POWER SYSTEMS, INC.

TEST REPORT

CERTIFIED ENGINEERING TEST REPORT

Interchangeability and Dielectric Tests

HUBBELL® Separable Connectors
35 kV 200 Ampere
Loadbreak Products

"Series 600"

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NOTE:
Because Hubbell Power Systems has a policy of continuous product improvement, we reserve the right to change design and specifications without notice.

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INTRODUCTION

The HUBBELL®, Three Phase Rated, 35 kV Class, 200 Ampere, Loadbreak Elbow and Integrated Bushing are designed to meet or exceed the requirements of the ANSI / IEEE Standard 386-1985, Separable Insulated Connector Systems for Power Distribution Systems above 600 V.

PURPOSE:

This test series was conducted to establish and document the performance characteristics of the Elbow and Integrated Bushing in accordance with the Design Tests (7.2) specified in the ANSI / IEEE Standard 386-1985.

Interchangeability testing was conducted with Cooper (RTE) 35 kV, Three Phase rated, Elbows and Integrated Bushings.

RATINGS:

VOLTAGE RATINGS AND CHARACTERISTICS

ANSI / IEEE Std 386-1985, Section 5.1, Table 1.

Class ....35 kV
Phase to Ground ....21.1 kV
Phase to Phase Maximum...36.6 kV
Basic Impulse Level (BIL)......................................150 kV
Alternating Current Withstand (1 minute) ....50 kV
Direct Current Withstand (15 minutes)............103 kV
Minimum Corona Voltage Level (3 pc).................26 kV

CURRENT RATINGS AND CHARACTERISTICS

ANSI / IEEE Std 386-1985, Section 5.2, Table 2.

Continuous Current Rating ....200 A (RMS)
Switching Current Rating...200 A (RMS)
Fault-Closure Current Rating
(0.17 Seconds) ....10,000 A (RMS/SYM)
Short Time Current Rating (0.17 Seconds).... 10,000 A (RMS/SYM)
(3.0 Seconds) .... 3,500 A (RMS/SYM)

PROCEDURE:

Testing was performed in GE Company Laboratories in accordance with ANSI/IEEE Standard 386-1985. Measurements conform to the specifications and standards, where defined. In all cases professional engineering techniques were utilized to maintain the highest level of accuracy and detail.

TEST PROGRAM:

Testing was conducted in accordance with the ANSI/IEEE Std 386-1985.

CERTIFICATION:

The data and information contained herein is believed to be reliable and in accordance with the cited industry standards and accepted engineering practice. This test program was conducted under the direction of the following GE Company personnel.

T. Walker Brown Date 3/8/90

T. W. Brown, PE, Senior Engineer
Connector Engineering
Component Products Operation
Transformer Business Department

Professional Engineer
State of Georgia
Registration No. 9674

W D Scharer Date 3/8/90

W. D. Scharer, Manager
Connector Engineering
Component Products Operation
Transformer Business Department

INDEX OF TESTING

1.0 DESIGN TESTS:

ANSI/IEEE Std 386-1985, Section 7.2

The design tests performed were as listed in Table 3 of the standard and compliance of the design with this standard was demonstrated.

2.0 TEST CONDITIONS:

ANSI/IEEE Std 386-1985, Section 7.3

Compliance with the specified test conditions was maintained throughout the testing program.

3.0 DIELECTRIC TESTS:

Testing was conducted with the Hubbell Power Systems Model #9U01DBE654 and GE Integrated Bushing Model #9U02DBC001

3.1 Corona Voltage Level.

ANSI/IEEE Std 386-1985, Section 7.4

The corona extinction voltage level of 26 kV at 3 pico coulombs sensitivity was exceeded for each test sample as shown in Data Table 1.

3.2 Alternating-Current Withstand Voltage Test.

ANSI/IEEE Std 386-1985, Section 7.5.1

The connectors withstood the specified test voltage for 1 minute without flashover or puncture. Data is provided in Data Table 1.

3.3 Direct-Current Withstand Voltage Test.

ANSI/IEEE Std 386-1985, Section 7.5.2

The test voltage had a negative polarity and the connector withstood the specified test voltage for 15 minutes without flashover or puncture. Data is provided in Data Table 1.

3.4 Impulse Withstand Voltage Test (BIL).

ANSI/IEEE Std 386-1985, Section 7.5.3

The test voltage was a 1.2/50 μs wave having the crest value (BIL) shown in the following tables. Each connector was subjected to three positive and three negative full-wave impulses without flashover or puncture.

