HUBBELL® POWER SYSTEMS, INC.

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Cable Accessories Test Report Bulletin CH 9904-00
15 kV & 25 kV 600 Ampere
Deadbreak Connector System

CERTIFICATION

The Hubbell Power Systems three phase rated, 15 kV and 25 kV Class, 600 Ampere, Deadbreak System is designed to meet or exceed the requirements of the IEEE Standard 386-1995, "Separable Insulated Connector Systems for Power Distribution Systems above 600 Volts". This product complies with the interface dimensions in Figure 11 of this standard.

This report is to certify that the tests shown in the following table have been successfully performed on Hubbell Power Systems, 15 kV and 25 kV Deadbreak Connector System in accordance with IEEE 386-1995. Separate reports shown in the table provide details of the tests.

Test	Standard	Section	Report No.	Issue Date
Corona Voltage Level	IEEE 386-1995	7.4	Bulletin CH 9904-01	2005-03-11
Dielectric (ac, dc, impulse)	IEEE 386-1995	7.5	Bulletin CH 9904-02	2005-03-11
Short-time Current	IEEE 386-1995	7.6	Bulletin CH 9904-03	2005-03-11
Current Cycling for Uninsulated-600A	IEEE 386-1995	7.9	Bulletin CH 9904-04	2005-03-11
Current Cycling for Insulated-600A	IEEE 386-1995	7.11	Bulletin CH 9904-05	2005-03-11
Accelerated Sealing Life	IEEE 386-1995	7.12	Bulletin CH 9904-06	2005-03-11
Cable Pull-out	IEEE 386-1995	7.13	Bulletin CH 9904-07	2005-03-11
Test-point Cap	IEEE 386-1995	7.16	Bulletin CH 9904-08	2005-03-11
Test-point	IEEE 386-1995	7.17	Bulletin CH 9904-09	2005-03-11
Shielding	IEEE 386-1995	7.18	Bulletin CH 9904-10	2005-03-11
TapMaster Junction	---	---	Bulletin CH 9904-11	2005-03-11

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TEST REPORT Bulletin CH 9904-01

Corona Voltage Level

TEST PROCEDURE:

Each of the test samples consisted of one cable ready 600 Amp elbow, one basic insulating plug, two insulating caps and one 3-position junction. The test voltage was raised to 20% above the minimum corona voltage level of 19 kV. If corona exceeded 3 pC, the test voltage was lowered to 19 kV and was maintained at this level for at least 3 seconds but not more than 60 seconds. Corona readings taken during this period did not exceed 3 pC.

TEST RESULTS:

All samples tested met the requirements of Section 7.4 of IEEE Standard 386 - 1995. Table 1 shows a summary of the Corona Voltage Level Test results.

Table 1. Summary of Corona Voltage Level Tests

Sample	Result
1	Passed
2	Passed
3	Passed
4	Passed
5	Passed
6	Passed
7	Passed
8	Passed
9	Passed
10	Passed

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TEST REPORT Bulletin CH 9904-02

Dielectric Tests
(ac, dc and, Impulse Withstand Tests)

TEST PROCEDURE:

Each of the test samples consisted of one cable ready 600 Amp elbow, one basic insulating plug, two insulating caps and one 3-position junction. For ac withstand tests, the test voltage was raised to 40 kV in not more than 30 seconds. The connector withstood the specified test voltage for one minute without flashover or puncture. For dc withstand tests, the test voltage had a negative polarity and was raised to 78 kV. The connector withstood the specified test voltage for 15 minutes without flashover or puncture. For impulse withstand tests, the test voltage had a 1.2/50 microsecond waveshape with a crest value (BIL) of 125 kV. All connectors were subjected to three positive and three negative full-wave impulses.

TEST RESULTS:

All samples tested met the requirements of Section 7.5 of IEEE Standard 386 - 1995. Table 1 shows a summary of the Dielectric Test results.

