7	53.8	40.9	38.0	60.8	45.6	38.8	56.2	42.0	38.3	102.4	31.8	8.5
14	55.3	40.9	37.0	53.0	40.1	37.3	59.0	43.4	37.9	56.0	41.9	37.8	101.6	30.9	9.0
15	55.1	42.0	38.9	53.5	41.8	39.4	58.6	44.1	39.0	55.5	42.3	38.5	101.9	32.1	9.1
16	53.9	40.3	37.4	52.0	39.8	37.7	57.8	42.5	37.8	54.1	40.5	37.6	102.1	31.3	8.9
17	54.2	39.7	35.7	51.9	39.0	36.0	59.3	44.0	37.5	54.5	40.1	37.0	103.0	30.3	8.8
18	53.9	39.2	35.5	51.5	38.4	35.6	62.0	47.9	38.1	54.2	40.0	36.2	102.0	29.4	8.9
19	54.2	39.7	36.0	51.8	38.9	36.0	64.0	51.1	39.9	54.8	40.2	37.2	102.4	30.8	9.2
20	54.0	40.0	36.0	51.9	39.4	36.4	62.6	48.9	39.1	54.8	40.8	37.3	102.4	29.9	9.1
21	53.6	39.4	35.3	51.4	38.6	35.9	61.3	46.9	38.1	54.6	40.2	36.7	102.6	29.9	9.1
22	53.8	39.5	35.4	51.7	38.7	35.9	60.4	45.5	37.9	55.3	40.4	36.8	101.5	30.2	8.9
23	54.1	39.9	36.0	52.0	39.2	36.4	59.9	44.7	38.1	55.4	41.3	37.2	101.8	30.4	9.2
24	53.9	39.8	35.7	51.9	39.0	36.3	59.8	43.9	38.0	55.0	41.0	37.6	100.9	30.1	9.0
25	53.6	39.2	35.7	51.5	38.6	35.8	58.7	42.6	37.3	55.1	40.9	36.9	100.1	29.9	8.9
26	53.4	39.0	35.6	51.6	38.7	35.7	58.1	42.4	37.1	54.5	40.1	37.0	100.6	31.0	8.9
27	55.7	43.1	39.8	54.8	43.0	40.3	60.2	45.6	40.2	57.8	44.3	40.0	101.9	32.1	9.1
28	54.6	40.9	36.4	53.0	40.6	36.8	59.1	43.8	38.4	56.0	41.9	38.1	103.1	31.2	9.0
29	53.2	39.9	36.0	51.9	39.3	36.5	57.8	42.4	37.8	55.0	41.2	37.8	102.4	31.3	9.0
30	52.9	40.0	37.0	52.0	39.9	37.4	57.9	42.8	37.9	54.6	41.8	37.8	102.1	32.8	9.1
31	54.6	42.5	39.3	53.8	42.2	39.8	59.8	44.9	40.0	56.2	43.7	39.9	102.6	32.9	8.9
32	54.8	41.4	37.4	53.6	40.9	37.8	59.7	44.0	39.1	56.3	42.3	38.8	103.0	32.0	9.2
33	54.0	40.6	36.9	52.9	40.3	37.1	58.8	43.2	38.3	56.0	41.9	38.2	101.8	32.0	7.9
34	52.7	40.3	37.2	51.7	40.1	37.7	57.9	43.0	38.1	54.6	41.7	38.0	102.2	32.0	9.0
35	54.6	42.3	39.2	53.9	42.0	39.6	60.0	44.7	40.1	56.0	42.8	40.0	103.8	33.2	8.8
36	59.7	47.7	39.4	53.9	41.2	38.3	59.9	44.4	39.9	57.8	44.0	39.9	102.1	33.3	9.0
37	58.9	46.5	38.6	53.0	40.5	37.3	59.2	43.6	38.5	55.5	41.5	38.4	102.3	32.5	9.2
38	55.2	42.0	37.8	52.9	40.3	37.9	58.8	43.6	38.7	56.0	42.1	38.6	101.9	32.2	8.9
39	57.2	45.1	39.5	53.6	41.4	39.5	59.6	44.2	39.9	56.8	42.9	39.9	101.7	32.7	8.6
40	57.5	46.2	39.3	52.8	40.7	38.6	57.9	43.3	38.5	55.3	42.0	38.1	101.7	31.5	9.2
41	55.1	43.4	38.2	51.7	39.9	37.6	57.2	42.1	37.5	54.0	40.8	37.2	100.8	32.0	9.0
42	55.3	43.2	38.6	52.4	40.6	38.3	57.5	42.8	38.4	55.1	41.5	38.0	100.1	31.1	8.9
43	54.3	42.1	38.4	53.1	41.5	39.0	58.0	43.4	38.9	55.5	42.0	38.7	100.5	30.9	9.1
44	52.8	40.6	36.9	51.9	39.9	37.3	56.4	41.8	37.0	53.0	40.1	36.7	100.3	31.0	9.1
45	53.5	41.1	37.0	51.8	39.5	37.2	56.2	41.5	36.9	53.3	40.1	36.8	100.4	31.8	9.2
46	53.8	41.4	37.5	52.0	39.9	37.9	56.8	42.0	37.5	54.0	40.6	37.5	101.5	31.4	8.7
47	54.4	42.0	38.1	53.6	41.3	38.6	57.2	42.7	38.1	54.2	41.4	37.9	100.9	30.8	9.2
48	53.9	41.7	37.4	52.9	40.7	37.9	56.9	42.0	37.3	54.2	40.8	37.1	102.4	31.6	9.0
49	54.8	42.9	37.4	52.8	40.2	37.4	56.7	41.8	37.2	53.7	40.0	36.8	103.2	32.0	9.1
50	55.9	44.6	38.5	53.4	41.0	38.3	56.6	41.9	37.8	53.8	41.1	37.4	102.9	31.7	8.9
Max. Delta	5.3 (8)	5.8 (36)	3.9 (8)	4.8 (8)	4.5 (8)	4.0 (8)	6.6 (8)	7.5 (8)	4.7 (8)	5.5 (8)	5.0 (8)	3.7 (8)	100.1 103.8	29.4 33.3	7.9 9.2