Data Table 1. Hubbell Elbow / GE Integrated Bushing

Elbow	9U01DBE654
Insulation Diameter Range	(1.020" to 1.160")
Integrated Bushing Cat. No.	9U02DBC001
Cable Insulation Thickness	345 mils
Cable Insulation	XPLE
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Solid
Compression Connector	9U09AAW134 (Short Bi-Metal)

Sample No.	Corona Extinction (kV rms)	--------Withstand------------- AC 50 kV 1 Min.	DC 103 kV 15 Min.	Impulse 150 kV BIL (1.2x50 μs)
1	27	PASS	PASS	PASS
2	27	PASS	PASS	PASS
3	29	PASS	PASS	PASS
4	27	PASS	PASS	PASS
5	29	PASS	PASS	PASS
6	32	PASS	PASS	PASS
7	31	PASS	PASS	PASS
8	31	PASS	PASS	PASS
9	31	PASS	PASS	PASS
10	31	PASS	PASS	PASS

4.0 SHORT-TIME CURRENT TEST:

ANSI/IEEE Std 386-1985, Section 7.6

The Test was performed on the following sample assemblies.

Elbow	9U01DBE654
Integrated Bushing	9U02DBC001
Cable Insulation	XPLE
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Solid
Compression Connector	9U09AAW134 (Short Bi-Metal)
Compression Tool	Burndy Y-35
Compression Die	Burndy U-243 (1 impression)

The assemblies passed the specified test current without separation of the interface or impairing the ability to meet the other requirements of the Standard. The test results are summarized below.

Data Table 2. Short-Time Current Rating

Sample No.	Current (Amperes rms/sym)	Duration (Seconds)
1	10,000+ 3,500+	0.17+ 3.00+
2	10,000+ 3,500+	0.17+ 3.00+
3	10,000+ 3,500+	0.17+ 3.00+
4	10,000+ 3,500+	0.17+ 3.00+

5.0 SWITCHING AND FAULT CLOSURE TESTS:

Tests were performed using Hubbell Elbows, Catalog Number 9U01DBE655 and GE Company Integrated Bushings, Catalog Number 9U02DBC001.

5.1 Switching Tests.

ANSI/IEEE Std 386-1985, Section 7.7

Each Elbow and Integrated Bushing combination was subjected to 10 complete switching operations under the conditions listed in Fig 12, Table 4, of the Standard without arcing to ground or impairing its ability to meet the other requirements of the Standard. The test circuit used was in compliance with Fig 12 (b) of the Standard. The operating procedure for the switching test involved two connector combinations, connected in series, with a power mechanical operator making one elbow, followed immediately by breaking the other elbow; one minute later this sequence was reversed, and repeated.

The test requirements were passed.

See Data Table 3 (Appendix) for test results.

5.2 Fault-Closure Tests.

ANSI/IEEE Std 386-1985, Section 7.7

Elbow and Integrated Bushing Combinations having completed the switching test were tested with the fault current given in Table 2 of the Standard. Testing was conducted in the same sequence used for the switching test. The test circuit used was in compliance with Fig 13 (b) of the Standard.

The test requirements were passed.

See Data Table 3 (Appendix) for test results.

6.0 CURRENT CYCLING TESTS:

6.1 Uninsulated Components.

ANSI/IEEE Std 386-1985, Section 7.9.

Testing was conducted in compliance with ANSI C119.4-1986.

All tests were satisfactorily passed.

For the Elbow connector, all Resistance measurements were from the equalizer to the Elbow Probe. The reported temperature measurements were made on the Elbow Crimp Connector which was the highest temperature recorded.

For the Bushing, resistance measurements were made from the Elbow probe to the Bushing busbar. The reported temperature measurements were made between the bushing contact to probe and the piston contact to bushing container.

See Data Tables (Appendix)

Data Table 4. Equalizer to Elbow Probe with Bi-metal Connector (0.625" OD-Short).

Data Table 5. Elbow Probe to Bushing Busbar.

6.2 Insulated Components.

6.2.1 ANSI/IEEE Std 386-1985, Section 7.10 (Option A).

The test was performed with the following sample assemblies.

Elbow	9U01DBE664
Integrated Bushing	9U02DBC001
Cable Insulation Thickness	345 mils
Cable Insulation Type	XLPE
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Solid
Compression Connector	9U09AAW164 (Long Bi-Metal)
Compression Tool	Burndy Y-35
Compression Die	Burndy U-243 (2 impression)

Test was satisfactorily passed.

See Data Table 6. (Appendix) for test results.

6.2.2 ANSI/IEEE Std 386-1985, Section 7.10 (Option B).

Mechanical Operation, ANSI/IEEE Std 386-1985, Section 7.10.1

Current Cycling, ANSI/IEEE Std 386-1985, Section 7.10.2

This test is similar to the Option A test except for the application of rotational and off-axis operating forces. Each Elbow is assembled with a one-half inch wide pulling band for the off-axis opening force. Each connector is subjected to 6 complete test cycles, each consisting of the mechanical operation followed by current cycling. The mechanical operation consists of a 10° minimum rotation about the probe axis, followed by 5 off-axis opening operations with the closure force applied to the pulling eye.