Table 1. Summary of Dielectric Tests

Sample	ac - 40 kV rms (1 Minute)	dc - 78 kV (15 minutes)	Impulse - 125 kV crest (3 Pos. 3 Neg.)
1	Passed	Passed	Passed
2	Passed	Passed	Passed
3	Passed	Passed	Passed
4	Passed	Passed	Passed
5	Passed	Passed	Passed
6	Passed	Passed	Passed
7	Passed	Passed	Passed
8	Passed	Passed	Passed
9	Passed	Passed	Passed
10	Passed	Passed	Passed

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TEST REPORT Bulletin CH 9904-03

Short-time Current Test

TEST PROCEDURE:

Test samples were mounted in a manner approximating service conditions and the test voltage was below the rated voltage of the test samples. Current magnitudes were measured in accordance with IEEE C37-09-1979, "IEEE Standard Test Procedure for ac High-voltage Circuit Breakers Rated on a Symmetrical Current Basis".

Each test sample consisted of:

600A Elbow
600A 3-Position Junction
600A Insulating Plug
600A Insulated Cap
600A Cable Adapter
600A Compression Connector
Cable Conductor Type: Copper
Cable Conductor Size: 500 kcmil.

TEST RESULTS:

The test samples withstood the current without separation of interfaces or impairing the ability to meet other requirements of the standard. All samples tested met the requirements of Section 7.6 of IEEE Standard 386 - 1995. Table 1 shows individual results of the Short-time Current Test.

Table 1. Summary of Short-time Current Test

Sample Number	Current (kA)	Duration (s)	Result
1	10	3.03	Passed
2	10	3.03	Passed
1	25	0.25	Passed
2	25	0.25	Passed

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TEST REPORT Bulletin CH 9904-04

Current Cycling Test for Uninsulated Components of 600 Amp Connectors

TEST PROCEDURE:

Tests were conducted in accordance with ANSI C119.4-1991, "Conductors for Use between Aluminum-to-Aluminum or Aluminum-to-Copper Bare Overhead Connectors", utilizing 750-kcmil aluminum conductor for 600 amp connectors. The test was made without insulation on the conductor or current-carrying parts of the connector to avoid deterioration of the insulation that may occur at the maximum temperature of this test. The test loop consisted of four 750-kcmil connectors joined together with two bus assemblies of a deadbreak bushing.

TEST RESULTS:

The conductor system met the requirements given for Class A connectors in ANSI C119.4-1991. All samples tested met the requirements of Section 7.9 of IEEE Standard 386 - 1995. Table 1 shows a summary of the Current Cycling Test results.

Table 1. Resistance Readings (mΩ) of 600 A Uninsulated Connector Current Cycling Test

Test Cycle: 1.5 hour on/1.5 hour off
Test Current: 1035 A (nominal)
Conductor Size & Type: 750 kcmil Stranded Aluminum
Conductor Preparation: Wire Brush with Anti-Oxidant
Control Conductor Length: 4 ft., 2 ft. Between Equal. and Conn.
Crimping Tool: Burndy Y48 BH
Crimping Die: Burndy C39AR, Number of Crimps: 2

	Initial	25TH	50TH	75 TH	100TH	125TH	165TH	205TH	245TH	325TH	405TH	485TH	500TH
Ambient	23.1	23.4	23.3	23.4	22.7	23.1	23.3	23.4	23.6	23.5	23.4	23.7	23.3
Equal 1 to Conn 1	0.142	0.064	0.065	0.066	0.063	0.064	0.064	0.064	0.064	0.065	0.065	0.064	0.064
Conn 1 to Conn 2	0.060	0.021	0.021	0.022	0.020	0.021	0.021	0.020	0.020	0.021	0.021	0.020	0.021
Conn 2 to Equal 2	0.166	0.064	0.066	0.065	0.063	0.063	0.063	0.063	0.065	0.064	0.065	0.064	0.064
Equal 2 to Equal 3	0.168	0.106	0.106	0.107	0.106	0.106	0.106	0.105	0.106	0.106	0.107	0.106	0.106
Equal 3 to Conn 3	0.087	0.061	0.059	0.060	0.060	0.061	0.060	0.059	0.060	0.060	0.061	0.060	0.060
Conn 3 to Conn 4	0.064	0.022	0.021	0.022	0.021	0.022	0.020	0.020	0.021	0.022	0.022	0.021	0.022
Conn 4 to Equal 4	0.073	0.065	0.066	0.066	0.064	0.065	0.064	0.065	0.066	0.065	0.066	0.065	0.065