Table 4

Cycle	Ambient (°C)	B15 (mΩ)		B16 (mΩ)		B17 (mΩ)		B18 (mΩ)	
9	32.2	.62	1.9%	.62	3.2%	.60	.3%	.62	.3%
20	29.9	.62	1.9%	.61	4.9%	.58	3.8%	.62	.3%
32	32.8	.62	1.9%	.64	0%	.63	4.4%	.62	.3%
40	32.0	.63	0.3%	.64	0%	.60	.3%	.64	2.8%
50	32.1	.67	5.7%	.69	7.2%	.60	.3%	.61	1.9%
Average		.632		0.640		0.650		.622	

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.

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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Cycle	B9		B10		B19		B20		Cable Temp.	Room Temp.
	a	b	a	b	a	b	a	b		
1	64.8	43.9	64.4	44.1	61.9	46.7	61.9	47.4	91.7	27.5
2	62.4	44.3	62.3	44.4	61.2	47.8	60.2	47.9	92.2	28.1
3	62.6	44.0	62.1	44.2	61.3	47.7	60.1	47.8	92.3	28.1
4	68.6	45.9	68.4	46.9	64.8	49.9	65.9	50.7	92.0	30.2
5	68.0	45.6	68.3	46.8	64.9	49.4	65.7	50.0	91.8	30.7
6	67.1	44.3	67.3	45.7	63.8	48.2	64.8	48.8	90.7	29.9
7	66.8	43.7	67.3	45.2	63.7	47.8	64.3	48.4	91.2	29.2
8	67.8	45.5	68.0	46.9	64.6	49.3	65.7	50.1	91.8	30.2
9	68.0	45.4	68.4	47.1	64.8	49.1	65.7	50.0	91.9	30.6
10	67.5	45.0	67.9	46.7	64.6	49.0	65.6	49.9	91.8	30.4
11	67.1	44.2	67.7	46.0	64.1	48.2	65.1	49.1	91.9	29.4
12	68.0	45.6	68.4	47.3	64.7	49.3	65.7	50.1	91.8	30.3
13	68.1	45.7	68.6	47.4	64.9	49.3	65.8	50.0	91.9	30.7
14	67.7	45.4	68.3	47.0	64.8	49.4	65.9	50.1	92.3	30.5
15	67.3	44.9	68.0	46.6	64.5	48.9	65.6	49.8	92.0	30.1
16	67.7	45.8	68.3	47.3	64.8	49.8	65.9	50.4	92.1	30.5
17	67.6	45.4	68.1	46.9	64.6	49.3	65.9	50.2	92.0	30.3
18	67.2	44.6	67.7	46.3	64.3	48.7	65.4	49.7	92.1	29.9
19	67.3	44.5	67.8	46.1	64.3	48.6	65.4	49.6	92.2	29.6
20	67.9	45.4	68.4	46.9	64.8	49.4	66.0	50.3	92.3	30.1
21	68.3	46.0	68.7	47.8	65.2	50.1	66.2	50.8	92.3	31.2
22	67.5	44.9	68.1	46.7	64.5	49.0	65.8	49.9	92.2	30.1
23	67.6	44.7	68.0	46.6	64.4	48.8	65.8	49.8	92.2	29.8
24	67.4	45.4	67.8	46.9	64.3	49.3	65.7	50.0	92.3	30.0
25	68.6	46.3	68.8	47.9	65.5	50.2	66.4	51.0	92.6	31.2
26	67.7	45.2	68.2	46.9	64.8	49.2	65.9	50.0	92.2	30.2
27	67.5	44.6	67.9	46.2	64.4	48.6	65.7	49.7	92.5	29.6
28	67.2	44.6	67.7	46.3	64.3	48.6	65.6	49.7	92.4	29.4
29	67.4	44.7	67.9	46.4	64.4	48.8	65.8	49.8	92.3	29.8
30	66.9	44.0	67.6	45.7	64.1	48.0	65.1	48.8	92.2	28.7
31	66.7	43.8	67.4	45.5	63.9	47.8	65.2	48.6	92.7	28.4
32	67.1	44.4	67.5	46.1	64.0	48.4	65.3	49.5	92.4	28.9
33	67.1	44.4	67.5	46.0	64.0	48.4	65.3	49.4	92.3	29.1
34	66.7	43.8	67.4	45.6	63.8	47.9	64.9	48.5	92.2	28.4
35	66.8	43.4	67.4	45.1	63.8	47.5	64.8	48.3	91.2	28.0
36	67.4	45.0	67.6	46.7	64.1	49.1	65.4	49.9	92.2	29.2
37	67.7	44.4	68.3	46.1	64.5	48.7	65.9	49.7	92.3	29.5
38	66.6	43.5	67.1	45.4	63.4	47.6	64.2	48.3	92.3	28.1
39	66.8	43.3	67.3	45.0	63.6	47.4	64.5	48.2	92.4	28.0
40	67.1	44.8	67.4	46.3	64.0	48.8	65.1	49.8	92.2	28.6
41	66.8	43.6	67.3	45.5	63.7	47.8	64.8	48.4	92.2	28.4
42	66.6	43.1	67.0	44.9	63.4	47.2	64.4	48.0	92.3	27.9
43	66.3	42.9	66.9	44.8	63.2	47.1	64.2	47.9	92.3	27.4
44	66.9	43.5	67.5	45.4	63.8	47.7	64.7	48.4	92.2	27.9
45	67.1	43.9	67.7	45.7	64.1	48.0	65.3	48.9	92.1	28.3
46	66.4	43.0	66.9	44.9	63.3	47.2	64.3	48.1	92.3	27.8
47	66.4	43.1	67.0	45.0	63.3	47.2	64.3	48.1	92.4	27.7
48	66.7	43.4	67.1	45.3	63.4	47.5	64.5	48.3	92.2	27.9
Average	67.1	44.5	67.5	46.1	64.1	48.5	65.0	49.3	92.1	29.3