The test was performed using both the Short (Standard) and Long Bi-Metal compression connectors in the following sample assemblies.

Elbow	9U01DBE655
Integrated Bushing	9U0DBCB001
Cable Insulation Thickness	345 mils
Cable Insulation Type	XLPE
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Conc. Stranded
Compression Connector	9U09AAW135 (Short Bi-Metal)
Compression Tool	Burndy Y-35
Compression Die	Burndy U-243 (1 impression)

Test was satisfactorily passed.

See Data Table 7A (Appendix) for test results.

Elbow	9U01DBE655
Integrated Bushing	9U0DBCB001
Cable Insulation Thickness	345 mils
Cable Insulation Type	XLPE
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Conc. Stranded
Compression Connector	9U09AAW165 (Long Bi-Metal)
Compression Tool	Burndy Y-35
Compression Die	Burndy U-243 (2 impressions)

Test was satisfactorily passed.

See Data Table 7 (Appendix) for test results.

7.0 ACCELERATED SEALING LIFE TEST:

ANSI/IEEE Std 386-1985, Section 7.12

The test was performed with the following sample assemblies and the results are summarized below.

Elbow	9U01DBE654
Integrated Bushing	9U02DBC001
Cable Insulation Thickness	345 mils
Cable Insulation Type	XLPE
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Solid
Compression Connector(RTE)*	2609459A04 (Short Bi-Metal)
Compression Tool	Burndy Y-35
Compression Die	Burndy U-243 (1 impression)

* The Hubbell Bi-Metal connector was not available at time of test. Equivalency of the Hubbell connector has been established in Insulated & Uninsulated Current Cycling tests.

The test procedure used was as follows.

1. The samples were aged at 120°C for three weeks, then operated once.

2. The samples were connected in series and subjected to 50 current cycles. They are heated in air during the 3 hour "current on" period followed immediately by submersion in 25°C conductive water for the 1 hour "current off" period.

3. On completion of the current cycling each sample was subjected to the design impulse test (3 positive and 3 negative full waves).

Data Table 8. Accelerated Sealing Life

Sample No.	Impulse Withstand 150 kV BIL
1	Pass
2	Pass
3	Pass
4	Pass

8.0 CABLE PULL-OUT TEST:

ANSI/IEEE Std 386-1985, Section 7.13

The test was performed with the following sample assemblies.

Cable Insulation Type	TRXLPE
Cable Insulation Thickness	175 mils
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Conc. Stranded
Compression Connector	9U09AAW165 (Long Bi-Metal)
Compression Tool	Burndy MD-6
Compression Die	Burndy W-243 (4 impressions)

Four connector/cable assemblies were tested and withstood the required 200 pounds tensile force applied for one minute.

An added evaluation, not required by the ANSI/IEEE Std 386-1985 was performed as follows.

The cable assemblies, after being subjected to the 200 pound tensile force for one minute, were installed in Hubbell 15kV Elbows.

The Elbows were mated with a GE 15 kV Integrated Bushing. The assembly was subjected to the current cycling test per ANSI/IEEE 386-1985, Section 7.10. Option A.

The Compression Connector in the Elbow-Integrated Bushing assemblies maintained a temperature below that of the control cable throughout the 50 cycle test.

9.0 OPERATING-FORCE TEST:

ANSI/IEEE Std 386-1985, Section 7.14.

The test consists of a loadmake operation followed by a loadbreak operation within 10 minutes, with the force applied to the operating eye parallel to the axis of the probe.

The Operating Force must range between 50 and 200 pounds for connectors without hold-down bails, at temperatures of -20°C, +25°C and +65°C.

The test was performed with the following sample assemblies and the results are summarized below.

Elbow	9U01DBE654
Integrated Bushing	9U02DBC001

The operating force was applied at a rate of 20 inches per minute.

Data Table 9. Operating Force

Sample No.	Operating Force (pounds)					
	Loadmake			Loadbreak		
	-20°C	+25°C	+65°C	-20°C	+25°C	+65°C
1	265	158	115	245	167	130
2	280	168	120	255	178	77
3	280	170	125	250	200	150
4	275	170	130	275	180	132

10.0 OPERATING-EYE TEST:

ANSI/IEEE Std 386-1985, Section 7.15.

A static tensile force of 300 pounds was applied to the operating eye in the direction of normal operation, for a duration of one minute.

Following the static tensile force test a rotational force of 120 inch pounds applied in a clockwise and counter-clockwise direction.