Corrected to 20 ºC

	Initial	25TH	50TH	75 TH	100TH	125TH	165TH	205TH	245TH	325TH	405TH	485TH	500TH
Ambient	20	20	20	20	20	20	20	20	20	20	20	20	20
Equal 1 to Conn 1	0.140	0.063	0.064	0.065	0.062	0.063	0.063	0.063	0.063	0.064	0.064	0.063	0.063
Conn 1 to Conn 2	0.059	0.020	0.021	0.022	0.020	0.021	0.021	0.020	0.020	0.021	0.021	0.020	0.021
Conn 2 to Equal 2	0.166	0.064	0.066	0.065	0.063	0.063	0.063	0.063	0.065	0.064	0.065	0.064	0.064
Equal 2 to Equal 3	0.168	0.106	0.106	0.107	0.106	0.106	0.106	0.105	0.106	0.106	0.107	0.106	0.106
Equal 3 to Conn 3	0.087	0.061	0.059	0.060	0.060	0.061	0.060	0.059	0.060	0.060	0.061	0.060	0.060
Conn 3 to Conn 4	0.064	0.022	0.021	0.022	0.021	0.022	0.020	0.020	0.021	0.022	0.022	0.021	0.022
Conn 4 to Equal 4	0.073	0.065	0.066	0.066	0.064	0.065	0.064	0.065	0.066	0.065	0.066	0.065	0.065

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TEST REPORT Bulletin CH 9904-05

Current Cycling Test for 600 Amp Insulated Components

TEST PROCEDURE:
Four test samples were assembled in series on 750 kcmil insulated aluminum conductors having a length of 36 inches. A control cable was installed in the current-cycling loop between two equalizers. The length of the control cable was 72 inches. The equalizers used were in accordance with ANSI C119.4-1991, "Conductors for Use between Aluminum-to-Aluminum or Aluminum-to-Copper Bare Overhead Connectors". The tests were conducted at an ambient temperature of 19 to 25 ºC in a space free of drafts. The current-cycle amperes were adjusted to result in a steady-state temperature of 90 ± 5 ºC on the surface of the conductor of the control cable. The temperature was measured at the approximate center of the control cable. The test consisted of 50 current cycles, with the current on for 6 hours and off for 6 hours for each cycle. The temperature of the hottest spot of the test samples was measured every 10 cycles.

Each test sample consisted of:
- 600A 2-Postion Junction
- 600A Elbow
- 600A Insulated Plug
- 600A Cable Adapter
- 600A Compression Connector.

TEST RESULTS:
The temperature of the hottest spot of the test samples did not exceed the temperature of the conductor of the control cable. All samples tested met the requirements of Section 7.11 of IEEE Standard 386 - 1995. Table 1 shows individual results of the Current Cycling Test.

Table 1. Current Cycling Test for 600A Insulated Components

Test Cycle	Temperature (ºC)								
	Control Conductor	Sample 1		Sample 2		Sample 3		Sample 4	
		Spot 1	Spot 2	Spot 1	Spot 2	Spot 1	Spot 2	Spot 1	Spot 2
10	93.8	88.8	88.3	86.2	89.8	86.8	83.8	85.0	89.1
20	91.4	87.2	86.7	83.2	87.5	84.7	80.8	81.6	86.5
30	91.0	86.6	86.7	83.6	87.5	85.2	80.4	82.5	86.0
40	89.8	85.4	85.6	81.3	85.5	83.2	79.7	80.5	84.1
50	90.8	85.3	85.7	81.3	85.6	83.6	79.9	81.0	84.5

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TEST REPORT Bulletin CH 9904-06

Accelerated Sealing Life Test

TEST PROCEDURE:
Four connector assemblies were placed in an oven with 121ºC temperature and remained there for three weeks. After this time elapsed, the four samples were removed from the oven and subjected to 50 cycles of the following sequence of operations.

1. The assemblies were heated in air using sufficient current to raise the temperature of the conductor of the control cable to 90ºC ± 5ºC for 4 hours.
2. The assemblies were de-energized and within 3 minutes, submerged in 25ºC ± 5ºC conductive water (5000Ω/cm maximum) to a depth of 30 cm for 2 hours. After the 50th cycle, each connector and cable assembly should withstand a design impulse test.
3. The test point, if provided, should be capable of passing the voltage test.