Table 6

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 After Acc. Life Sealing Test	Test Point Indication	
B1	23Kv / 0.3pC	40kV / 1m Pass	1.2/50µS ±125kV 3 Shots Each Pass	1.2/50µS ±125kV 3 Shots Each Pass	13.0kV	15kV
B2	23Kv / 0.4pC	40kV / 1m Pass			13.5kV	15kV
B3	23Kv / 0.3pC	40kV / 1m Pass			13.5kV	15kV
B4	23Kv / 0.2pC	40kV / 1m Pass			13.0kV	15kV
Remark	• Cable Temp：87.0~92.1℃ • Water Temp：26.7~30.3℃ • Resistance of Water：3514 Ω-cm • Depth of Water：60 cm • Test Point Voltage Testing is applied with 15.0kV					

Table 7

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
D1	203 lbf	Pass
D2	204 lbf	Pass
D3	204 lbf	Pass
D4	202 lbf	Pass

Table 8

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
B21	149.60	177.54	126.06	102.52	126.50	183.48
B22	140.58	152.90	133.76	116.60	131.56	172.04
B23	178.42	156.64	141.46	124.30	126.72	144.32
B24	135.08	168.52	95.48	124.52	127.38	140.58

Table 9

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
B5	Pass	Pass	Pass
B6	Pass	Pass	Pass
B7	Pass	Pass	Pass
B8	Pass	Pass	Pass

Table 10

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	
B21	24	19	43	22	15	20
B22	24	20	26	25	17	18
B23	18	19	32	24	18	18
B24	25	22	40	32	17	18

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
B21	Pass	Pass	Pass
B22	Pass	Pass	Pass
B23	Pass	Pass	Pass
B24	Pass	Pass	Pass

Table 12

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 shall be at least 1.0 pF (pF)	The ratio of the capacitance between test point and shield to the capacitance between test point and conductor shall not exceed 12.0
B1	8.08	10.282
B2	7.84	10.276
B3	7.95	10.448
B4	7.84	10.409
B5	7.78	10.343
B6	7.90	10.245
B7	7.79	10.359
B8	8.01	10.322
B9	7.89	10.407
B10	8.04	10.607

Table 13

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 28 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
B11	3936Ω	1205Ω	2114Ω	2032Ω
B12	3838Ω	1552Ω	2454Ω	2331Ω
B13	3771Ω	1751Ω	3213Ω	2462Ω
B14	3914Ω	1565Ω	2057Ω	2944Ω

Table 14