The tests were accomplished without any distortion to the eye and all samples passed corona voltage level requirement after the mechanical testing.

Data Table 10. Operating Eye

Sample	Static Force 300 pounds	Rotation Forces	Corona Extinction Voltage (kV/rms)
1	Pass	Pass	30
2	Pass	Pass	28
3	Pass	Pass	26
4	Pass	Pass	28

11.0 TEST POINT CAP TEST:

11.1 Test-Point Cap Operating-Force.

ANSI/IEEE Std 386-1985, Section 7.16.1.

The test consists of removing the test-point cap, with a force gradually applied to the test-point eye parallel to the axis of the probe.

The Operating Force must range between 8 and 49 pounds for connectors without hold-down bails, at temperatures of -20°C, +25°C and +65°C.

Data Table 11. Operating Force

Sample No.	Operating Force (pounds)		
	-20°C	25°C	65°C
1	28	18	13
2	26	14	18
3	28	14	15
4	27	20	17

11.2 Test-Point Cap Operating Withstand Test.

ANSI/IEEE Std 386-1985, Section 7.16.2.

A static tensile force of 100 pounds was applied to the Test-Point Cap Operating Eye, in the direction of normal operation, for a duration of one minute, at temperatures of -20°C, +25°C and +65°C.

Distortion of the operating eye is acceptable provided the test-point cap is serviceable after the test.

The Hubbell Test-Point Cap passes the test requirements.

12.0 TEST-POINT TESTS:

12.1 Test-Point Capacitance Test.

ANSI/IEEE Std 386-1985, Section 7.17.1.

The capacitance between the test point and the conductor system meets the requirement of 1.0 pF minimum, and the ratio of capacitance between the test point and shield to the capacitance between the test point and conductor system does not exceed 12.0 maximum. See Data Table 12.

12.2 Test-Point Voltage Test.

ANSI/IEEE Std 386-1985, Section 7.17.2.

The test point voltage test was conducted using a portable HI-Z Voltmeter, Model VM25-A with a VMP5-A probe tip, Manufactured by the Ross Engineering Corporation.

Data Table 12. Test-Point Tests.

Elbow Sample No.	Capacitance, Picofarads		Capacitance Ratio (12.0 Max.)	Indicated Voltage(kV) (22 kV Applied)
	Tap-Cable	Tap-Ground		
1	1.43	10.33	7.2	19
2	1.41	10.50	7.4	19
3	1.38	10.49	7.6	19
4	1.41	10.42	7.4	19
5	1.39	10.45	7.5	19
6	1.42	10.38	7.3	19
7	1.37	10.36	7.6	19
8	1.43	10.08	7.0	19
9	1.30	10.14	7.8	18
10	1.04	9.28	8.9	16

13.0 SHIELDING TEST:

ANSI/IEEE Std 386-1985, Section 7.18.

Testing was conducted in compliance with IEEE Std 592-1977.

13.1 Shield Resistance.

The semiconducting shield resistance was measured between the cable entrance and the farthest extremity from the cable entrance at 20°C and 90°C from production samples and samples aged in an air oven for 504 hours at 120°C.

Data Table 13. Shield Resistance, Ohms (5000 Ohms Max.)

Elbow Sample No.	Oven Aged, 504 Hrs @ 120°C		Elbow Sample No.	Recent Production	
	20°C	90°C		20°C	90°C
1	27	35	5	52	47
2	27	33	6	56	45
3	45	52	7	61	48
4	33	45	8	67	49

13.2 Fault Current Initiation.

The fault current initiation test was performed on elbows assembled as follows.

Elbow Catalog Number	9U01DBE654
Insulation Diameter Range	(1.020"to 1.160")
Elbow Probe (standard)	9U09DAW002
Cable Insulation Type	XLPE
Cable Insulation Thickness	345 mils
Cable Conductor	Aluminum
Cable Conductor Type	# 1/0 AWG Solid
Compression Connector	9U09AAW134 (Short Bi-Metal)
Compression Tool	Burndy Y-35
Compression Die	Burndy U-243 (1 impression)
Faulting Rod	3/8" Dia. Copper-Tungsten

The copper-tungsten faulting rod was located between the semiconducting shield and the probe at the extremity farthest from the cable entrance.

The circuit parameters were 7 kV Maximum and 10,000 Amperes, RMS, Symmetrical available short circuit current.

Each specimen was subjected to two tests causing initiation of a fault current arc to ground, each operation having a minimum current flow duration of 10 cycles.