Each sample assembly consisted of:

600A Elbow
600A Cable Adapter
600A Compression Connector
600A Connecting Plug or 3-Position Junction
600A Insulated Plug and Cap (for Junctions)
Cable Conductor Type: Aluminum (Copper for Junctions)
Cable Conductor Size: 750 kcmil Stranded (500 kcmil for Junctions)

TEST RESULTS:
All samples tested met the requirements of Section 7.12 of IEEE Standard 386 - 1995. Table 1 shows individual results of the Accelerated Sealing Life Test.

Table 1. Accelerated Sealing Life Test

Sample Number	Impulse Withstand (125 kV BIL)	Test Point Indication
1, with Connecting Plug	Passed	Passed
2, with Connecting Plug	Passed	Passed
3, with Connecting Plug	Passed	Passed
4, with Connecting Plug	Passed	Passed
5, with Junction	Passed	Passed
6, with Junction	Passed	Passed
7, with Junction	Passed	Passed
8, with Junction	Passed	Passed

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TEST REPORT Bulletin CH 9904-07

Cable Pull-out Test (Tensile Strength)

TEST PROCEDURE:

The 600 Amp elbow compression connector was held in a manner that did not affect the strength of the connection. A tensile force of 200 lbf was applied to the cable conductor for 1 minute.

Each sample assembly consisted of:

600 A Compression Connector
Cable Insulation Thickness: 175 mils
Cable Insulation Type: XLPE
Cable Conductor Type: Aluminum
Cable Conductor Size: 1/0 AWG Stranded
Compression Tool: Kearney H-1
Compression Die: Kearney 840 (Four Crimps).

TEST RESULTS:

All samples tested met the requirements of Section 7.13 of IEEE Standard 386 - 1995.

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TEST REPORT Bulletin CH 9904-08

Test-point Cap Test

1. Test-Point Cap Operating Force

TEST PROCEDURE:

A tensile force was gradually applied to the test-point cap in the direction parallel with the probe axis at -20ºC, 25ºC, and 65ºC. The force required to remove the test-point cap should be within the range of 8 to 49 lbf.

TEST RESULTS:

All samples tested met the requirements of Section 7.16 of IEEE Standard 386 - 1995. Table 1 shows individual results of the Test-point Cap Operating Force Test.

Table 1. Test-point Cap Operating Force Test

Sample Number	Operating Force (lbf)		
	-20ºC	25ºC	65ºC
1	30	28	12
2	30	22	12
3	24	28	14
4	34	25	11

2. Test-Point Cap Operating Withstand

TEST PROCEDURE:

A tensile force of 100 lbs was applied to the test-point cap operating eye for 1 minute at -20ºC, 25ºC, and 65ºC. Some distortion of the operating eye was acceptable provided the test-point cap was serviceable after the test.

TEST RESULTS:

All samples tested met the requirements of Section 7.16 of IEEE Standard 386 - 1995.

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TEST REPORT Bulletin CH 9904-09

Test-point Test

1. Test-point Capacitance Test

TEST PROCEDURE:

An elbow was installed on a cable of the type. The shielding of the elbow was grounded in the normal manner. The capacitance from the test-point of the elbow to the cable conductor and the test-point to the shield was measured with suitable instruments and proper shielding techniques.

TEST RESULTS:

The capacitance between the test-point and the cable conductor was at least 1.0 pF. The ratio of the capacitance between the test-point and shield to the capacitance between test-point and cable conductor did not exceed 12. All samples tested met the requirements of Section 7.17 of IEEE Standard 386 - 1995. Table 1 shows individual results of the Test-point Capacitance Test.

Table 1. Test-point Capacitance Test (pF)

Sample Number	Test-point to Cable	Test-point to Ground	Capacitance Ratio
1	1.2	7.9	6.6
2	1.2	7.7	6.4
3	1.2	8.1	6.8
4	1.2	7.8	6.5
5	1.2	7.8	6.5
6	1.2	8.2	6.8
7	1.2	7.8	6.5
8	1.2	7.7	6.4
9	1.1	7.8	7.1
10	1.2	7.6	6.3

2. Test-point Voltage Test

TEST PROCEDURE:

A test voltage was applied to the conductor system of the connector. The response of a suitable sensing device on the test-point indicated an energized condition.