Data Table 14. Shield Fault Current Initiation

Elbow Sample No.	Test No.	Test Voltage (kV)	Test Current Amperes	Duration Cycles
1	1	6.0	11,700	10.5
	2	6.0	11,700	14.5
2	1	6.0	11,700	12.0
	2	6.0	11,700	11.5
3	1	6.0	11,700	12.0
	2	6.0	11,700	12.0
4	1	6.0	11,700	11.5
	2	6.0	11,700	11.5

INTERCHANGEABILITY

Intermixed Hubbell Elbows and Integrated GE Bushings and Cooper (RTE) manufacture were tested for switching and Fault Closure performance in accordance with the ANSI / IEEE Std 386-1985, Sections 7.7 and 7.8.

INDEX OF TESTING:

Data Table 3. Switch & Fault Closure Test

Hubbell Elbow, 9U01D--6--

GE Co. Integrated Bushing, 9U02DBC001

	Switching (SCT 075)		Fault Close (SCT 077)	
Sample No.	Pass/Fail	Osc. # of Last Opern.	Pass/Fail	Osc. #
1	P	2526B	P ---|	161
2	P	2526M	P |	162
3	P	2546B	P |	163
4	F (10)(A)	2546M	-- |	
5	P ---|	2566B	P |	164
6	P |	2566M	P |	165
7	P |	2586B	P |	166
8	P |	2586M	P (15)	167
9	P |	2606B	P |	168
10	P |	2606M	P |	169
11	P |	2626B	P |	170
12	P (16)	2626M	P |	171
13	P |	2646B	P |	172
14	P |	2646M	P |	173
15	P |	2666B	P |	174
16	P |	2666M	P ---|	175
17	P |	2686B	Not Tested	
18	P |	2686M	Not Tested	
19	P |	2706B	Not Tested	
20	P ---|	2706M	Not Tested	

P = Pass, F = Failure   Test Dates: 9/16/87 - 9/23/87

( ) = Failed on operation no.

(A) = Conductor in feed cable broke, test circuit failure.

Each Switching and Fault Close Operation was recorded by an oscillogram. Fault Close oscillograms show no external ground current.

ANSI C119.4 - 1986 ELECTRICAL TEST DATA SHEET

BI-METAL ELBOW CONNECTOR (0.625" OD/SHORT) 9U09AAW135

RESISTANCE MEASURED FROM EQUALIZER TO ELBOW PROBE (21.1/36.6kV)

TEST DATE: 10/24/89 - 12/6/89

TEST NUMBER: SCE89-025

TESTED BY: T.W. BROWN / T. AUSTIN

NO. OF CYCLES: 503
TEST CYCLE: 1 HOUR ON / 45 MIN. OFF *
TEST CURRENT: 239 AMPERES
* OFF = FAN COLLED

CONDUCTOR SIZE & TYPE: #1/0 AWG, 19 STRAND, COMPRESSED ALUMINUM
CONDUCTOR PREPARATION: WIRE BURSH WITH ANTI-OXIDANT
ANTIOXIDANT: ALNOX UG
CONTROL CONDUCTOR LENGTH: 6 FT.

CRIMPING TOOL: BURNDAY Y-35
CRIMPING DIE: BURNDY U-243
NO. OF CRIMPS: 1
PROBE TORQUE: 150 LB-IN

CYCLE	TEMPERATURE (DEG C) AMBIENT	CONTROL	RISE	CONNECTOR 1	2	3	4	TEMPERATURE DIFFERENCE (CONTROL - CONNECTOR) 1	2	3	4	VARIATION FROM AVERAGE (AVERAGE - DIFFERENCE) 1	2	3	4	RESISTANCE, MICROHMS (CORRECTED TO 20 DEG C) 1	2	3	4	VARIATION FROM AVERAGE, % SPEC [< OR =] +/- 5% 1	2	3	4
0	24	---	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	23	127	104	56	56	56	55	71	71	71	72	1	2	2	2	191.8	189.8	191.8	188.8	.16	-.1	-.4	-.6
50	23	124	101	56	56	56	55	68	68	68	69	4	5	5	5	190.8	188.8	191.8	188.8	-.4	-.6	-.4	-.6
75	23	125	102	55	55	56	54	70	70	69	71	2	3	4	3	191.5	191.5	192.5	190.5	.0	.8	-.1	.3
102	23	128	105	56	57	57	55	72	71	71	73	0	2	2	1	189.8	189.8	191.8	189.8	-.9	-.1	-.4	-.1
130	23	130	107	57	58	57	56	73	72	73	74	-1	1	-1	0	190.8	189.8	191.8	189.8	-.4	-.1	-.4	-.1
171	23	128	105	57	57	57	56	71	71	71	72	1	2	2	2	193.8	188.8	192.8	189.8	1.2	-.6	.1	-.1
203	24	131	107	58	58	58	57	73	73	73	74	-1	-1	-1	0	191.1	190.1	191.1	189.1	-.2	.1	-.8	-.5
255	23	128	105	57	56	56	55	71	72	72	73	1	1	1	1	190.8	188.8	191.8	188.8	-.4	-.6	-.4	-.6
325	24	133	109	59	58	58	57	74	75	75	76	-2	-3	-3	-2	191.1	190.1	192.1	189.1	-.2	.1	-.3	-.5
421	23	133	110	56	56	56	55	77	77	77	78	-5	-5	-5	-4	191.8	190.8	194.8	190.8	.2	.5	1.1	.4
485	24	130	106	58	57	57	56	72	73	73	74	0	-1	-1	0	191.8	190.8	192.8	190.8	.2	.5	.1	.4
503	25	135	110	60	58	58	58	75	77	77	77	-3	-5	-5	-3	192.8	189.8	196.7	193.8	.7	-.1	2.1	2.0

	1	2	3	4
AVERAGE TEMPERATURE DIFFERENCE	72.3	72.5	72.5	73.6
MIN ALLOWABLE TEMP DIFFERENCE	62	63	63	64
MIN TESTED TEMP DIFFERENCE	68	68	68	69

	1	2	3	4
AVG RESISTANCE	191.5	189.9	192.6	190.0
MIN ALLOWABLE	182	180	183	181
MIN TESTED	189.8	188.8	191.1	188.8
MAX ALLOWABLE	201	199	202	200
MAX TESTED	193.8	191.5	196.7	193.8

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(DT4-9005)

DATA TABLE 4. CURRENT CYCLING, UNINSULATED, ELBOW CONNECTOR = BI-METAL SHORT

ANSI C119.4 - 1986 ELECTRICAL TEST DATA SHEET

TEST DATE: 10/24 TO 12/6/89

UNINSULATED CONDUCTOR - 21.1/36.6 kV INTEGRATED BUSHING - 9U02DBC001

TEST NUMBER: SCE89-025

RESISTANCE MEASURED FROM ELBOW PROBE TO BUSHING BUSBAR

TESTED BY: T.W. BROWN / T. AUSTIN

NO. OF CYCLES: 503
TEST CYCLE: 1 HOUR ON / 45 MIN. OFF *
TEST CURRENT: 239 AMPERES
* OFF = FAN COOLED

CONDUCTOR SIZE & TYPE: #1/0 AWG - 19 STRAND COMPRESSED ALUMINUM
CONDUCTOR PREPARATION: WIRE BRUSH WITH OXIDE INHIBITOR
ANTIOXIDANT: ALNOX UG
CONTROL CONDUCTOR LENGTH: 6 FEET

CRIMPING TOOL: BURNDY Y35
CRIMPING DIE: U243
NO. OF CRIMPS: 1
PROBE TORQUE: 150 LB-IN

CYCLE	TEMPERATURE (DEG C) AMBIENT	CONTROL	RISE	CONNECTOR 1	2	3	4	TEMPERATURE DIFFERENCE (CONTROL - CONNECTOR) 1	2	3	4	VARIATION FROM AVERAGE (AVERAGE - DIFFERENCE) 1	2	3	4	RESISTANCE: RESISTANCE, MICROHMS (CORRECTED TO 20 DEG C) 1	2	3	4	VARIATION FROM AVERAGE, % SPEC [< OR =] +/- 5% 1	2	3	4
0	24	---	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--				
24	23	127	104	45	46	46	45	82	81	81	82	0	1	1	1	133.5	136.4	136.4	129.5	-.25	-.6	-.5	-.9
50	23	124	101	46	47	46	46	78	77	78	78	4	5	4	5	133.5	136.4	136.4	129.5	-.2	-.6	-.5	-.9
75	23	125	102	45	46	46	45	80	79	79	80	2	3	3	3	134.0	137.0	137.0	130.0	.1	-.2	-.2	-.6
102	23	128	105	47	48	47	46	81	80	81	82	1	2	1	1	132.5	136.4	136.4	129.5	-1.0	-.6	-.5	-.9
130	23	130	107	47	48	47	47	83	82	83	83	-1	0	-1	0	134.5	138.4	137.4	130.5	.5	.8	.2	-.2
171	23	128	105	47	48	47	47	81	80	81	81	1	2	1	2	134.5	137.4	136.4	131.5	.5	.1	-.5	.6
203	24	131	107	49	49	48	48	82	82	83	83	0	0	-1	0	133.0	136.9	135.9	129.0	-.6	-.3	-.9	-1.3
255	23	128	105	47	47	47	46	81	81	81	82	1	1	1	1	133.5	136.4	136.4	129.5	-.2	-.6	-.5	-.9
325	24	133	109	49	49	48	48	84	84	85	85	-2	-2	-3	-2	133.5	137.4	136.4	130.5	-.2	.1	-.5	-.2
421	23	133	110	47	47	46	46	86	86	87	87	-4	-4	-5	-4	133.5	137.4	138.4	132.5	-.2	.1	.9	1.3
485	24	130	106	48	48	48	47	82	82	82	83	0	0	0	0	135.4	138.4	137.4	132.5	1.2	.8	.2	1.3
503	25	135	110	50	49	49	48	85	86	86	87	-3	-4	-4	-4	134.5	138.4	141.4	134.5	.5	.8	3.1	2.8