TEST RESULTS:

All samples tested met the requirements of Section 7.17 of IEEE Standard 386 - 1995. Table 2 shows individual results of the Test-point Voltage Test.

Table 2. Test-point Voltage

Sample Number	Applied Voltage (kV)	Test-point Voltage (kV)
1	15.0	12.5
2	15.0	11.0
3	15.0	10.5
4	15.0	12.0
5	15.0	12.5
6	15.0	12.5
7	15.0	13.0
8	15.0	12.5
9	15.0	11.5
10	15.0	12.5

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TEST REPORT Bulletin CH 9904-10

Shielding Test

1. Shield Resistance Test

TEST PROCEDURE:

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

The resistance of the semi-conducting shield of 600A elbow test samples was measured using the voltammeter method. The voltage was measured with the current adjusted to 1.0 mA ± 0.2 mA. 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 unaged test specimens and samples that had been oven aged for 504 hours at 121ºC. Resistance measurements were made with the test specimen temperature at 20ºC and 90ºC.

TEST RESULTS:

All test samples did not exceed 5000 Ω. All samples tested met the requirements of Section 7.18 of IEEE Standard 386 - 1995. Table 1 shows individual results of the Shield Resistance Test.

Table 1. Shield Resistance (Ω)

Sample Number	Unaged		Sample Number	Aged	
	20 ºC	90 ºC		20 ºC	90 ºC
1	61	67	5	59	46
2	49	64	6	52	50
3	51	68	7	53	47
4	65	75	8	45	33

2. Fault-current Initiation Test

TEST PROCEDURE:

The test procedure and requirements were in accordance with the Fault-Current Initiation Test in IEEE Standard 592-1990, "IEEE Standard for Exposed Semiconducting Shields on Premolded High-Voltage Cable Joints and Separable Insulated Connectors". The circuit parameters were 6 kV maximum and 11 kA rms symmetrical available short circuit current. Each specimen was subjected to two tests causing initiation having minimum current flow duration of 10 cycles.

TEST RESULTS:

All samples tested met the requirements of Section 7.18 of IEEE Standard 386 - 1995. Table 2 shows individual results of the Fault-current Initiation Test.

Table 2. Fault-current Initiation Test

Sample Number	Test Number	Test Voltage (kV)	Test Current (kA)	Duration (Cycles)
1	1	6.0	11	11.5
1	2	6.0	11	11.0
2	1	6.0	11	11.0
2	2	6.0	11	11.5
3	1	6.0	11	11.5
3	2	6.0	11	11.5
4	1	6.0	11	12.0
4	2	6.0	11	11.0

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TEST REPORT Bulletin CH 9904-11

TapMaster™ Junctions

CERTIFICATION:

The test program contained herein was conducted under the direction of Kearney Electrical Laboratory, Kearney Company, McCook, IL, and Hotsplicer Corporation, Wauconda, IL. The test report, 15kV and 25kV Multipoint Junctions, Test Report #2799.RPT, is in accordance with the cited industry standards and accepted engineering practice.

15kV and 25kV Class MULTIPLE POINT JUNCTIONS
Test Report #2799.RPT
May 1995.

Introduction

Hotsplicer Corporation's Dead-Break Junction Bars are designed to meet a variety of Separable Insulated Connector System applications. The unique J-Bar manufacturing process allows customers to specify which connector interface is required at each tap position. This "connector system flexibility" allows customers to utilize any combination of 15kV / 200 A and 25kV / 600 A separable connectors.

The design ratings of the J-Bar bus system will meet 25kV Class (900 Amp) Ratings.

Ratings

Class	25 kV	15 kV
Phase to Ground (rms)	15.2 kV	8.2 kV
Phases to Phase Maximum (rms)	26.3 kV	14.4 kV
Basic Impulse Level (BIL), 1.2 x 50 wave	125 kV	95 kV
Alternating Current Withstand (1 minute)	40 kV	34 kV
Direct Curent Withstand (15 minutes)	78 kV	53 kV
Minimum Corona Voltage Extinction	19 kV	11 kV
Continuous Current Rating	900 Amps (rms)	900 Amps (rms)
8-Hour Overload Current Rating	1200 Amps (rms)	1200 Amps (rms)
Momentary Current Ratings (0.17 sec)	25,000 Amps (rms/sym)	25,000 Amps (rms/sym)
Momentary Current Ratings (3.0 sec)	10,000 Amps (rms/sym)	10,000 Amps (rms/sym)

Summary of Test Results

Test program performed at Kearney Co.'s McCook, IL Power Research Laboratory and at Hotsplicer Corporation, Wauconda, IL.

The Hotsplicer Dead-Break Junction Bars meet or exceed applicable ANSI/IEEE Std. 386-1985 requirements.

1.0 Corona Voltage Level

Five sample units were used for testing. The units were 6 position junctions with two 600 A interfaces at both end positions and four 200 A wells in the middle. The units were tested on a ground plate with Elastimold insulating caps installed over the 600A interfaces. The 200 A wells were filled with silicone oil. A ground strap was wrapped around junction semicon. The test voltage is raised to 20% above the 19 kV extinction level. If corona exceeds 3 pC, the voltage is lowered to to 19 kV and is held for at least 3 seconds and no more than 60 seconds. Corona levels taken during time period must not exceed 3 pC.

Results: All 5 samples met corona extinction levels listed in Table 1.

Table 1. Corona

Sample No.	Junction ID	Date	CIV	CEV	pC at 19kV
1	1012.jbr (622226)	5-5-95	NA	NA	<3
2	1012.jbr (622226)	5-5-95	NA	NA	<3
3	1012.jbr (622226)	5-5-95	NA	NA	<3
4	1012.jbr (622226)	5-5-95	NA	NA	<3
5	1012.jbr (622226)	5-5-95	NA	NA	<3

2.0 Thermal Cycling

The five units from Table 1. were thermal cycled for 10 days in an environmental chamber. The units cycled from -40° C to 140° C in a 24 hour period per Hotsplicer Specification No. SPC .1002.

Results: The units were inspected via X-ray with no damage found.
The 5 units were corona tested a second time confirming the values in Table 1.

3.0 AC Withstand Voltage

Units were placed on a ground plate with high voltage attached to 600A interface. Test voltage was raised to 40 kV in less than 30 seconds. Each unit was held at 40 kV for 1 minute.

Results: All 5 samples passed AC Withstand to 40 kV.

4.0 DC Withstand Voltage

Units were placed on a ground plate with high voltage attached to 600A interface. A negative polarity DC voltage was raised to 78 kV. Each unit was held at 78 kV for 15 minutes.

Results: All 5 samples passed DC Withstand to 78 kV.

4.0 Impulse Withstand Voltage

Four units were tested. Two JB6.666666 and two JB6.622226.
The 200A interfaces were mated with Hubbell bushing inserts and the 600A interfaces were mated with Elastimold insulating caps. Each unit received three positive and three negative shots at 125kV (1.2 x 50 wave).
Results: The 4 junctions passed the 125kV BIL rating without flashover or puncture.

5.0 Continuous Current

Procedure

The internal copper bus system was checked for thermal stability by cycling one unit (No. JB6-62226-25kV) for three days at 900 amps for 8 hours continuous.
Bolted connections were placed on the 600A ends.
Temperature readings were taken at various times as shown in Table 2.
On day 4, the current was raised to 1200 amps for 8 hours with the temperature recorded in Table 3.

Table 2. Continuous Current - 900 Amps (8 hours On for 3 days)

900 amp Continuous - Ambient Temperature - 21° C		
Time	Epoxy° C (Day1, Day2, Day3)	Cu Bus° C (Day1, Day2, Day3)
8:00	22, 22, 22	22,22,22
9:00	30,29,30	40,41,41
12:30	32,31,33	48,48,48
1:30	34,34,33	48,47,48
3:00	34,33,34	48,48,48
4:00	34,34,34	48,48,48

Table 3. 8 Hour Overload Current -1200 Amps

1200 amp Continuous - Ambient Temperature - 21° C		
Time	Epoxy° C	Copper Bus° C
8:00	21	21
9:00	34	54
12:30	43	70
1:30	43	70
3:00	45	70
4:00	43	72