	1	2	3	4		1	2	3	4
AVERAGE TEMPERATURE DIFFERENCE	82.1	81.7	82.3	82.8	AVG RESISTANCE	133.8	137.3	137.2	130.7
MIN ALLOWABLE TEMP DIFFERENCE	72	72	72	73	MIN ALLOWABLE	127	130	130	124
MIN TESTED TEMP DIFFERENCE	78	77	78	78	MIN TESTED	132.5	136.4	135.9	129.0
					MAX ALLOWABLE	140	144	144	137
					MAX TESTED	135.4	138.4	141.4	134.5

TDJC09A 2/1/90
(DT5-9005)

DATA TABLE 5. CURRENT CYCLING, UNINSULATED, PROBE TO BUSHING BUSBAR

DATA TABLE 6 - CURRENT CYCLING - INSULATED - TEMPERATURE MEASUREMENTS - (OPTION A)

Temperature - °C Control Conductor vs Connector Elements														
Cycle NO.	Ambient	Control Conductor	Elbow Connector				Female Contact				Piston Contact			
			Sample No.				Sample No.				Sample No.			
			1	2	3	4	1	2	3	4	1	2	3	4
10	23.1	89.4	54.8	53.9	56.1	53.7	47.4	46.1	47.7	45.9	43.4	42.3	42.9	42.0
20	22.7	88.8	54.0	53.2	55.3	52.8	46.4	45.2	46.8	44.9	42.2	41.3	42.1	41.0
30	24.0	91.7	56.2	55.5	57.7	55.1	48.8	47.6	49.2	47.3	44.6	43.6	44.3	43.3
40	21.3	87.4	52.2	51.6	53.7	51.1	44.7	43.9	45.6	43.5	40.7	40.1	40.8	39.6
50	21.7	89.1	53.4	52.8	54.9	52.2	45.7	44.9	46.6	44.4	41.6	41.0	41.8	40.5

Conclusion: The warmest connector component temperature does not exceed the temperature of the control conductor.

Thermocouple Placement:
- On barrel of Elbow Connector near mid-point.
- On female Contact in bushing.
- On Piston Contact in bushing.
- On Control Cable at mid-point.
- Ambient

Data Table 6. Current Cycling, Insulated (Option A)

DATA TABLE 7 - CURRENT CYCLING - INSULATED - TEMPERATURE MEASUREMENTS - (OPTION B)
(with Bi-Metal Connector, Long)

Cycle NO.	Temperature - °C Control Conductor vs Connector Elements													
	Ambient	Control Conductor	Elbow Connector				Female Contact				Piston Contact			
			Sample No.				Sample No.				Sample No.			
			1	2	3	4	1	2	3	4	1	2	3	4
48	23.6	92.0	62.7	58.9	60.1	60.5	45.5	43.1	45.1	48.1	51.5	48.1	50.8	53.6

Conclusion: The warmest connector component temperature does not exceed the temperature of the control conductor.

Thermocouple Placement:
- On barrel of Elbow Connector near mid-point.
- On female Contact in bushing.
- On Piston Contact in bushing.
- On Control Cable at mid-point.
- Ambient

One current cycle represents (8) continuous cylces, each consisting of (3) hours on and (3) hours off.

The complete test consists of (30) open/close operations and (48) current cycles.

Data Table 7. Current Cycling, Insulated (Option B)

DATA TABLE 7A - CURRENT CYCLING - INSULATED - TEMPERATURE MEASUREMENTS - (OPTION B)
(with Bi-Metal Connector, Short)

Cycle NO.	Temperature - °C Control Conductor vs Connector Elements													
	Ambient	Control Conductor	Elbow Connector				Female Contact				Piston Contact			
			Sample No.				Sample No.				Sample No.			
			1	2	3	4	1	2	3	4	1	2	3	4
48	25.9	99.1	84.1	84.3	73.1	72.6	52.5	51.2	48.8	42.9	62.9	61.4	57.2	56.7

Conclusion: The warmest connector component temperature does not exceed the temperature of the control conductor.

Thermocouple Placement:
- On barrel of Elbow Connector near mid-point.
- On female Contact in bushing.
- On Piston Contact in bushing.
- On Control Cable at mid-point.
- Ambient

One current cycle represents (8) continuous cylces, each consisting of (3) hours on and (3) hours off.

The complete test consists of (30) open/close operations and (48) current cycles.

Data Table 15. Switch & Fault Closure Test

Hubbell Elow, 9U01D--6--

Cooper (RTE) Integrated Bushing, Model # 2637024C01M
(Mfg. date 2/87)

Sample No.	Switching (SCT 075) Pass/Fail	Switching (SCT 075) Osc. # of Last Opern.	Fault Close (SCT 077) Pass/Fail	Fault Close (SCT 077) Osc. #
31	P	2726B	P ---|	176
32	P	2726M	P |	177
33	P	2746B	P |	178
34	P	2746M	P |	179
35	P	2766B	P |	180
36	P	2766M	P |	181
37	F (7)	2780B	-- |	
38	P ---|	2586M	P (15)	182
39	P |	2806B	P |	183
40	P |	2806M	P |	184
41	P |	2826B	P |	185
42	P (9)	2826M	P |	186
43	P |	2846B	P |	187
44	P |	2846M	P |	188
45	P |	2866B	P |	189
46	P ---|	2866M	P ---|	190
47	F (4)	2874B	Not Tested	
48	P	2886M	Not Tested	
49	P	2906B	Not Tested	
50	P	2906M	Not Tested	
51	P	2926B	Not Tested	
52	P	2926M	Not Tested	
53	P	2946B	Not Tested	
54	P	2946M	Not Tested	
55	F (6)	2958B	--	
56	P	2966M	Not Tested	
57	F (8)	2982B	--	
58	P	2986M	Not Tested	
59	P	3006B	Not Tested	
60	P	3006M	Not Tested	

P = Pass, F = Failure Test Dates: 9/16/87 - 9/23/87

( ) = Failed on operation no.

Each Switching and Fault Close Operation was recorded by an oscillogram. Fault Close oscillograms show no external ground current.

Data Table 16. **Switch & Fault Closure Test**

GE Company Integrated Bushing, Model 9U02DBC001

Cooper (RTE) Elbows, Models 2637076--- or 2637077---
(Three Phase Rated)

Sample No.	Switching (SCT 1797) Pass/Fail		Switching (SCT 1797) Osc. # of Last Opern.	Fault Close (SCT 1974) Pass/Fail		Fault Close (SCT 1974) Osc. #
1	P		1793B	Not Tested		
2	P		1793M	P		113
3	F		1813B	--		
4	F		1813M	--		
5	P		1833B	P		114
6	P		1833M	P		115
7	P		1853B	P		116
8	P		1853M	P		117
9	P		1873B	P		118
10	P		1873M	P	(15)	119
11	P		1893B	P		120
12	P		1893M	P		121
13	P		1913B	P		122
14	P		1913M	P		123
15	P		1933B	P		124
16	P		1933M	P		125
17	P	(26)	1953B	P		126
18	P		1953M	P		127
19	P		1973B	Not Tested		
20	P		1973M	Not Tested		
21	P		1993B	Not Tested		
22	P		1993M	Not Tested		
23	P		2013B	Not Tested		
24	P		2013M	Not Tested		
25	P		2033B	Not Tested		
26	P		2033M	Not Tested		
27	P		2053B	Not Tested		
28	P		2053M	Not Tested		
29	P		2073B	Not Tested		
30	P		32073	Not Tested		

P = Pass, F = Failure Test Date: 12/10/85

Each Switching and Fault Close Operation was recorded by an oscillogram. Fault Close oscillograms show no external ground current.

Data Table 17. Switch & Fault Closure Test

GE Company Integrated Bushings, Model 9U02DBC001

Cooper (RTE) Elbow, Single Phase (21.1kV) with GE Three Phase Probe (21.1/36.6kV)

Sample No.	Switching (SCT 1726) Pass/Fail	Switching (SCT 1726) Osc. # of Last Opern.	Fault Close (SCT 1852) Pass/Fail	Fault Close (SCT 1852) Osc. #
1	P ---|	4120B	P ---|	67
2	P |	4120M	P |	68
3	P |	4140B	P |	69
4	P |	4140M	P |	70
5	P (10)	4160B	P (10)	71
6	P |	4160M	P |	72
7	P |	4180B	P |	73
8	P |	4180M	P |	74
9	P |	4200B	P |	75
10	P ---|	4200M	P ---|	76

P = Pass, F = Failure Test Date: 10/14/87 - 10/16/87

Each Switching and Fault Close Operation was recorded by an oscillogram. Fault Close oscillograms show no external ground current.